SOAP-BUBBLES,

AND THE FORCES WHICH MOULD THEM.

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(Continued.)

I want you now to consider what is happening when two flat plates partly immersed in water are held close together. We have seen that the water rises between them. Those parts of these two plates, which have air between them and also air outside them (indicated by the letter *a* in Fig. 11), are each of them pressed equally in opposite directions by the pressure of the air, and so these parts do not tend to approach or to recede from one another. These parts again which have water on each side of each of them (as indicated by the letter *c*) are equally pressed in opposite

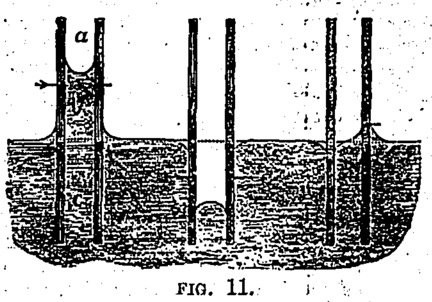


FIG. 11.

directions by the pressure of the water, and so these parts do not tend to approach or to recede from one another. But those parts of the plates (*b*) which have water between them and air outside would, you might think, be pushed apart by the water between them with a greater force than that which could be exerted by the air outside, and so you might be led to expect that on this account a pair of plates if free to move would separate at once. But such an idea though very natural is wrong, and for this reason. The water that is raised between the plates being above the general level must be under a less pressure, because, as every one knows, as you go down in water the pressure increases, and so as you go up the pressure must get less. The water then that is raised between the plates is under a less pressure than the air outside, and so, on the whole, the plates are pushed together. You can easily see that *this is the case.* I have two very light hollow glass beads such as are used to decorate a Christmas tree. These will float in water if one end is stopped with sealing-wax. These are both wetted by water, and so the water between them is slightly raised, for they act in the same way as the two plates, but not so powerfully. However, you will have no difficulty in seeing that the moment I leave them alone they rush together with considerable force. Now if you refer to the second figure in the diagram, which represents two plates which are neither of them wetted, I think you will see, without any explanation from me, that they should be pressed together, and this is made evident by experiment. Two other beads which have been dipped in paraffin wax so that they are neither of them wetted by water float up to one another again when separated as though they attracted each other just as the clean glass beads did.

If you again consider these two cases, you will see that a plate that is wetted tends to move towards the higher level of the liquid, whereas one that is not wetted tends to move towards the lower level, that is if the level of the liquid on the two sides

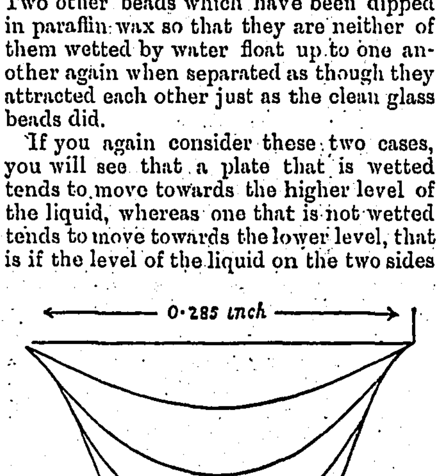
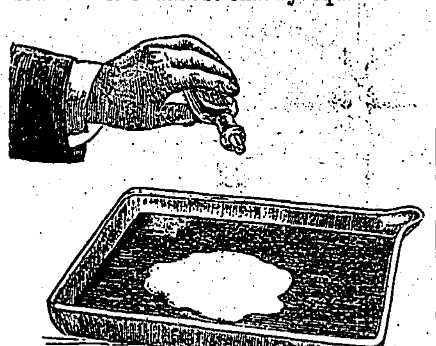


FIG. 12.

is made different by capillary action. Now suppose one plate wetted and the other not wetted, then, as the diagram imperfectly shows, the level of the liquid between the plates where it meets the non-wetted plate is higher than that outside, while where it meets the wetted plate it is lower than that outside; so each plate tends to go away from the other, as you can see now that I have one paraffined and one clean ball floating in the same water. They appear to repel one another.

