**On the frothing of urine and other organic liquids / by Robert Kirk.**

from complications—and, perhaps, of all the forms, hot air is preferable. This is easily obtained in private practice by means of a spirit lamp, cane-bottom chair, and crinoline.

*9th September, 1881.*—Since the above was written (17th June, 1881) the progress towards recovery has not been quite so rapid as during the previous months; but whether this can or can not be attributed to the fact that the patient, as is usual with her class, discontinued the treatment in a great measure, if not wholly, as soon as all inconvenience disappeared, may be left an open question till, after resuming the previous treatment, the result of the next few months is known.

There is, however, a general improvement over the whole of the affected areas. The tissues are softer, and there is now no difficulty in pinching up any part of the skin into a fold. On the anterior and outer aspect of the forearm there is a narrow band of perfectly normal skin extending to the wrist, and little or no induration can be detected on the posterior aspect of the leg. All the tendinous bands have disappeared, and there is no pain even on rubbing the parts pretty firmly. The general health is very good.

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## ON THE FROTHING OF URINE AND OTHER ORGANIC LIQUIDS.

By ROBERT KIRK, M.D., Partick, Glasgow,
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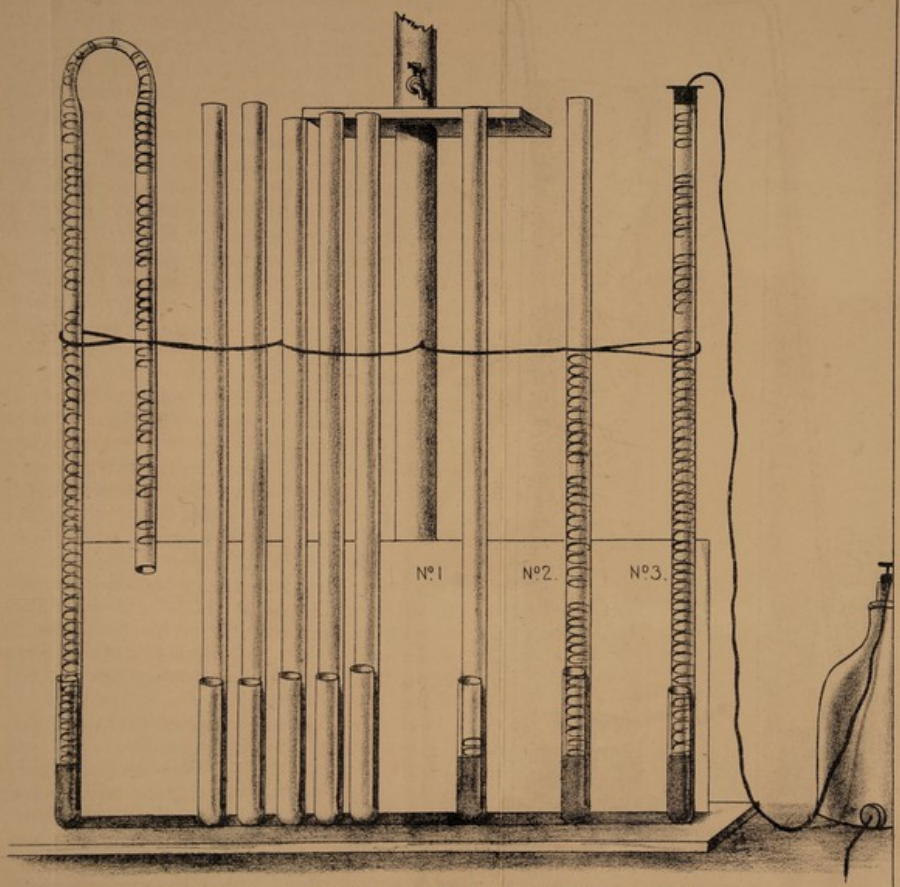
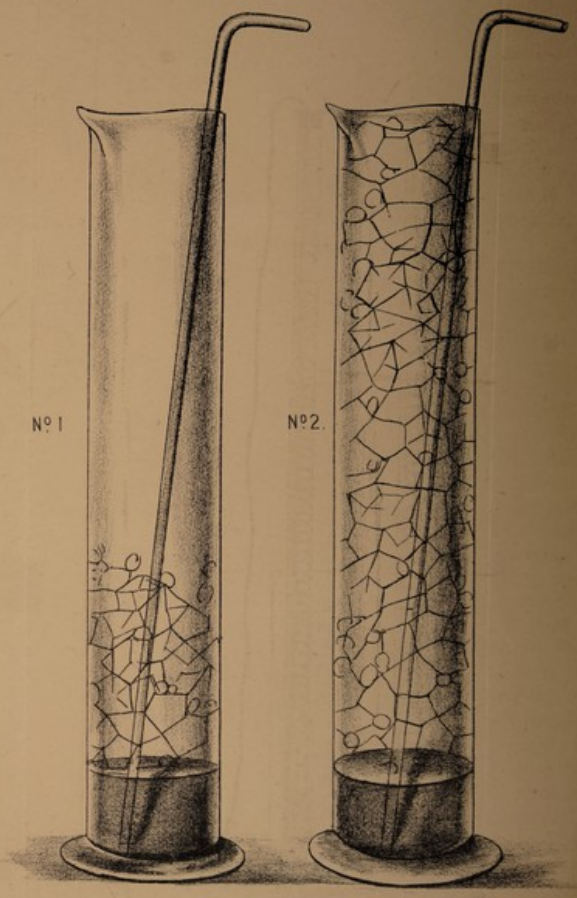
(*With Lithographic Plate.*)

