SOAP-BUBBLES,

AND THE FORCES WHICH MOULD THEM.

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(Continued.)

At the conclusion of the last lecture I showed you some curious experiments with a fountain of water, which I have now to explain. Consider what I have said about a liquid cylinder. If it is a little more than three times as long as it is wide, it cannot retain its form ; if it is made very much more than three times as long, it will

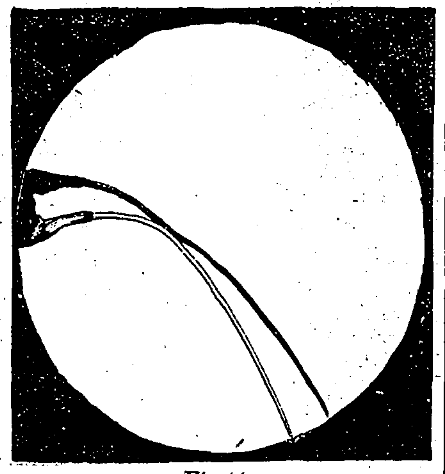

Fig 44.

break up into a series of beads. Now, if in any way a series of necks could be developed upon a cylinder which were less than three diameters apart, some of them would tend to heal up, because a piece of a cylinder less than three diameters long is stable. If they were about three diameters apart, the form being then unstable, the necks would get more pronounced in time, and would at last break through, so that beads would be formed. If necks were made at distances more than three diameters apart, then the cylinder would go on breaking up by the narrowing of these necks, and it would most easily break up into drops when the necks were just four and a half diameters apart. In other words, if a fountain were to issue from a nozzle held perfectly still, the water would most easily break into beads at the distance of four and a half diameters apart, but it would break up into a greater number closer together, or a smaller number further apart, if by slight disturbances of the jet very slight waists were impressed upon the issuing cylinder of water. When you make a fountain play from a jet which you hold as still as possible, there are still accidental tremors of all kinds, which impress upon the issuing cylinder slightly narrow and wide places at irregular distances, and so the cylinder breaks up irregularly into drops of different sizes and at different distances apart. Now these drops, as they are in the act of separating from one another, and are drawing out the waist, as you have seen, are being pulled for the moment towards one another by the elasticity of the skin of the waist ; and, as they are free in the air to move as they will, this will cause the hinder one to hurry on, and the more forward one to lag behind, so that unless they are all exactly alike both in size and distances apart they will

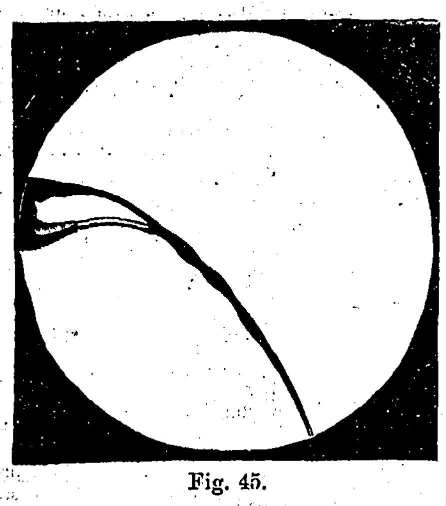

Fig. 45.

many of them bounce together before long. You would expect when they hit one another afterwards that they would join, but I shall be able to show you in a moment that they do not ; they act like two india-rubber balls, and bounce away again. Now it is not difficult to see that if you have a series of drops of different sizes and at irregular distance bouncing against one another frequently, they will tend to separate and to fall, as we have seen, on all parts of the paper down below. What did the sealing-wax or the smoky flame do ? and what can the musical sound do to stop this from happening ? Let me first take the sealing-wax. A piece of sealing-wax rubbed on your coat is electrified, and will attract light bits of paper up to it. The sealing-wax acts electrically on the different water-drops, causing them to attract one another, feebly, it is true, but with sufficient power where they meet to make them break through the air-film between them and join. To show that this is no fancy, I have now in front of the lantern two fountains of clear water coming from separate bottles, and you can see that they bounce apart perfectly (Fig 44). To show that they do really bounce, I have colored the water in the two bottles differently. The sealing-wax is now in my pocket ; I shall retire to the other side of the room, and the instant it appears the jets of water coalesce (Fig 45). This may be repeated as often as you like, and it never fails. These two bouncing jets are in fact one of the most delicate tests for the presence of electricity that exist. You are now able to understand the first experiment. The separate drops which bounced away from one another, and scattered in all directions, are unable to bounce when the sealing-wax is held up, because of its electrical action. They therefore unite, and the result is, that instead of a great number of little drops falling all over the paper, the stream pours in a single line, and great drops, such as you see in a thunder-storm, fall on the top of one another. There can be no doubt that it is for this reason that the drops of rain in a thunder-storm are so large. This experiment and its explanation are due to Lord Rayleigh.

