EDITORIAL

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COMMENCEMENTS.

During the month of June most of the schools and colleges of pharmacy hold their commencement exercises—a year has closed, another will soon open. The number of applicants knocking at the doors of these schools and colleges now exceeds the number of students who can be accommodated by some of these institutions. The result will be that qualification rather than priority in making application will govern in the selection of the student body, and this will influence the discussions of pharmaceutical conferences this year.

The same conditions obtain in most institutions of learning—a dean of a medical college recently made the statement that the college with which he was connected had more than one thousand applicants, and out of this number only 150 could be accepted because of facilities and accommodations. Such proportions need revision, either there are not enough medical colleges, or too many desire to take up the practice of medicine, or both. All of the applicants had the required preliminary education, and, as a result, some will take up other studies, or engage in other work; others will enter the related fields of medicine and some those which are objected to by "legitimate" medicine. There is need for more physicians in certain communities wherein the state may be at fault on account of withholding financial support from the medical department of the state university; the same is probably true of pharmacy schools.

The development of pharmacy differs from that of medical practice; in the latter, professional service is followed by all; in that of the former, a considerable number engage in business and do not pursue pharmacy in fact, after graduation.

Changes have occurred, but it is difficult to say exactly what the trend is, or will be. On this, to some extent, the classes in pharmacy schools hereafter will depend, but it must be recognized that the training for pharmacy fits individuals for many other activities, and year by year the pharmacy schools are turning out better-educated trained men and women, and some of these leave pharmacy to engage in other work wherein one or the other of the underlying sciences is essential, and the training for pharmacy very helpful. So while argument seems well supported that within a few years there will not be so many students in pharmacy schools, there is also the one just presented, for which there is conclusive evidence.

The statement is still occasionally made that there will be a division within the drug business and that this will influence the schools, but it can hardly be said that progress in that direction has been rapid. Others hope for the day of coöperation of all medical activities that will bring medicine and pharmacy together in the laboratories represented not only by the institutions of learning but of those attached to or part of manufacturing establishments, associated for comprehensive research and service. Such work has been done, but not in a coördinated and cooperative way—the manufacturer has responded to the pharmacists' and physicians' demands, the laboratories of the schools and of the manufacturers have produced and standardized the products and the materia medica, but there has not been the fullest coördinated coöperation of the industries, the professions and the schools.

There has been a growth of "isms," due largely to indifference of the public, but also to the fact that there has not been the fullest coöperation possible between the interests referred to in the preceding paragraph. Admitting that there is difference in preliminary educational standards, there are possibilities in shaping them in such a way that a better working coöperation and coördinaton will be brought about which will benefit all branches of medicine and enlist a greater public interest in sustaining and advancing medicine, because of service rendered.

Commencements mark periods in the lives of men and women and of the activities in which they are engaged. E. G. E.

THE ALUMNI.

THE former attitude toward alumni was that expressed by a college president; when asked what he thought of a proposed effort toward the organization of the alumni of his institution, "What is the good of it?" he replied, "besides I have all I can do to manage the faculty and students."

The estimate is different to-day, and each graduate who goes out is either an asset or a liability to the institution and to the profession for which he has been educated. The value of the Alma Mater to its alumni bears a somewhat similar relation.

There is a growing realization of responsibility by both the institutions and their graduates. This consciousness has made the large endowments of older institutions possible, and is quite as essential as the college spirit. Alumni should be potent in the affairs of the institutions which prepared them for their life-work, in fact, an integral part of them. So that they will be of a great influence for good and advancement it is very necessary that the student body should not only be carefully selected, but the ideals of the profession held before them during their student years, and also their obligations. It is true some of these ideals are soon shattered, but the attachment of the alumni for their Alma Mater is growing, and not so much, as some would have us believe, because of the associations during the college years, but for that which has made it possible for them to achieve success and deserve the regard of fellow-citizens.

There are possibilities which alumni can promote; the standing of their school or college is a matter of importance and pride; so also the alumni body reflects credit or discredit on the Alma Mater—there is a potential relation which has its influence for good, or may prove disastrous.

Wilfred Shaw, general secretary of the Alumni Association of the University of Michigan, in the current issue of *Scribner's* writing of "The Power of Alumni in University Life," states: "For the most part, as we view it to-day, the alumni support of our universities has been not only progressive but intelligent. It has brought new currents into many a university backwater. In return we know that the campus, with its idealism, and devotion to truth, wherever it may be found, has not been without its wholesome stimulus to those who, having passed its portals, have returned once more for renewed inspiration."

"Who should drink to Alma Mater, cheer for her, work for her, subscribe to her necessities, tell her how to run things generally, if not her Alumni?"

E. G. E.

REORGANIZATION OF THE AMERICAN PHARMACEUTICAL ASSOCIATION.

UNDOUBTEDLY, the majority of members agree that the editor of an official association organ should present a subject of great importance to the association for consideration rather than express his views thereon, and, when there is a division of opinion, to impartially publish or present both views on a question. This is the attitude of the writer, and, in his opinion, this statement is borne out by the editorial in the April issue, JOURNAL A. PH. A., p. 243. For the reasons expressed, no further comment is made by him. In this issue, papers dealing with the subject are printed; the authors participated in the discussions at one or more of the meetings of A. Ph. A. branches. E. G. E.

CLEVELAND PUBLIC SQUARE.

Eastern Section of Cleveland's Public Square.—From the Public Square radiate several of the city's principal streets and through it pass most of the city's car lines.

The American Pharmaceutical Association and associated organizations will meet in Cleveland during the week of August 14.

PHYSICS IN PHARMACY.

Author's Comments.

Utensils. Experience in this series of researches inclines the operator to prefer for meniscus observation the ordinary ten-cc stoppered cylinder (Fig. 1). For researches later described it should be divided into tenths. It need scarcely be stated that the observed meniscus aside from light refractions is subject to perplexing influences whatever may be the form or size of the container. Such complications as these tend to bring the personal equation into play, often helpful, again as a disturbing factor.