As early as the time of Hippocrates it was known that certain pathological urines, subsequently recognised as albuminous, formed a froth of bubbles on the surface. This fact was referred to by Dr. Southey in his Lumleian Lectures,* and Dr. Arthur Hill Hassall, in commenting on it, has observed that "the occurrence of retained and persistent air bubbles on the surface of urine is nearly always of pathological significance; and that their presence, when rightly understood, is capable of affording valuable practical information, although, so far as I am aware, the subject has not hitherto been followed out with the requisite care and minuteness." † The following account of a few observations, extending over about two

* *Brit. Med. Journal*, 9th April, 1881. P. 541.
† *Ibid.*, 14th May, 1881. P. 767.




N°1. PHYSALISATION OF WATER. N°2. PHYSALISATION OF NORMAL URINE.
N°3. PHYSALISATION OF ALBUMINOUS URINE.




N°1. NON-PHYSALISABLE ALBUMINOUS URINE. N°2. HIGHLY PHYSALISABLE ALBUMINOUS URINE.

years, which I have made on the bubble of albumen and the froth of various specimens of urine may, it is hoped, prove of some interest.

When we blow a current of air through an albuminous liquid, as blood serum or a solution of ovalbumen, a remarkable formation of bubbles rises to the surface. This phenomenon is familiar to all, although it does not seem to have received much notice. The bubbles, when blown up in a large glass jar, are for the most part of a pentagonal form on the sides of the vessel; they are much tougher, thicker, and stronger than soap bubbles, and do not refract light strongly like the latter. It is remarkable how they persist after very great dilution of the albumen. If we dilute blood serum with 200 or 300 volumes of water, and put a small quantity of the liquid into the bottom of a tall glass jar of about the same cubic capacity as the lungs of an adult, and by means of a glass tube blow a full expiration through it, the bubbles will still rise to the top of the jar with scarcely a single gap amongst them. Blood serum or hydrocele serum may still be distinguished from mere water by the bubble after dilution with more than a thousand volumes of the latter. The fluid from an ordinary hydrocele, supposing it could be blown out after dilution in a continuous sheet, would form a bubble membrane many square miles in extent. By comparing different forms of albumen, by diluting them in this manner, I arrived at the conclusion that serum albumen possessed this property in a somewhat higher degree than ovalbumen. Equal quantities, as far as could be determined by the nitric acid or boiling tests, were compared with each other.

My observations have been chiefly confined to the urine, and especially to albuminous urine. It is evident that the spontaneous production of froth or air bubbles on the surface of any urine must depend on two causes:—(1) a certain property of the liquid, and (2) the presence of gas in it. If any gas arise from decomposition, or air be introduced by agitation, these bubbles will form in proportion as the liquid possesses the property which gives rise to them. What class of urines most readily produces gases, or to what extent the production of such gases is to be regarded as pathological, I have not made the subject of observation; my attention has been solely directed to the degree in which various urines possess the property which enables these bubbles to form when a current of air of given amount is driven through them. Proceeding in this way I obtained the following results.