You may also notice that the surface of the liquid near a wetted plate is curved, with the hollow of the curve upwards, while near a non-wetted plate the reverse is the case. That this curvature of the surface is of the first importance I can show you by a very simple experiment, which you can repeat at home as easily as the last that I have shown. I have a clean glass bead floating in water in a clean glass vessel, which is not quite full. The bead always goes to the side of the vessel. It is impossible to make it remain in the middle, it always gets to one side or the other directly. I shall now gradually add water until the level of the water is rather higher than that of the edge of the vessel. The surface is then rounded near the vessel, while it is hollow near the bead, and now the bead sails away towards the centre, and can by no possibility be made to stop near either side. With a paraffined bead the reverse is the case, as you would expect. Instead of a paraffined bead you may use a common needle, which you will find will float on water in a tumbler, if placed upon it very gently. If the tumbler is not quite full the needle will always go away from the edge, but if rather overfilled it will work up to one side, and then possibly roll over the edge; any bubbles, on the other hand, which were adhering to the glass before will, the instant that the water is above the edge of the glass, shoot *away from the edge in the most sudden* and surprising manner. This sudden change can be most easily seen by nearly filling the glass with water, and then *gradually dipping in and taking out* a cork, which will cause the level to slowly change.

So far I have given you no idea what force is exerted by this elastic skin of water. Measurements made with narrow tubes, with drops, and in other ways, all show that it is almost exactly equal to the



G. 13.

weight of three and a quarter grains to the inch. We have, moreover, not yet seen whether other liquids act in the same way, and if so whether in other cases the strength of the elastic skin is the same.

You now see a second tube identical with that from which drops of water were formed, but in this case the liquid is alcohol. Now that drops are forming, you see at once that while alcohol makes drops which have a definite size and shape when they fall away, the alcohol drops are not by any means so large as the drops of water which are falling by their side. Two possible reasons might be given to explain this. Either alcohol is a heavier liquid than water, which would account for the smaller drop if the skin in each liquid had the same strength, or else if alcohol is not heavier than water its skin must be weaker than the skin of water. As a matter of fact alcohol is a lighter liquid than water, and so still more must the skin of alcohol be weaker than that of water.

We can easily put this to the test of experiment. In the game that is called the tug-of-war you know well enough which side is the strongest: it is the side which pulls the other over the line. Let us then make alcohol and water play the same game. In order that you may see the water, it is colored blue. It is lying as a shallow layer on the bottom of this white dish. At the present time the skin of the water is pulling equally in all directions, and so nothing happens; but if I pour a few drops of alcohol into the middle, then at the line which separates the alcohol from the water we have alcohol on one side pulling in, while we have water on the other side pulling out, and you see the result. The water is victorious; it rushes away in all directions, carrying a quantity of the alcohol away with it, and leaves the bottom of the dish dry (Fig 13).

This difference in the strength of the skin of alcohol and of water, or of water containing much or little alcohol, gives rise to a curious motion which you may see on the side of a wine-glass in which there is some fairly strong wine, such as port. The liquid is observed to climb up the sides of the glass, then to gather into drops, and to run down again, and this goes on for a long time. This is explained as follows:—The

FIG. 14.

thin layer of wine on the side of the glass being exposed to the air, loses its alcohol by evaporation more quickly than the wine in the glass. It therefore becomes weaker in alcohol or stronger in water than that below, and for this reason it has a stronger skin. It therefore pulls up more wine from below, and this goes on until there is so much that drops form, and it runs back again into the glass, as you now see upon the screen (Fig 14). There can be no doubt that this movement is referred to in Proverbs xxiii., 31: 'Look not upon the wine when it is red, when it giveth his color in the cup, when it moveth itself aright.'

If you remember that this movement only occurs with strong wine, and that it must have been known to every one at the time that these words were written, and used as a test of the strength of wine, because in those days every one drank wine, then you will agree that this explanation of the meaning of that verse is the right one. I would ask you also to consider whether it is not probable that other passages which do not now seem to convey to us any meaning whatever, may not in the same way have referred to the common knowledge and customs of the day, of which at the present time we happen to be ignorant.