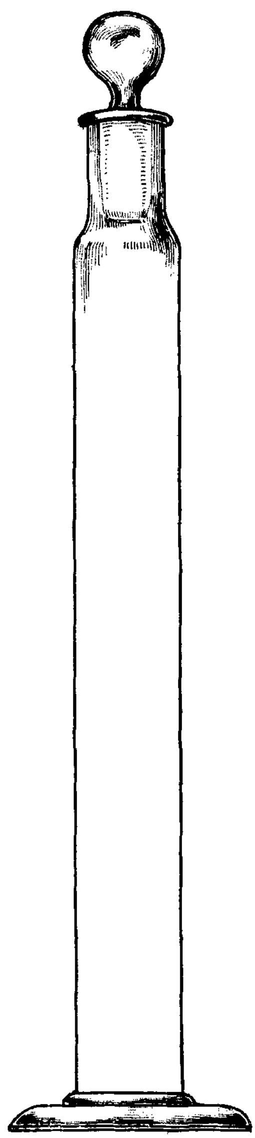

Fig. 1.

That mathematical formulas can be applied to such experiments as are herein presented, and that delicate apparatus devised for special purposes may yet be applied to the problem as a whole, needs no argument. It is sufficient to say that the author appreciates that he lacks such opportunities for precision as these could offer.

Illustrations. The meniscus illustrations that follow, utilize fractions only of the cylinder, meniscus curvatures being represented as lines. In a comprehensive way the object is thus fairly attained. These lines are not always typical of the exact plane division, as can be comprehended if one attempts to formulate into a simple diagram the bisected view of so complex and elastic a structure as is embodied by some (most) of them They present many features not apparent in the halving of a solid orange, be it round or oblique.

Reagents. Originally the liquids were, when possible, U. S. P. 1879 standard, manufactured by Powers and Weightman and Rosengarten & Sons. Not all used were, however, recognized by that work and several differ from present pharmaceutical standards. Alcohol and ethers, for example, were very different from those of succeeding editions as well as of the present U. S. P., which fact introduced interesting complications in the recent verification repetitions by J. T. Lloyd.

Verifications (1922) have been made with Squibb's and Baker's C. P. reagents. Surprising are some of the discords between these and the original. As a rule they are due (as often stated in the text) to variations between the old-time standards of the reagents, and the present. These deviations in themselves are seemingly annoying, but in connection with the subject as a whole very gratifying to the author, as will be shown if he is so fortunate as to complete publication of the old manuscript.

Personal Equation. Fortunately, after forty years have passed, the writer was relieved of the responsibility of reviewing the old manuscript as well as of repeating the experiments. His son, John Thomas Lloyd, took upon himself this task, for which his several years' experience in Cornell University research laboratory admirably fitted him. Otherwise, notwithstanding friends have long urged publication, it is doubtful whether the writer would have ventured to put the work into print after so long an interval.

The author deems it eminently proper that these research studies should appear in the PROCEEDINGS OF THE AMERICAN PHARMACEUTICAL ASSOCIATION as a continuation of connected contributions ("Precipitates in Fluid Extracts") temporarily interrupted in the year 1885, and appreciates the opportunity.

CINCINNATI, MARCH, 1922.

PART I.

PHYSICS IN PHARMACY.* (EXPERIMENTATION.)

BY JOHN URI LLOYD.

Outline of the Study. Perhaps it is more difficult to establish data for a commencement of the experimental study of pharmacy than it is to initiate a process for a more restricted scientific research. This because pharmacy includes so many subjects that press forward in a body and severally demand recognition. It is a matter of regret that in this paper fragmentary selections from many topics must necessarily be made, and also that many enticing and radiating phases of study and experimentation must altogether be excluded.

It should also be borne in mind, as will be quickly perceived, that this study is directed toward such phases of our art as are not included in the usual pharmacal publications. Indeed, the title "A Study *in* Pharmacy," instead of "A Study *of* Pharmacy," was selected because it permitted such discriminative processes.

We shall be drawn to the consideration of many physical processes generally disregarded as pertaining to pharmacy but which intimately concern some of its complications and outreaches. Among such the phenomena, solution and its radiations, stands at the very doorway of pharmacy manipulation. Consequently, the general phenomenon of solution has already been especially mentioned (PROC. AM. PHARM. ASSOC., 1879–85) as including such physical forces as capillarity, mass attraction, diffusion and osmosis. Although largely neglected these influences and connected problems are yet in the author's opinion scarcely less important in pharmacal fields than is pure chemistry. Mass or contact action, structural affinity, and elective attributes of comparatively passive agents, surely produce compounds or bundles of structures not subject to rules as yet known to govern atomic wanderings, these being vital to the study of pharmaceutical preparations made of vegetable structures.

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* These experiments and drawings were made during and closely following the series of articles, "Precipitates in Fluid Extracts," published in the PROCEEDINGS OF THE AMERICAN PHARMACEUTICAL ASSOCIATION, 1879 to 1885. The author then considered it vital to the progress of that contribution. After these decades it may yet be a serviceable continuation thereof.

This fragment (Experimentation) was vitalized as part of Chapter IV of our "Study in Pharmacy" issued in 1894 in the form of leaflets and privately presented to a few close friends in pharmacy. The original constitutes a hundred pages of print mainly devoted to pharmacal phenomena.

Fallacies. Liabilities to Error in Manipulation.

It seems as though our pharmacy authors have given too little consideration to, or at least have not prominently presented to us, the many fallacies and complications involved in our field by experimental investigation.

Hence, I shall, as a venture, first attempt to demonstrate that the experimenter must be constantly on his guard, lest he draw unwarranted conclusions from experimental observations. In order to establish this fact more forcibly than by a mere statement the following simple experimental examples will be introduced as illustrations, although it must be accepted that such complications are not restricted to pharmacy but concern alike similar problems met by scientists working in adjacent fields.

Measuring Liquids.