1. Urine, whether normal or otherwise, is almost invariably frothy, so as to be easily distinguished from mere water by this peculiarity. This, indeed, any one may observe in the act of micturition.

2. The degree in which urine possesses the property on which this phenomenon depends, varies extremely in different cases, but it is never very great except in pathological urines. I have found it highest in—1. The majority of specimens of albuminous urine, but certainly *not in all*. 2. Certain high coloured urines. 3. Some urines containing bile pigments, although in such cases it was not much above normal.

It was evident that the power of frothing depended on certain constituents, and the proportions in which they might be present. These constituents seemed to be, in healthy urine, the extractives (more especially, perhaps, creatinine). Not all the pigments, however, seemed to confer this property on the urine, for I have met with one specimen of a very high coloured urine which gave scarcely any froth with the air current. Dr. Hassall supposes that frothing is sometimes connected with feeble acidity or alkalinity; in other cases with an excess of mucus; but as far as I have observed, these circumstances do not affect it much. He refers to a remarkable spontaneous formation of froth in a case of diabetes. One case of this disease has come under my observation, and in it there was no increased production of froth, either spontaneously or by the air current. He observes that the froth could not be due to decomposition of the sugar, as it formed the moment the urine was voided. It may have been due to some special circumstance unconnected with the mere presence of sugar, seeing that little or no froth forms in some other cases of diabetes. But although I found no froth in the diabetic urine I have mentioned, I may state that after the use of Trommer's test very tenacious and beautiful bubbles form. When a succession of such bubbles is blown into a glass tube and allowed to dry there, they form a series of transparent and refractive membranes, which will keep in the tube without breaking for weeks together. The resinous bodies resulting from decomposition of the pigments also produced remarkable bubbles.

Sometimes the bubble reveals the presence of certain drugs. Thus, the urinary bubble of a patient who is taking copaiba shows a beautiful bluish-green colour, from the presence of the oil. The same may be produced by adding a small quantity of the oil of copaiba, or other oils, to normal urine. The very fine layer which the oil forms on the surface of the liquid

also shows the same colour, but the oil must be present in larger quantity than occurs in a patient taking copaiba to produce this effect.

With reference to the subject of albuminous urines, it was found that in the majority of cases the albumen seemed not inferior to serum albumen in its power of forming froth. But in some cases it was otherwise, and I have met with a few cases in which the albumen had entirely lost the power of bubbling up with the air current, while there were others in which it appeared at any rate considerably diminished. It seemed, therefore, that albuminous urines might be divided into three classes with respect to this phenomenon.

1. There were cases in which the albumen did not differ from serum albumen.

2. Cases in which the albumen had to a considerable extent lost the power of frothing.

3. Cases in which this power was nearly altogether lost.

I am not aware that any one has ever mentioned the fact that cases of the last class occur, although it is probably one of some importance. It would appear to indicate that the condition of the kidney in such cases must be different from that in which the albumen possesses its usual properties. Cases of the kind have not been numerous. One was a case of albuminuria in a female aged 75 years. The albumen sometimes amounted to half the tube in this case; there was anasarca and ascites, and considerable diminution of the quantity of urine, which sometimes fell as low as 9 oz. daily. After this condition had lasted for more than a month the patient was threatened with uræmic symptoms: intense headache, vomiting, impairment of vision, and stupor. These, however, passed off in two days, the amount of urine gradually increased, and the patient eventually made a good recovery. It is now two years since the commencement of the attack, and she is in very good health; the urine when last examined (about nine months ago) presenting only the faintest trace of albumen. Throughout the whole course of the case the albumen was frequently examined, and even when present in large quantity it showed scarcely any bubble whatever. This fact is more especially interesting in connection with the recovery of the case, for as far as I have had the opportunity of observing, the absence of bubble is a favourable symptom, generally showing that we have not to deal with chronic Bright's disease, although the converse is not invariably the case.