The smoky flame, as lately shown by Mr. Bidwell, does the same thing. The reason probably is that the dirt breaks through the air-film, just as dust in the air will make the two fountains join as they did when they were electrified. However, it is possible that oily matter condensed on the water may have something to do with the effect observed, because oil acts quite as well as a flame, but the action of oil in this case, as when it smooths a stormy sea, is not by any means so easily understood.

When I held the sealing-wax closer, the drops coalesced in the same way ; but they were then so much more electrified that they repelled one another as similarly electrified bodies are known to do, and so the electrical scattering was produced.

You possibly already see why the tuning-fork made the drops follow in one line, but I shall explain. A musical note is, as is well known, caused by a rapid vibration ; the more rapid the vibration the higher is the pitch of the note. For instance, I have a tooth-wheel which I can turn round very rapidly if I wish. Now that it is turning slowly you can hear the separate teeth knocking against a card that I am holding in the other hand. I am now turning faster, and the card is giving out a note of a low pitch. As I make the wheel turn faster and faster, the pitch of the note gradually rises, and it would, if I could only turn fast enough, give so high a note that we should not be able to hear it. A tuning-fork vibrates at a certain definite rate, and therefore gives a definite note. The fork now sounding vibrates 128 times in every second. The nozzle, therefore, is made to vibrate, but almost imperceptibly, 128 times a second, and to impress upon the issuing cylinder of water 128 imperceptible waists every second. Now it just depends what size the jet is, and how fast the water is issuing, whether these waists are about four and a half diameters apart in the cylinder. If the jet is larger, the water must pass more quickly, or under a greater pressure, for this to be the case ; if the jet is finer, a smaller speed will be sufficient. If it should happen that the waists so made are anywhere about four diameters apart, then, even though they are so slightly developed that if you had an exact drawing of them you would not be able to detect the slightest change of diameter, they will grow at a great speed, and therefore the water column will break up regularly, every drop will be like the one behind it, and like the one in front of it, and not all different, as is the case when the breaking of the water merely depends upon accidental tremors. If the drops then are all alike in every respect, of course they all follow the same path, and so appear to fall in a continuous stream. If the waists are about four and a half diameters apart, then the jet will break up most easily ; but it will, as I have said, break up under the influence of a considerable range of notes, which cause the waists to be formed at other distances, provided they are more than three diameters apart. If two notes are sounded at the same time, then very often each will produce its own effect, and the result is the alternate formation of drops of different sizes, which then make the jet divide into two separate streams. In this way, three, four, or even many more distinct streams may be produced.

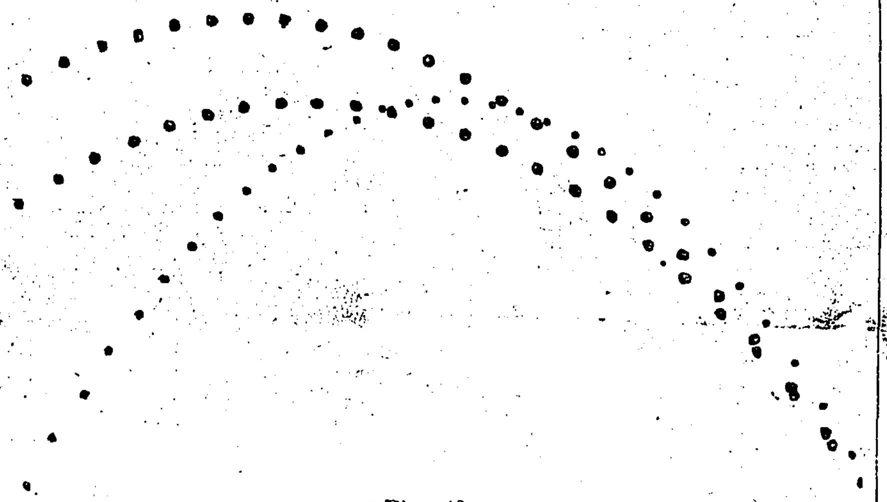

Fig. 46.