In measuring liquids, we are confronted at the outset with exceptional opportunities for error of experimentation. We must anticipate disturbances of vision that present themselves to whoever attempts to locate an object through the agency of light that passes through different media. The observer cannot (and does not) trust his vision alone in this the first step in a work with solvents. If he relies implicitly on eye presented phenomena without mental analysis he cannot measure a liquid exactly. True, the error of experiment will be small in many instances, but error at all should not appear in scientific work. The personal equation variation here depends not so much on physical blundering or awkward hands as on mental carelessness or lack of training of the senses that leads to failure to credit unseen phenomena intrusions.

Confronting us as experimentalists with liquids within glass containers, at the very commencement, we find the well-known aberration of a ray of light when it passes through different media. For example, when light passes diagonally into a dense transparent medium with parallel sides the ray is deflected toward the perpendicular and on emerging therefrom is again deflected into a course

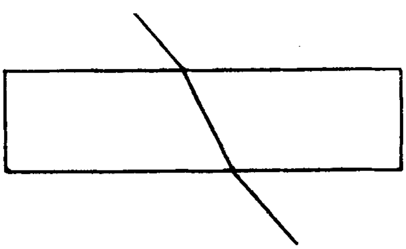

Fig. 2.

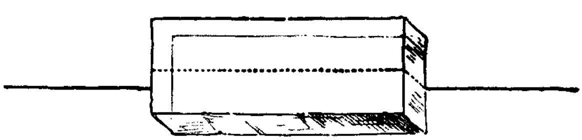

Fig. 3.

parallel with the original (Fig. 2). An object thus presents itself to the eye in a location where it does not exist. All have verified this school-book assertion or may do so by placing a plate of glass over a ruled line (Fig. 3). The line appears to be broken at the point where it passes beneath the glass and the continuation beneath is apparently separated from the extremities. The thickness of the plate of glass and the angle of vision govern the degree of displacement. The Indian thrusts his harpoon where the eye sees no fish.

In measuring liquids we have to contend with additional illusions. The graduated scale on the glass is not on a plane surface but on a cylinder. The matter is thereby further complicated, under certain conditions even to the total extinction of part of the contents within such a vessel. Hold a glass cylinder or plain tumbler about two inches in diameter parallel to the eye and then thrust a slender pencil or rod down one side; when it strikes the water it will disappear (Fig. 4). Move the rod towards the center and as that portion beneath the liquid comes into view it appears to be broken from the rod where it strikes the surface of the water (Fig. 5). It will be seen that if the operator places the rod so as to be able to really locate the portion that is beneath the water it must be exactly in the center of the glass (Fig. 6). Next, hold the glass about a foot below the level of the eye and place the pencil diagonally behind it. The pencil not only appears to be broken apart, but the portion behind the water is disconnected from the object and curiously distorted (Fig. 7). Place the glass about a foot below the level of the eye with the pencil crossed behind it and the part behind the glass is seen to be decidedly curved (Fig. 8). Raise the glass until the pencil is parallel with the eye and it assumes a normal appearance (Fig. 9). From these experiments it becomes evident that if an observer expects to locate the position of an object under these conditions, the object and the vessel must both be exactly on a level with the eye. It may be added that the glass of the vessel must also be of uniform thickness and density.

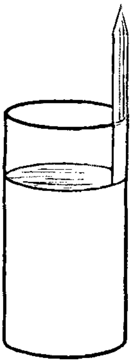

Fig. 4.

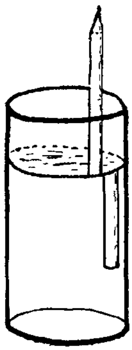

Fig. 5.

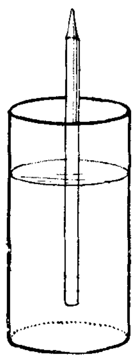

Fig. 6.

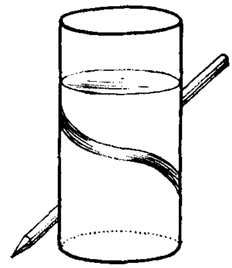

Fig. 7.

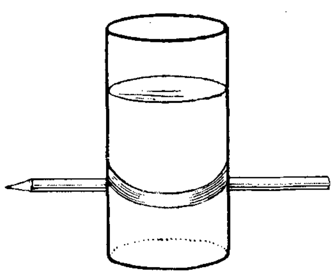

Fig. 8.

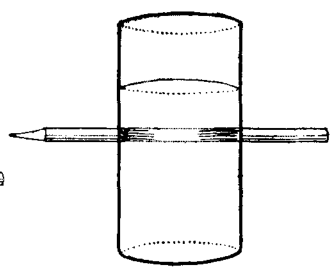

Fig. 9.

As the diameter of the vessel decreases, the optical disturbances just described increase and with small tubes great care must be taken to consider the influences cited if the operator hopes to exactly locate an object either inside the glass vessel or beyond it.

It may occur to the reader, in the act of measuring with a graduate or other chemical glass, that the location of the surface of a liquid is different from that of an object behind the liquid or in it, and that the foregoing series of illustrations, while sufficient to demonstrate the facts stated, needs yet further enlargement if applying to the pharmacist's field. In this connection the necessary details will present themselves as our work progresses.

As a further example, the appearance of a refractive medium at the zone of contact, apparently distinct from either of two contact liquids, may become so realistic that we cannot from presented optical evidence question its material existence. That such a phenomenon, however, may be altogether deceptive is easily demonstrated by creating an artificial mirage as follows:

Pour a little mercury into a cylinder.[1] Its surface assumes the appearance of the curved line in Fig. 10.

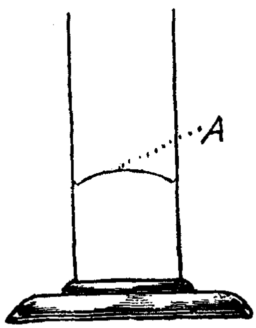

Fig. 10.