Another case was that of a man, aged 63, in whom album-

inuria resulted from prolonged retention. The urine was very bloody, and at first the albumen presented a considerable bubble, but in a short time cystitis set in and the urine ceased to froth. Not a single bubble rose to the surface, although it contained 150 degrees of albumen, as estimated by Dr. Roberts' dilution method. Now a few drops of blood added to water, the quantity being so small as to communicate to it but a slight tinge of colour, will give it the power of frothing up with air in a very marked manner. It was evident, therefore, that something had acted on the albumen in the case of this bloody urine and altered it. It seemed probable that the agent which had produced this result was the large quantity of vesical mucus resulting from the cystitis, which is well known to act as a ferment on urea, and may exercise a similar action on albumen. The urine contained much pus, but was only slightly ammoniacal. This case also recovered completely. Whatever the explanation of the loss of the power of frothing, it seemed at all events not to be due to any action taking place in the kidney, since the urine did not lose this character till the cystitis set in. It is further to be observed in this case that not only had the albumen lost the power of forming froth, but that the normal urinary bubble, if we may call it so, was also absent. But whilst some action taking place in the bladder seemed to account for the state of the albumen in this case, it could not be so in the former case. In that instance the conclusion seems inevitable that the cause of the change in the albumen must be sought for in the kidney.

It may be well to add that the albumen in the above cases was ordinary albumen with respect to its chemical reactions; it was not paralbumen; neither was it paraglobulin precipitable by salt; but simply albumen, coagulable by heat and acid.

In two other cases, in which occasional albuminuria resulted from passive renal hyperæmia (as far as I diagnosed), due to cardiac disease, and both occurring in subjects about 65 years of age, the albumen was generally the same as in the former two cases.

With regard to cases of the second class, in which the frothing power is perceptibly diminished but not quite lost, I have chiefly found this to occur in some cases of puerperal albuminuria, but more especially in cases of post-scarlatinal dropsy (glomerulo-nephritis). As a rule, it has appeared that cases accompanied with diminished secretion of urine are more apt to lose the froth, while cases in which there is a copious secretion of albuminous urine generally retain it. Is the difference determined by the integrity or otherwise of

the epithelium lining the tubules, and its power of performing its functions? Has the less frothy albumen been altered by any action of the epithelial cells, or is it due to some inflammatory action?

The greater number of cases of albuminuria which have come under my notice since I began to pay any attention to this phenomenon have been cases in which the frothing was nearly if not quite as well marked as in serum albumen. Amongst these was a case of phthisis complicated with albuminuria and anasarca, in which there was a copious secretion of urine of low density. It presented all the features which Grainger Stewart has pointed out as enabling us to diagnose amyloid degeneration of the kidney with great probability during life. Another case is one (still alive) of chronic Bright's disease, which has been under observation for two years, and in which the albumen has always shown a marked bubble. Other cases, however, in which the albumen frothed equally well, did not prove cases of chronic Bright's disease, or, at all events, they temporarily recovered.

Another fact remains to be mentioned. The froth of albuminous urine is to a certain extent affected by the reaction of the liquid. This is not so evident when the quantity of albumen is large; but when the quantity is not considerable, it will often be found that the bubble will not form so perfectly some time after the urine has been rendered alkaline, but that it may be again restored by a few drops of acetic acid. In one case which came under observation, in which the quantity of albumen was small, the urine generally neutral, or sometimes alkaline when voided, it was often observed that the bubble would not form till acid was added. Its instantaneous appearance with the acid was a very striking phenomenon. It is not in every case that this can be equally well seen.

The difference between an albuminous urine with a very marked bubble and one in which there is scarcely any is represented in the accompanying diagram (see lithographic plate). No. 1 is a large glass jar about 18 inches high, containing about two ounces of albuminous urine, giving a precipitate of about one-sixth of the tube, from one of the cases already mentioned. No 2 is a similar jar, with the same quantity of albuminous urine, giving a nearly equal precipitate, from the case of chronic Bright's disease which has been under observation for the last two years. It will be seen that, in the latter, the bubbles rise to the top of the jar, while in the former they do not rise more than two inches above

the surface of the liquid. Although the current of air be continued, the bubbles refuse to ascend, but rapidly break. In this case, indeed, the frothing is rather less than that of healthy non-albuminous urine. The word *physalisable*, used in the plate, I shall refer to by and bye.