I can now show you photographs of some of these musical fountains, taken by the instantaneous flash of an electric spark, and you can see the separate paths described by the drops of different sizes (Fig. 46). In one photograph there are eight distinct fountains all breaking from the same jet, but following quite distinct paths, each of which is clearly marked out by a perfectly regular series of drops. You can also in these photographs see drops actually in the act of bouncing against one another, and flattened when they meet, as if they were india-rubber balls. In the photograph now upon the screen the effect of this rebound, which occurs at the place marked with a cross, is to hurry on the upper and more forward drop, and to retard the other one, and so to make them travel with slightly different velocities and directions. It is *for this reason that they afterwards follow* distinct paths. The smaller drops had no doubt been acted on in a similar way, but the part of the fountain where this happened was just outside the photographic plate, and so there is no record of what occurred. The very little drops of which I have so often spoken are generally thrown out from the side of a fountain of water under the influence of a musical sound, after which they describe regular little curves of their own, quite distinct from the main stream. They, of course, can only get out sideways after one or two bouncings from the regular drops in front and behind. You can easily show that they are really formed below the place where they first appear, by taking a piece of electrified sealing-wax and holding it near the stream close to the nozzle and gradually raising it. When it comes opposite to the place where the little drops are really formed, it will act on them more powerfully than on the large drops, and immediately pull them out from a place where the moment before none seemed to exist. They will then circulate in perfect little orbits round the sealing-wax, just as the planets do round the sun ; but in this case, being met by the resistance the air, the orbits are spirals, and the little drops after many revolutions, ultimately fall upon the wax, just as the planets would fall into the sun after many revolutions, if their motion through space were interfered with by friction of any kind.

(To be Continued.)

POWER.

Have you read the book of Frederick S. Arnot, the African explorer, and pioneer of the missionary cause? You will be surprised at first at the readiness with which the savages listened to his story of God the Father, and Jesus Christ our Saviour. But I think you will find the secret in one of his lion stories. In passing one day with his black 'lads' through a clump of reedy grass, a great lion sprang at the hindermost lad, who was carrying the mat and blanket. With lightning quickness Arnot threw himself so as to cover the boy's body, and the brute, confused by the movement, sprang several feet short of his victim, too close to Arnot for him to use his gun. The natives fled like deer, and the traveller's fate seemed sealed. But 'Daniel's God is still the same to us,' he writes in his diary. The lion himself became 'rattled,' and made off. 'I'd go anywhere with a white man who throws his own body between a lion and a black lad of no account,' said the tribe's chief. There it is! You can wield almost miraculous power over men, when you can prove that you count not your own life dear, if *only you render high service to God and* your fellow.

HIS FAITHFULNESS.

BY MRS. HELEN E. BROWN.

A timid little soul was I
E'en from my earliest years
My head was prone to questionings
And tremulous with fears.

How can I cross this narrow space
Of earth? I oft would say :
How can I all these dangers face,
These foes that throng my way?

I loved my work, and yet I feared
I could not do it well :
And dread of failure or mistake
Hung o'er me like a spell.

One day I cried, 'Lord, let me go
To your bright, heavenly sphere,
Where dread of failure shall not blight
Nor doubt oppress, nor fear.'

'No, no, my child,' in gentle tone
He whispered, 'lest you miss
Life's choicest lesson—faith's sweet rest ;
The triumph-work of grace.

'Lo, I am with you all the days,
And will be to the end :
Put your weak hand within my own,
And on my strength depend.

'I'll go with you through all the way,
To hold and help and teach ;
And some sweet day, the work all done,
You heaven you shall reach.'

Glad hour, when Jesus took my hand,
And clasped me to his heart!
His love has never failed me since,
And never will depart.

Trust him, ye timid little souls ;
Trust him, ye aged saints ;
Our God the universe controls,
And never tires or faints.

Have ye not known, have ye not heard,
How strong he is, and true?
The hand that holds and rules the stars
Will guide us safely through.

Come magnify the Lord with me ;
Let us exalt his name ;
His tender love and faithfulness
Our gladdest praises claim.

—*American Messenger.*