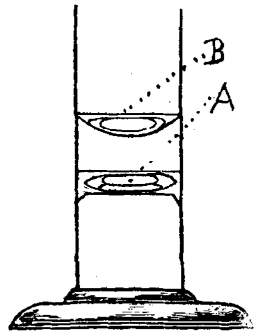

Fig. 11.

Pour upon it a layer of carbon disulphide, then look transversely through it; the mercury surface and carbon disulphide surface appear as A, Fig. 11.

The transparent, complicated structure A appears to exist *over* the surface of the mercury. It is as realistic (to me) as a lake of water that once seemed to spread before my eyes in a dry desert, and possibly results from similar phenomena on a small scale.

We know, however, that such a compound medium cannot be made of mercury and carbon disulphide as well as we know that the lake upon the arid plain is a delusion. Neither can we understand, from eye observation only, how the brilliant raised structural ring A, in Fig. 11, can have been formed as a delusion and maintained in position by contact of mercury with carbon disulphide. That it exists seems unquestionable, for it can be also seen through the overlying liquid as a central projection by looking down upon it.

Pour now upon the surface of the carbon disulphide a layer of water, and the liquids at once arrange themselves as in Fig. 12.

The floating section over the mercury remains somewhat altered, the carbon disulphide contact with the water being shown as an even curve, B, the air surface of the water as A.

Fill now the tube entirely with water and cork it. The water surface no longer exists and the ring complication over the mercury disappears (Fig. 13).

[1] These diagrams are natural size.

It is thus demonstrated to have been simply a reflection of the meniscus and surface B, of the carbon disulphide, in Fig. 11, and of the pendent drop A, of the water surface in Fig. 12. It had no material existence, being an optical illusion, and yet to the unqualified sense of sight it was as materialistic as the mercury itself.

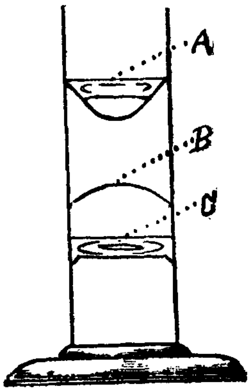

Fig. 12.

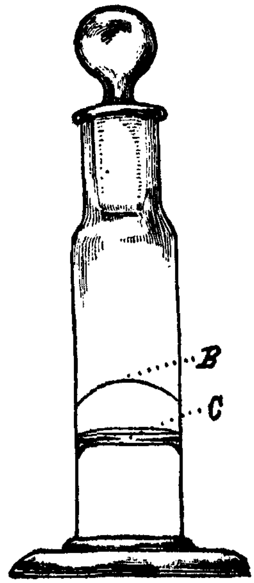

Fig. 13.

Fully as pronounced, even more perplexing, delusions appear in other phases of experimentation, as will be shown hereafter in connection with the media of different refractive powers that sometimes seem to form and rest as sections, between contact liquids.

Transparent Mercury. Deceptive and strikingly realistic is the appearance of a globule of mercury resting in a conical paper as may be shown by the following experiment: Fold a small filter paper into a cone shape, and pour into it a globule of mercury about the size of a large pea. By inclining the paper so that the light from a side window is cast down upon it, the globule becomes limpidly transparent excepting a spot near its center. There a black speck nestles, seemingly seated beneath an overlying crystalline solution that to the sense of sight is typical of transparency, through which can be seen, if the eye can be trusted, the very texture of the paper beneath. If the experiment be made by folding a printed paper instead of a plain one the deception of the misled eye is even more conspicuous. The lines of print seem then to pass unbroken beneath the limpid globule, each as it enters the liquid curving somewhat toward a common center, which is the black spot that nestles beneath the apparently clear medium as is shown by Fig. 14. And yet we know that the globule of mercury is as opaque as charcoal.

In experimental work such as is to follow this introduction the operator who trusts to appearances may thus be deluded by reflection of the liquid surfaces from above and reflection from surfaces in contact, as well as by the further refraction, dissipation and reflection of light from the glass and the mediums within. Such distractions, and others similar, tend to delude the experimenter and may easily culminate in self-deception, and, even with the utmost care, without methodical calculation, may lead to the most glaring errors of judgment from which the author appreciates he has not escaped.

Fig. 14.

Enough we hope has now been cited to support our preliminary statement that in such directions as these the sense of sight is reliable only when the trained mind qualifies by reasonings and deductions the impressions received on the retina.

In our field all who experiment must unconsciously guard against accepting as realities that which is unreal. Since all persons are not constituted so as to make the same subconscious theoretical deductions, it naturally follows that even in so simple a matter as the measuring of a liquid, or descriptions connected therewith, differences may be expected in the results obtained by conscientious manipulators.

And there is, lastly, ever confronting us another influence, often most serious, against which the experimenter must guard, *viz.*, his *prejudices*. Having caught a glimpse of a phenomenon, the next step may be to formulate a theory concerning it. Then we meet the danger line; for too often the operator becomes thereafter a partisan and is led subconsciously to twist subsequent experimental facts towards the theory of his own creation.

When an investigator experiences a feeling of regret at the result of an experiment, he is near, perhaps across, the danger line. Scientific *surprise* in such cases is pleasurable if one be unbiased. Research is a trust in which the manipulator is but a recording agent. Soon, unless he retrace his course when *fact* proves painful, he who forgets his responsibilities will find himself seeking for experiments by which to substantiate a self-constructed theory based on inadequate premises. An experimental disappointment based on a practical discovery may prove of exceptional scientific value.

Summary. (1922) These several pages and illustrations, scraps of an old document, are perhaps of little interest now. And yet, as the author once wrote them to precede the studies that follow, possibly rather to keep himself in a critical mind concerning delusions he should avoid, than to be of service to others, he has ventured to record them as an introduction to a series of investigations he is so bold as to title "Physics in Pharmacy."

PART II.

PHYSICS IN PHARMACY.*

(Surface Divisions between Liquids. Pendent Drops.)