A remark may be made in passing on the subject of the bubble as a test for albumen in urine. It is only in this aspect, I believe, that the albumen bubble in urine has ever been mentioned, and it is generally said that it cannot be relied on as a test, as it may be present in non-albuminous urines. This is quite true; and not only so, but from the foregoing observations it is evident that its absence is no proof of the absence of albumen. Nevertheless, in many cases it is of considerable value as raising a suspicion, to be verified or not by other evidence; and I think it is frequently quite conclusive of itself. Any books I have read on the subject only refer to the froth which may form spontaneously on the surface. But this is not sufficient. Let some air be blown in, and the appearance of the bubble is much more characteristic. In a pale urine, if the albumen be of the frothy sort, there is little difficulty in deciding the question; at all events, I have met with no clear urine giving any similar phenomenon. This might frequently prove useful to the practitioner in country districts. With a small piece of india-rubber tubing, to which a glass mouth-piece may be added as required, or even with the stem of a tobacco pipe, he may generally make pretty certain of the presence of albumen.

These facts appeared to indicate that this line of investigation deserved to be more systematically followed out. It is evident that we have here a phenomenon depending on a certain property of organic liquids, and that we ought to be able to state the degree in which it is possessed by any given liquid. To what extent does one urine differ from another with respect to this phenomenon, or one form of albumen from another? While physicists have made the soap bubble the subject of numerous experiments, the albumen bubble has received no attention at the hands of physiologists. As far as I am aware, it is not even mentioned in any physiological text book; neither is there any term in use to express the phenomenon or property in question. As it would be convenient—nay, almost indispensable, to have such a term, I might venture to suggest, to designate bubble formation, the word *physalisation*, from φυσαλίς, ίδος, a bubble; a root which furnishes us also with the necessary terms physalise, physalisable, &c. A form of albumen, therefore, characterised

by a considerable power of forming bubbles with air, might be designated, as I have done in the plate, physalisable. For the property on which frothing or physalisation depends there seems also to be no generally recognised term. Albuminous liquids and others of a similar kind are generally spoken of as viscid; but this phenomenon does not depend on mere viscidity, for oils, which are highly viscid, scarcely physalise at all. Only a single highly refractive bubble appears on the surface of an oil, which breaks the instant it forms. Not only so, but oil has quite an extraordinary power of preventing the frothing of albumen. If some ovalbumen in strong solution be put in a wide shallow vessel, and a single small drop of oil be allowed to spread over the surface of it, not more than a single bubble will appear on the surface; whereas, were it not for the oil, the bubbles would rise tier above tier. It seems to me that the property on which frothing depends might correctly be denominated *plasticity*. This term is applied by physicists to matter in a semi-solid state, such as putty and the like, capable of being moulded into any special form, and although the application here proposed is not strictly identical, it may nevertheless be said to be closely analogous. For the bubble membrane is certainly a semi-solid form, and, indeed, may sometimes be dried without breaking, and then answers perfectly to the definition of strictly solid matter, just as dried putty would do. Besides, these plastic liquids seem really formed by plants and animals as an intermediate stage in the transformation of matter from the liquid state to that kind of conformation of the solid parts characteristic of living beings.

If such frothing liquids, then, may be spoken of as plastic, it remains to consider how to determine the degree in which any particular liquid possesses this property. By allowing the bubble to form under certain given conditions, and ascertaining what amount of force it would require to break it, it would seem that we might arrive at this result. The experiments on the soap bubble recorded in philosophical works, or the calculations on the surface tension which we find in them, do not answer this practical end. I do not know by what means this might be easily realised, but I may mention a few tentative experiments which I have tried with an apparatus shown in the plate. It consists of a U shaped glass tube with a long and a short limb, the long one being about 3 feet, and the short one 6 inches long. The diameter of the bore of the tube is about $\frac{3}{4}$ of an inch. It is mounted vertically on a stand, resting on the convexity of the bend. A