Ether, in the same way, has a skin which is weaker than the skin of water. The very smallest quantity of ether on the surface of water will produce a perceptible effect. For instance, the wire frame which I left some time ago is still resting against the water-skin. The buoyancy of the glass bulb is trying to push it through, but the upward force is just not sufficient. I will however pour a few drops of ether into the glass, and simply pour the vapor upon the *surface* of the water (not a drop of liquid is passing over), and almost immediately sufficient ether has condensed upon the water to reduce the strength of the skin to such an extent that the frame jumps up out of the water.

There is a well-known case in which the difference between the strength of the skin of two liquids may be either a source of vexation or, if we know how to make use of it, an advantage. If you spill grease on your coat you can take it out very well with benzine. Now if you apply benzine to the grease, and then apply fresh benzine to that already there, you have this result—there is then greasy benzine on the coat to which you apply fresh benzine. It so happens that greasy benzine has a stronger skin than the pure benzine. The greasy benzine before plays at tug-of-war with pure benzine, and being stronger wins and runs away in all directions, and the more you apply benzine the more the greasy benzine runs away carrying the grease with it. But if you follow the directions on the bottle, and first make a ring of clean benzine round the grease-spot, and then apply benzine to the grease, you then have the greasy benzine running away from the pure benzine ring and heaping itself together in the middle, and escaping into the fresh rag that you apply, so that the grease is all of it removed.

There is a difference again between hot and cold grease, as you may see, when you get home, if you watch a common candle burning. Close to the flame the grease is hotter than it is near the outside. It has therefore a weaker skin, and so a perpetual circulation is kept up, and the grease runs out on the surface and back again below, carrying little specks of dust which make this movement visible, and making the candle burn regularly.

You probably know how to take out grease-stains with a hot poker and blotting-paper. Here again the same kind of action is going on.

A piece of lighted camphor floating in water is another example of movement set up by difference in the strength of the skin of water owing to the action of the camphor.

(To be Continued.)

A BORN LAWYER.

A lawyer advertised for a clerk. The next morning the office was crowded with applicants—all bright, and many suitable. He bade them wait until all should arrive, and then arranged them all in a row and said he would tell them a story, note their comments, and judge from that whom he would choose.

'A certain farmer,' began the lawyer, 'was troubled with a red squirrel that got in through a hole in his barn and stole his seed corn. He resolved to kill the squirrel at the first opportunity. Seeing him go in at the hole one noon, he took his shotgun and fired away; the first shot set the barn on fire.'

'Did the barn burn?' said one of the boys.

The lawyer, without answer, continued: 'And seeing the barn on fire, the farmer seized a pail of water and ran to put it out.'

'Did he put it out?' said another.

'As he passed inside, the door shut to and the barn was soon in flames. When the hired girl rushed out with more water—'

'Did they all burn up?' said another boy.

The lawyer went on without answer: 'Then the old lady came out, and all was noise and confusion, and everybody was trying to put out the fire.'

'Did any one burn up?' said another.

The lawyer said: 'There, that will do; you have all shown great interest in the story.'

But observing one little bright-eyed fellow in deep silence, he said: 'Now, my little man, what have you to say?'

The little fellow blushed, grew uneasy, and stammered out: 'I want to know what became of that squirrel; that's what I want to know.'

'You'll do,' said the lawyer; 'you are my man: you have not been switched off by a confusion and barn burning and the hired girls and water pails. You have kept your eye on the squirrel.'—*Tact in Court.*

THE LIGHT THAT IS FELT.

A tender child of summers three,
Seeking her little bed at night,
Paused on the dark stair timidly.
'O mother! take my hand,' said she,
'And then the dark will all be light.'

We older children grope our way
From dark behind to dark before;
And only when our hands we lay,
Dear Lord, in thine, the night is day,
And there is darkness nevermore.

Reach downward to the sunless days
Wherein our guides are blind as we,
And faith is small and hope delays;
Take thou the hands of prayer we raise,
And let us feel the light of thee!

JOHN G. WHITTIER.

ONE BLOW RIGHTLY aimed with your hammer
That hits the nail well on the head,
Does more in making a building
Than a clamor that frightens the dead.
—*Ram's Horn.*