We are told that inherent in each volatile liquid an osmotic pressure exists,

* "Generalities of Solution" and "Contact Films between Liquids," to follow.

in recognition of which the liquid has a tendency to become a gas and then, obedient to laws of diffusion, pass into overlying space. If in a vessel confined, its vapor finally exerts a certain pressure on the liquid's surface, at which point evaporation ceases. When one volatile liquid is poured upon another, in a closed vessel, vapor pressures, as well as diffusion, force each liquid into the other, until finally, temperature being uniform, an equilibrium is established. As commonly expressed, each liquid is then saturated with the other.

Liquid Pressure.

Liquid dispersion, in this sense, is thus analogous to and complicated with vapor-pressure penetrations, although interchange of liquids takes place very much more slowly than gases, and is likewise perhaps less affected by circulations that follow alterations of temperature.

In cases where liquids are miscible in all proportions (*e. g.*, alcohol and water) molecular pressures, regardless of circulating currents made by temperature changes, finally produce an even admixture.[1] In other cases, the contact liquids even if both are volatile can only take up certain definite proportions of each other (*e. g.*, sulphuric ether and water), and occasionally, where neither liquid is volatile, none at all (*e. g.*, glycerin and liquid petrolatum). In it all, temperature often governs interchange more directly than does volatility.

When equilibrium results, a dividing line (plane) remains, as a rule, clearly defined between most separated or saturated solutions.[2] This plane viewed edgewise as a line is made of more or less complex films of intermediate liquids under tension, presenting meniscus phenomena viewed as a whole similar to an air surface meniscus.

When liquids are capable of mixing in all proportions, as already stated, no such surface films or tension surfaces form between them, osmotic or liquid pressure being untrammeled. Their surfaces of contact disappear in imperceptible unions as the liquids blend and commingle to unity or at least to seeming rest.[3] When they are imperfectly miscible, or hostile, tension surfaces or boundary films always exist between them, which require considerable energy of osmotic pressure to overcome. Such liquids, in escaping from one to the other, seem likened to evaporations or diffusions through a foreign film or films.[4]

Since all hostile liquids (taken for granted) when pure are bounded by surface films, it may be said that liquids capable of forming homogeneous mixtures (if the lighter be poured on the heavier) mutually rub out and affiliate

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[1] This is assumed. The writer has not been able to maintain a temperature actually unchanged.

[2] The formation of a dividing plane does not necessarily imply *saturation*. See later examples. The term *plane* refers to those portions of liquid contacts beyond the meniscus.

[3] Actual rest may be impossible unless unvarying temperature is maintained. Hence, a liquid of uniform admixture may be undergoing continuous structural alterations as shown by my previously published contributions.

[4] The foregoing, while explanatory of blanketed conditions, is not intended to be taken in a literally exact sense. The probabilities are that the film is constantly replaced as its surfaces disintegrate, and that the new film likewise is continually wearing away and being replaced. From my present view I would consider this stand more rational than the supposition that the liquid evaporates through the two films. Possibly both phases of phenomena are simultaneous. See experimental remarks to follow but which cannot appear in this part of the manuscript.

or absorb the opposing surface film faster than it can be produced. At least, I can see no evidence of even a temporary surface film in the contact surfaces of miscible liquids that mutually dissolve each other indefinitely. In such cases, the liquids being miscible to any extent, are never satisfied.

Thus, as an example, alcohol poured on water produces no surface film at the contact point. It can be gradually added to water without agitation until the mixture contains more alcohol than water without a film being produced, and the reverse is true. While different mediums constantly result,[1] at no time will a surface film appear. It may be said, then, that any proportion or mixture of alcohol and water that can be made will indefinitely affiliate the surface films of either alcohol or water in contact or of any mixture of alcohol and water that can be devised, destroying them as fast as they can be formed. A very complex problem is this; each seemingly thus absorbing the contact surface into itself and in return passing into the opponent.[2] Perhaps the term infinity of arrangements and rearrangements may be applied. The same is probably true of other liquids that mix in all proportions.

Surface Divisions between Liquids. The study of solvents seems, then, to begin with a study of films, which may be experimentally introduced as follows. Pour water into a beaker glass two inches in diameter and it will be crowned by a meniscus plane upturned at the edge (Fig. 15). Decant it into a tube $^3/_4$ inch in diameter and by close observation it will be seen that the section of division is

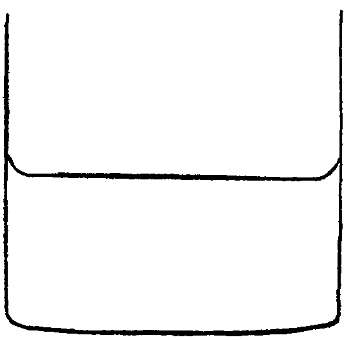

Fig. 15.

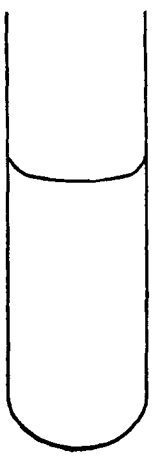

Fig. 16.

Fig. 17.

not a plane but a gentle curve (Fig. 16) while in a tube of one-eighth inch, the section of division becomes decidedly concave (Fig. 17). This also holds good for the plane between all immiscible liquids resting on each other in glass containers, excepting that for some combinations the surface of the lower liquid is

[1] See "Precipitates in Fluid Extracts," PROCEEDINGS AMERICAN PHARMACEUTICAL ASSOCIATION, 1879 to 1885.

[2] The subject of liquid film dialysis is considered hereafter. In the present case (alcohol *vs.* water), no films being formed, a conception of *dialysis* seems not to apply.

convex and with others it is concave, the upper resting oppositely. (See *Liquid Surfaces Capillarity*, not yet reached.)

Errors of Measurement.