considerable number of such tubes are mounted on the frame, that they may all be in the same condition with respect to dryness, &c., at any given time, so as to admit of a series of comparative experiments being made under precisely similar circumstances. The liquid to be tested is put into the bend of the tube, and air is drawn through it by means of an aspirator connected with the top of the long limb. The length of the bent part of the tube is so adjusted that the bubble of air, which is cut by the liquid in passing it, is large enough to occupy the entire diameter of the tube, so that the bubble-membrane which forms on the surface is a complete ring. These rings, if the liquid is physalisable, ascend the tube in a more or less unbroken series, constituting rather pretty objects as they do so. If one liquid be much more physalisable than another the difference is at once apparent by the greater height to which the bubbles will ascend in a given time. It is well known that they do not form so readily in a dry tube, so that the upper ones are most liable to break. Suppose we compare albuminous urine, normal urine, and water in this way, we get a result like that represented in the tubes marked 1, 2, and 3 in the plate. Let the air be drawn through the albuminous urine till the rings reach the top, which they will do with very few breaks; let it then be drawn through the normal urine for the same time and at the same rate, and they will seldom go half so far, while there will be more gaps in the row; whilst, as seen in the plate, in the case of water, not more than one, or at the most two, rings will form. If a small drop of oil be added, the physalisation will be effectually prevented in all. The albumen bubble will readily travel through very long tubes, and if the tube be contracted at one part, as shown in the bent tube at one end, the discs contract at the same part, and again dilate as they reach another wider part.

Even after very great dilution, albuminous liquids will still easily rise with the current to the top of the tube, and hence it was found necessary to have some other means of determining relative degrees of plasticity, and how far this property varied with the amount of albumen in solution. For this purpose an attempt was made to ascertain how much force was required to break the rings. A gentlemen who has often performed experiments with me suggested atmospheric pressure, and we accordingly, by means of a large and powerful syringe, capable of containing about four times as much air as the tube, forced air into the latter, after corking tightly the lower limb. But after diluting blood serum with 200 volumes

of water, we found that with our united strength we could not burst the bubble-membranes. The air passed through them, but broke only a very few. We next adopted the plan of directing a fine stream of water upon them from a graduated jar, which was connected with the top of the tube by means of a fine glass tube, drawn to a narrow point, and passing through a perforated cork. This was found to answer better, but the number of experiments yet made has not been sufficiently great to enable us to speak decisively of the results. But the quantity of water required is very different for solutions containing different amounts of albumen. It is remarkable how long the bubbles of a tolerably strong solution will bear a current of considerable power before they are all washed away. If they refuse to break with the stream, they yield on one side, allowing the water to glide over their surface and make its way past them down the side of the tube. A few general results obtained in the way indicated may be mentioned. These results were also tested by simply blowing up the bubbles with a tube in a large jar, after diluting the albumen down to a certain point with water. For instance, the bubble of ovalbumen was compared with that of serum albumen, after diluting them down to a point which gave a feeble reaction with nitric acid, such as one coming into view in 15 seconds. Amongst these results were the following:—

1. Serum albumen (equal quantities, as nearly as could be estimated, being compared) has greater plasticity than ovalbumen.

2. Fibrinogen, from hydrocele serum, and fibrinoplastin (serum globulin), from blood serum, have a high degree of plasticity, but I could not venture to say whether it is greater than that of serum albumen.

3. When albumen is transformed into acid or alkali albumen, or when the salt is removed from it by dialysis, the plasticity is at first not much affected, but in these cases it is sooner lost by keeping than otherwise.

4. When salt is added to an albuminous liquid the plasticity remains a long time. It also counteracts the effect of acid or alkali on the plasticity.

5. Any agent (as salt) which preserves the plasticity also preserves the albumen longest from decomposition; or conversely.

I would only add, in conclusion, that my object is not to point to any actual results, but only to draw attention to the subject. If any apparatus of a simple kind, whether similar

to the above or not, could be devised whereby we might correctly estimate the degree of this property, it would surely be of considerable practical value. Such an instrument might be called a *plasiometer*, if the term adopted in speaking of the property in question be allowed. It might be of importance to know how this property of organic liquids was affected by disease. In a case of anasarca which was under my care, and in which I allowed the serum to drain away, free from blood, by incisions in the skin of the legs, I found the albumen was far inferior to serum albumen in the power of physalising. In this case the serum albumen with which it was compared was that of ox blood. Was the serum of this patient's blood deficient in this property, or did the exuded serum differ from that of the patient's blood? I have also found other pathological albuminous fluids in which the albumen was deficient in this property.

