incentive to more advanced study. I am sure some students would read for their own pleasure parts of such books as:

Ball's, "Mathematical Recreations and Problems."

Schubert's "Mathematical Essays and Recreations."

Smith's "Teaching of Mathematics," and

DeMorgan's "Study of Mathematics."

Fine's "Number System of Algebra."

Fink's or Ball's "History of Mathematics."

Heath's "Series of Mathematical Monographs."

Dobson's "Pillow Problems," Flatland, etc.

COMPOSITION OF MOTIONS.

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It would be hard to devise a more useful piece of apparatus for illustrating the composition of motions than a narrow strip of elastic rubber (a broken rubber band) with a small ball of white paper tied to it at some point. In fig. 1, let the plane of the paper represent a blackboard and let the ends of such a strip of rubber be held against the blackboard between the fingers of the two hands at a and b , the rubber being held in a state of tension. Let c represent the ball of paper whose motion is to be studied. If the end a of the rubber strip is held stationary while the end b is moved along the surface of the blackboard following the line bb' the paper ball c will move along the line ce . If, on the contrary, b is fixed and a is moved to a' , c moves to d . If now a is held fixed and b is moved to b' and remains there while a is now moved to a' , the paper ball traces the path $c'ec'$. Again, recurring to the original position of the rubber band, if b is fixed while a is moved to a' and then b is moved to b' , the paper ball traces the path cdc' . Finally, starting with the original position, if both ends of the band are moved simultaneously from a and b with such speeds that a' and b' are reached at the same instant, then the paper ball traces the diagonal path cc' . By having the lines aa' , bb' and the parallelogram $cdc'e$ and its diagonal drawn on the blackboard beforehand, according to the construction which is obvious from the figure, one is prepared to show a most simple

FIG. 1

and striking illustration of the composition of successive and simultaneous motions. The experiment is one whose teaching value is high because of its simplicity and directness. It is perhaps best in this experiment to tie the paper ball to a point some distance from the centre of the rubber band as indicated in the figure.

If the paper ball is tied to the middle of the band, and the experimenter faces his audience, holding the ends of the band in his two hands, he is prepared to illustrate in a very simple manner some of the essential facts in connection with the composition of simple harmonic motions. In fig. 2 let ab represent the rubber strip and c the ball. If a is held stationary and b moved back and forth between b' and b'' , c moves between c' and c'' with

FIG. 2

a vibratory motion whose amplitude is one-half that of b . Similarly, c traverses the same path if b is fixed and a is moved between a' and a'' . If both hands are moved so that the motions $a'a''$ and $b'b''$ are always in the same direction, then c moves with double amplitude over the path c_1c_2 . Finally, if the hands are always moved in opposite directions, the point c remains stationary, thus showing the destructive interference of equal simple harmonic motions whose phases are opposed.

Another illustration of the same principle may be obtained by moving the hands vertically as indicated in fig. 3, instead of

horizontally. If the motions aa' and bb' of the hands are in the same phase, the ball traverses the path cc' ; if, however, the hands move in opposite phases one moving down while the other moves up, c remains stationary at the point o .

FIG. 3

With a little practice one can also illustrate the composition of two rectangular harmonic motions as indicated in fig. 4. With a stationary and b moving between b' and b'' , c traces the path de . With b stationary and a moving between a' and a'' , c moves between f and g . If the hands start from the positions $a' b'$, and move in the same period over the former paths, then c will trace

FIG. 4

the diagonal path hk . If the observer can by practice acquire sufficient skill to keep a difference of phase of 90° between the motions of the two hands so that the points a and b' , a'' and b , etc., will correspond, he will be able to show the resultant circular path of the point c . He will thus be able to illustrate the origin of circularly polarized light from the union of two plane polarized beams.

Figure 5 shows how the rubber band may be used to illustrate the composition of circular motions. With either end held stationary and the other traversing one of the circles a' or b' , the paper ball will trace the smaller circle c' . If the ends of the

band are made to traverse the two circles a' and b' both in the same direction and in the same phase, c will trace out the larger circle c'' . If, on the contrary, the motion of the circles c' b' are in opposite directions and so timed that the hands pass through the highest points of the two circles at the same instant, then c will traverse the vertical straight line de . The introduction

FIG 5

of a slight difference of phase will cause the line de to incline to one side or the other. This experiment enables one to illustrate not only the union of two circularly polarized beams to produce plane polarized light, but also to illustrate the rotation of the plane of polarization in quartz, etc.

BOYLE'S LAW, BY MEANS OF A CAPILLARY TUBE.

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The apparatus consists of a capillary tube one meter long with a bore of about one millimeter, sealed at one end and fastened to a meter stick with wires at three points. In the tube is about three centimeters of air and sixty centimeters of mercury. The meter stick is clamped to a table stand so as to move around a horizontal axis and to have its broad side facing the operator. The tube may be filled before sealing if care be taken to secure the proper amount of air while closing. This should be done by the teacher. The pupil should be given the tube mounted on the meter stick ready for work. The tube should always be handled with care and never taken from the meter stick on which it is mounted.