In addition to the fallacies of observation already mentioned (see Part I), we are now confronted with an opportunity to err in which the personal equation is a pronounced factor. It is evident that the meniscus consists in the uprising of the seemingly flat surface of Fig. 15, where the water nearing the glass curves upward. As we approach smaller tubes the proportion that is displaced or raised above the level increases, until with a tube of $^1/_8$ inch in diameter (Fig. 17), the problem is to determine whether the crown of the curve or a mean between that and the apex of the meniscus is nearer correct as a measurement of quantity, often a very difficult matter to determine. Since in this part of our work the object is mainly to draw attention to phases of general phenomena in which the aforenamed principles are involved, and not to ascertain how to obtain exact measurements, which feat possibly is beyond our facilities, we may for the present pass to a more careful examination of the general nature of contact surfaces such as have been mentioned.

It may at the outset be stated and reasonably accepted, that a line of demarcation that separates liquids resting against each other, if it be a perfect plane and a theoretical surface, would be, edgewise, invisible. Conditions connected with the refraction of light, their extreme thinness complicated by container refractions, and meniscus curvatures render it in our experience impossible, under ordinary conditions, to determine the exact position or contour of the complete dividing lines. Let us with these reservations attempt to study the general appearances of these planes of separation. (See *Fallacies*, Part I.)

The Gentle Curve.

In order to illustrate the difficulty attending an attempt to determine the exact edge of such a section, immerse a watch crystal or glass evaporating dish, of gentle curvature, in a beaker glass of water, and endeavor to place it in such a position that only the edge of the glass plane will be visible. The feat is impossible; part of the surface reflection always meets the eye. In like manner it is impossible (at least this writer has failed) to locate by the eye alone, the exact edge of the curved disk that lies between two liquids. Take, for example, the gradual curve that forms between liquid petrolatum and glycerin (Fig. 18), which at first glance seems to be a plane surface. It is similar to an evenly curved watch crystal, resting edgewise, within the tube. And yet this edge cannot be exactly located, for part of the surface of the disk must interfere, whenever we attempt to view the section as a whole. Either the upper or the lower surface, as the eye is above or below it, proves a light reflector, and from it the light is thus cast as from a mirror. Although the space of demarcation that located the boundaries between the liquids is probably infinitesimal and, viewed edgewise, may be actually invisible, the reflection from one or more of the surfaces is thus confused by the operator with what should be the edge of (space separating) the superimposed liquids, and which, to the observer, appears to be the real edge of the concave, disk-like segment.

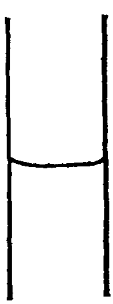

Fig. 18. Glycerin and liquid petrolatum.

In some cases, as with turpentine resting on glycerin (Fig. 19) the surface of the liquids is so nearly in a plane that the reflection from the curve of demarcation is hardly apparent, and consequently nearly invisible, appearing when the operator holds the tube exactly parallel with the eye, as a very faint line.

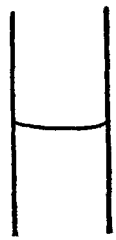

Fig. 19. Turpentine on glycerin.

Stronger Curves. As the lines of curvature increase the reflection from the apparent edges of the liquid becomes more clearly defined. This fact is exhibited by the mirror-like surfaces that form between water and chloroform (Fig. 20), or water and liquid petrolatum (Fig. 21) where the liquid petrolatum is poured on the water. If the reverse process is employed, and the water carefully poured on the liquid petrolatum, the curve crowns upward (Fig. 22). This phase of the problem (reversing of curves) is considered further along.

If carbon disulphide and glycerin be shaken together and allowed to separate the meniscus between the liquids is as Fig. 23. In these (Figs. 21 and 22) the

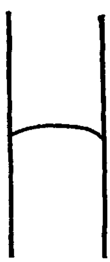

Fig. 20. Water on chloroform.

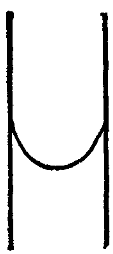

Fig. 21. Liquid petrolatum on water.

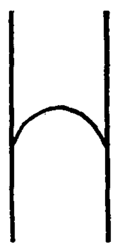

Fig. 22. Water on liquid petrolatum.

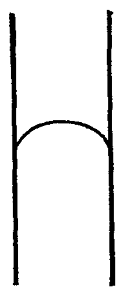

Fig. 23. Carbon disulphide on glycerin.

curvature is more pronounced than in other examples, *e. g.*, turpentine on glycerin (Fig. 19). In this case (Figs. 21 and 22) remarks concerning the invisible edge of the disk become strongly impressed upon the operator, for it is seen that with a tube of the diameter now used the crest of the curve crowned by the silver plane must be fully the tenth of an inch above the point where the prolongation of the visible curve (the apex of the meniscus) should strike the glass of the tube. Consider in this connection the division that forms between carbon disulphide on glycerin (Fig. 23), and the evidence is complete. (Also shown in reverse in Fig. 24 where the carbon disulphide is beneath the glycerin.)

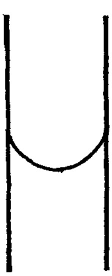

Fig. 24.

With each the glass contact is unseen, the edge where the liquids strike upon the glass being at such an angle as to make the edge transversely invisible. This principle can also be illustrated by nesting an empty test-tube in a tube a size larger that is filled with water. The curved end of the empty tube reflects the light exactly as does a mirror of liquid surfaces, and, although this mirror is distinct, the line of contact where tube touches tube cannot be easily identified.

Pan-like Edges.

In the foregoing examples we have referred to contact liquid surfaces that seemingly produce clear curves in a transparent medium, and which appear to strike the glass at about the prolongation of the visible curve. Authorities, so far as this writer is informed, do not dwell upon any other form of meniscus curve, or at least have not discussed it. All liquids do not seem, however, to form such curves. Some produce nearly parallel surfaces that just before (close to) contact with the glass turn up or down after the manner of a flat-bottomed pan. Mix benzine and alcohol sp. gr. 0.820 (U. S. P. 1880) and it will be seen that the line of separation is as follows (Fig. 25): Carbon disulphide and either alcohol or methyl alcohol exhibit but a slight turn next the glass (Figs. 26 and 27). In such cases as these it is evident that by reason of the aforenamed laws of refraction and connected complications we cannot hope by direct view through the side of a tube to catch the exact upturned edge of such a line (plane)[1] of division.