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## FALSE ANEURISM OF THE LABIUM (COMMONLY CALLED THROMBUS) FOLLOWING PARTURITION.

BY E. Æ. MACKINTOSH, M.B., C.M., Edin.; Maternity Hospital.

THE comparative rarity of such a complication as thrombus of the labia after parturition, the meagreness of the literature on the subject, and the difficulties which beset its detection during formation, have prompted me to record a case at present in this hospital.

On the afternoon of 31st August a patient was admitted so far advanced in labour that the usual preliminaries on entrance had to be dispensed with, and the patient immediately removed to the delivery room. Four or five minutes afterwards a child was born. At this time nothing abnormal was noticed about the parts. The pulse was 58, and in due time the woman was removed to a ward and slept.

About two and a-half hours after delivery, owing to a persistent oozing of blood, I was about to make an examination when I detected a large tumour-like body occupying the position of the left labium. This, on inspection, was seen to be the left labium, swollen to an enormous degree, extending from the pubes backwards to the folds of the nates, and laterally, obscuring the orifice of the vagina and the right labium, and being continuous with the thigh on the left side. The mucous

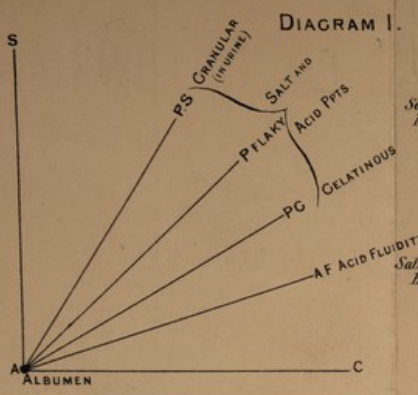
DIAGRAM I.
S
GRANULAR (INSOLUBLE)
PS
SALT AND
ACID PPTS
PFLAKY
GELATINOUS
PG
AF ACID FLUIDITY
A
ALBUMEN
C

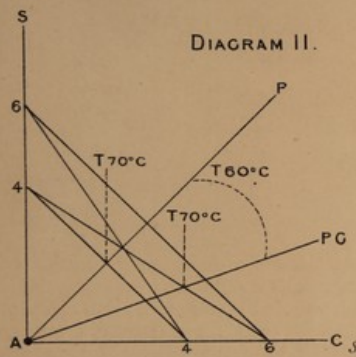
DIAGRAM II.
S
P
6
4
T70°C
T60°C
T70°C
PG
A
4
6
C

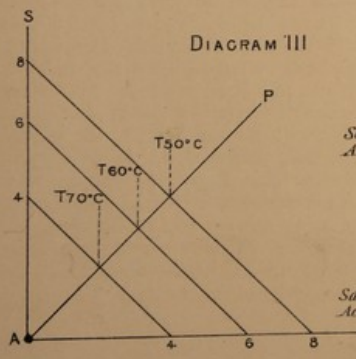
DIAGRAM III
S
8
6
4
P
T50°C
T60°C
T70°C
A
4
6
8
C

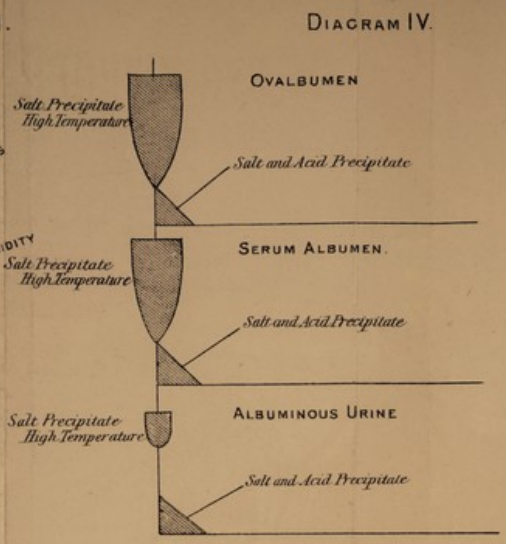
DIAGRAM IV.
OVALBUMEN
Salt Precipitate High Temperature
Salt and Acid Precipitate
SERUM ALBUMEN.
Salt Precipitate High Temperature
Salt and Acid Precipitate
ALBUMINOUS URINE
Salt Precipitate High Temperature
Salt and Acid Precipitate