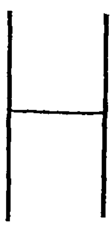

Fig. 25. Benzine and alcohol U. S. P. 1880.

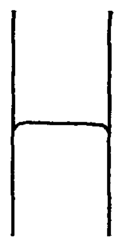

Fig. 26. Carbon disulphide and alcohol (1880).

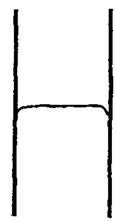

Fig. 27. Carbon disulphide and methyl alcohol.

The writer is aware that, by mathematical rules, the degrees of curvature of the meniscus of many liquids in air contact have been calculated, which perhaps may be reconciled with under surface planes and edges now under consideration but which present complications that surely exist, as can be shown, by studying the dividing planes between such liquid contacts as are offered by carbon disulphide and glycerin if viewed in a square bottle (Fig. 28).

Compound Curves

Let us now revert to those we have cited, and consider another point. By close observation it will be seen that in most cases, perhaps all, just before the surface division strikes the glass, there is a most decided curve. The diameter of the tube much influences the degrees of these curvations. They all seem to be pan-like in this sense, although some approach to insensible distances before becoming so, and others if in small tubes appear to be perfect curves. It is evident that such curvatures are not simple but compound, and that the degree of curvature increases as the glass is approached. In some cases, as with turpentine resting on glycerin, the crown is nearly flat (Fig. 19), or amelic alcohol on water (Fig. 29). Possibly the term "*family of curves*" or progressive curves is more nearly descriptive.[2] Having no conveniences for directly establishing by direct sight

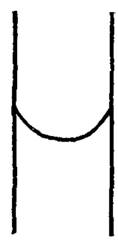

Fig. 28. Carbon disulphide on glycerin.

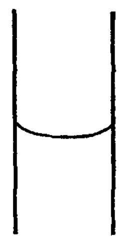

Fig. 29. Amelic alcohol and water.

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[1] Bear in mind that the term line refers to the bisected meniscus which as a whole is a more or less curved (bag-like) plane. Also that it is not a smooth edge as it appears to the normal eye, but usually jagged, torn, irregular as shown by magnification. This is illustrated further along. For our present purpose the edge is accepted as a line.

[2] In passing onto and off from a six-degree curve, the railway engineer has found that from a tangent to one degree thence each hundred feet increasing a degree to the maximum (six degrees), thence back in like manner to the opposing tangent, makes a curve scarcely appreciated as the

such minute curves, the writer has taken advantage of the reflection of a ray of light to determine whether such compound curves as are herein shown by observation, actually exist. This experiment is described as follows (Fig. 30):

Family of Curves. Add one grain of gelsemic acid to a pint of water in a small square vial and make it slightly alkaline with ammonia. Darken a window with opaque black paper and puncture the screen with a pin to permit a ray of sunlight to enter.[9] Then place the bottle containing the solution of gelsemic acid in the track of the ray of sunshine. From a side view it will appear a magnificent blue streamer. Lower the bottle slowly, and when the ray[2] strikes the under surface of the liquid it is at once deflected, the course being in a band downward (Fig. 31).

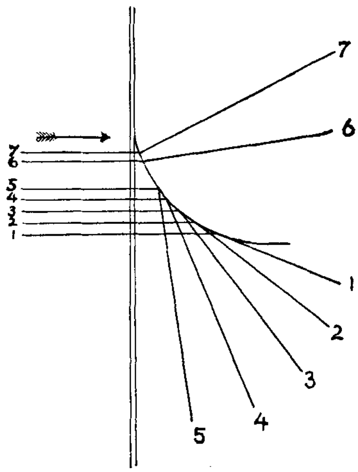

Fig. 30.
Drawn by Mr. A. J. Knapp.

By now looking directly towards the pinhole it will be found that it is invisible from opposite the exact surface line and can only be seen when the eye is in the track of the deflected ray, which is now below the surface of the liquid. By adroitly moving the bottle downward the ray is deflected increasingly (Figs. 31 to 34) and at last bursts from above the surface as shown by Fig. 36. The pinhole may be located (Fig. 34) by placing the eye above the liquid in the track

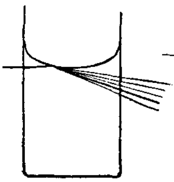

Fig. 31.

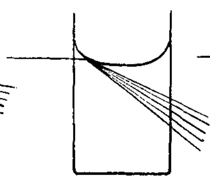

Fig. 32.

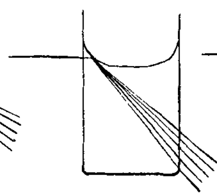

Fig. 33.

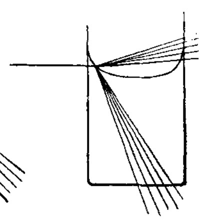

Fig. 34.

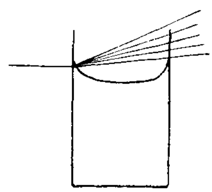

Fig. 36.

Drawn by Mr. A. J. Knapp from experiments.

shown by the upward streamer, and then it appears to be *above* the surface; and it may also be seen from the ray below the surface of the liquid, and then it seems to be situated *below* the liquid's surface. This special feature of light aberra-

train passes on and off from tangent to tangent. Some of our curves between liquids much resemble these mathematical constructions.

[1] It is best to darken the entire room in order to study the phenomenon more favorably. It is even better to construct a reflector just inside the window and throw a ray of sunlight against a piece of black paper punctured with a pin, the small compartment containing the mirror being enclosed to separate the operator from the light. By this means the ray of sunshine can be thrown in a parallel course and not at an angle. In this connection the writer will say that no artificial light has, in his hands, given the satisfaction of sunshine, and that the experiments illustrated herein were made with sunlight. (Original note.)