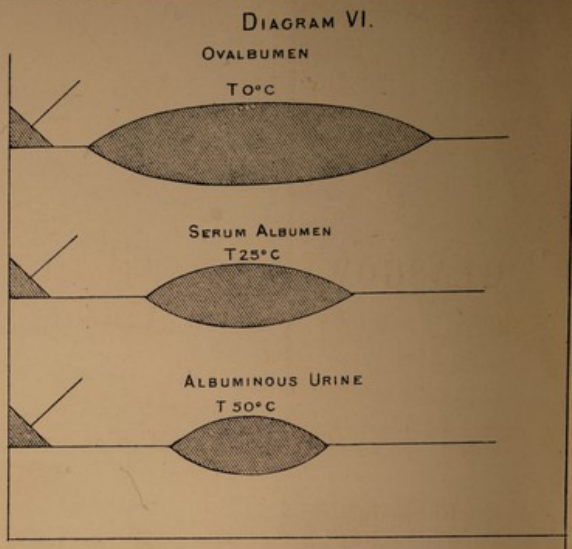
DIAGRAM VI.
OVALBUMEN
T0°C
SERUM ALBUMEN
T25°C
ALBUMINOUS URINE
T50°C

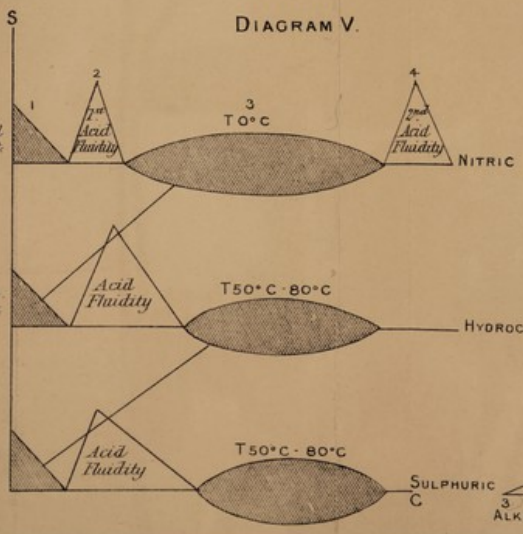
DIAGRAM V.
S
1
2
2nd Acid Fluidity
3
T0°C
4
2nd Acid Fluidity
Salt and Acid Ppt.
NITRIC
Salt and Acid Ppt.
Acid Fluidity
T50°C - 80°C
HYDROCHLORIC
Salt and Acid Ppt.
Acid Fluidity
T50°C - 80°C
SULPHURIC
C

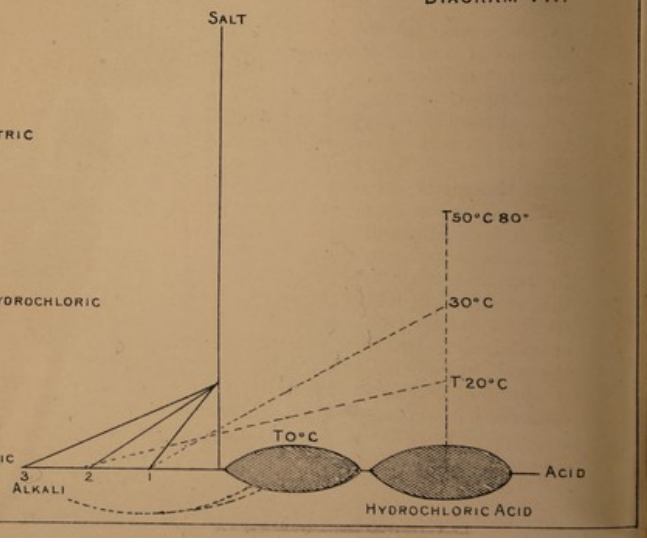
DIAGRAM VII.
SALT
T50°C 80°
30°C
T20°C
T0°C
3
2
1
ALKALI
ACID
HYDROCHLORIC ACID