Later (1922). These experiments were made before the practical use of the arc light. To-day, electricity might possibly be employed even better than sunlight.—J. U. L.

[2] Actually *bundle* of light rays. Theoretically, a ray is a line, far too small to be reached by this operation.

tion in connection with our subject, however, will be again discussed under the head of liquid surfaces, where it is more readily handled.

The illustrations herein submitted are not asserted to be mathematically exact as concerns the drawing of the angle of deflection, but they present the appearances as nearly exact as the artist (Mr. A. J. Knapp) could, offhand, represent them.

Possibly by means of this process of deflection in a *thread* of light, a bottle of solution of gelsemic acid being behind the tube containing the liquid that deflects the ray of light, the exact curve of the liquid surface curve can be determined even though it is too small otherwise for measurement. The ray of light deflects in accordance with the law of signs, as is graphically depicted in Fig. 30, and I see little reason to doubt that it will be shown by proper mathematical measurement that the meniscus of every liquid produces a *characteristic* curve, also that none are as simple as they appear. In this term "meniscus" I include the complete lines or planes separating immiscible liquids discussed in a future part of this paper.[1]

Refracting Mediums. In the foregoing instances, we have considered liquids as though they were, in themselves, under all conditions, perfectly transparent and limpid to the very contact planes between them. Indeed, it would have been injudicious to have previously questioned the matter, where all authorities seem to agree (and we have daringly so accepted) that when both the solvent and its solution are colorless and transparent, the sphere of separation is two nested surface films.

That in many cases local disturbances which could not arise from clear surface reflections occur about the line of liquid contact to diffract or disturb the light and thus overcome transparency is easily demonstrated. Pour a layer of acetone upon a layer of glycerin (Fig. 38) and observe the contact edges. Instead of a clear silvery line as heretofore observed, a gray medium results that appears to be about one-tenth of an inch in thickness. This phenomenon must be caused, it seems, at first thought, by mixtures of different solutions that produce temporary wavelets (as when water is poured into alcohol, or glycerin into water) that intercept the rays of light and which should disappear when the liquids are shaken together and come to perfect rest. However, upon agitating the liquids well together and allowing them to separate, it is seen that the grayish zone of disturbance is not removed, neither can it be overcome by any method I have devised. It maintains its position about the point of liquid contacts, appearing much like a wrinkle in a plate of glass.

Place the tubes containing these liquids before the light of a flame, and it is seen that the band is a zone of division that dissipates the light and *bisects* the

[1] In verifying these experiments made nearly forty years ago, J. T. Lloyd used a test-tube containing two immiscible liquids, in front of a large square bottle containing the ammoniated solution of gelsemic acid. He also used the arc light which could be handled readily, contrasted to sunlight. Another advantage was that he employed immiscible liquids, the meniscus between them conforming to our present experiments. Test-tube A; Solution Gelsemic Acid B; Ray of Lght C. This arrangement, sunlight being employed, is shown in our figured experiments of old, which are to follow.

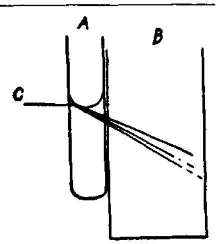

Fig. 37.

flame. Place it in the sunshine with a white screen close behind it and the zone casts a shadow upon the paper. Hold a line of print or a black horizontal line behind it and the line is effectually removed. Place the tube in an upright slit in a pasteboard box or before the pinhole in the dark room, and reflect a ray of sunshine against it by a mirror parallel with the surfaces of liquid contacts. The zone of division casts a dark band shadow.

This band with glycerin and acetone is of perceptible thickness and seemingly must be a stabilized medium of different refractive power from either of the adjacent solutions, intercepting some of the rays of light, torturing others. There seem at the zone of disturbance to be several solutions (mixtures) in unequal tensions, balanced in the aggregate, through which the struggling ray of light cannot pass directly. Such are the appearances of glycerin with acetone (Fig. 38) or acetic ether (Fig. 39) or sulphuric ether (Fig. 40). It is impossible for a ray of light to penetrate these gray refractive mediums and locate an anterior object either in exact outline or in substance correctly.

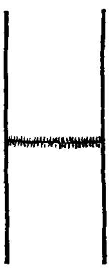

Fig. 38. Acetone on glycerin.

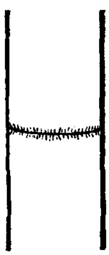

Fig. 39. Glycerin and acetic ether.

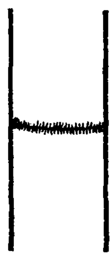

Fig. 40. Glycerin and sulphuric ether.

Reverting now to other liquids as well as those we have already considered, and examining them with the foregoing phenomenon in mind, now that the fact is mentally located, we often find a like disturbance (more or less prominently) exhibiting itself above or below the plane, even though the surface contacts may appear brilliant.

It will be observed in these instances that near the point of liquid contact there seems to be a swell as if the glass of the tube were here of uneven thickness. Whatever may be the cause of the phenomenon, its effect is to prevent the true line of liquid separation, as well as the precise curve of the meniscus between such liquids, from being accurately located.

Invisible Zones.

And, that perfectly invisible zones may be located about the contact surface of liquids of different densities at equilibrium or rest, may be exemplified as follows: Make a mixture of glycerin and acetone.

ARSENIC THERAPY.*

BY HOMER W. SMITH.

Mingo Park has said that Africa was fatal but fascinating. The same may be said of arsenic, for it has fascinated mankind since ancient days, and as to its being fatal—history is replete with evidence.

Hippocrates, the father of medicine, used regular (As_2S_2) and orpiment (As_2S_3) as an outside remedy for ulcers and similar ailments, according to Sharp,[1] who has written some interesting notes on the history of arsenic. It was known to the Romans and the Egyptians and played a large part in the endeavors of the latter

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* Presented before the Indianapolis Branch, American Pharmaceutical Association, March 21, 1922.