face and hands on. I knew at the time that as soon as these were put on he would change his mind, but I said nothing. Of course the clock would gain, and that not a little, and although the quicker motion of the pendulum may have overcome the cause of its stoppage to a certain extent, I am pretty sure that the piece which had been cut off was replaced before the clock went "fine."

That blunders like this can occur in the workshops of otherwise fair workmen must be ascribed to one fault—the one great fault in the system of apprenticeship in our country—the lack of laying a good foundation by teaching the physical principles upon which the performance of the work in hand depends.

Right here is where horological schools can do good work. Here is where lectures, even if given in the most primitive manner, and enjoyed by students for a short time only, prove to be of immense value. After following a reasonable course of these studies, if there is anything in the student it will come out. A desire to get at the bottom of things is created in him, and this desire followed by understanding and subsequent practice will lead him in the right direction to become a first-class workman.

It makes no difference how much he may be cautioned to be careful in his work, or to what extent the excellence of the nickel-plated American lathe and the fine work that can be done on it may be impressed upon him, if he remain ignorant of the mechanical laws governing his work he will keep on working in the dark. He will turn fine staffs which will not "spin"—because of some other, to him, inconceivable cause—and he will make all kinds of ridiculous experiments.

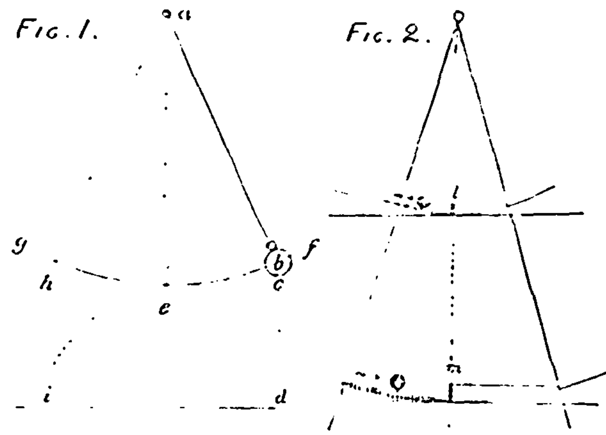
After having realized his mistakes, he may learn a lesson from them and avoid them in the future, but it will be a long time before he will be a safe workman, and it is safe to say he will never be a first-class one.

However, as horological schools are not accessible to all watchmakers, I propose, since my attention has been called to the matter, to follow up this introduction by a short article descriptive of the pendulum and its workings, in the columns of this journal, which by the grace of its editor is free to all.

The action of the pendulum is due to the force of gravity, that force which draws everything towards the centre of the earth, and to the momentum of forces which allows a body to move through space after the force which gave it its impulse has been discontinued.

Take a string, attach one end to a hook, *a*, (Fig. 1.) and the other to a weight, *b*, hold the weight out to the point *c* and drop it.

If left unimpeded it would drop directly to the ground in the direction of the line *c—d*; as it is, however, the string keeps the weight in suspense so that it cannot do so. But it does as nearly so as possible, and follows its inclination downward and moves along the curve *f—g* until it reaches the point *e*. The force of gravity alone has brought about this motion, and if it were not that all bodies set in motion have a tendency to continue to move for some time after the propelling power has been expended, the ball would stop at this point. But the ball having been set in motion, instead of following the course *e—i*, which, by virtue of the forces of gravity and momentum, it would take if it were at this point detached from the string, it is forced by the tension of the string to follow its original curve until it reaches the point *h*, where, its momentum having been counteracted by the same force of gravity which gave it, it finally comes to a standstill, only to be impelled in the opposite direction by the exercise of the same forces.




If it were not for the friction of the air and that caused by the resistance of the spring at the end of the rod, a pendulum once started would keep up its motion indefinately and we would have perpetual motion. However, from these causes the pendulum loses a little of its force at each vibration, and it is therefore necessary in the making of clocks to apply mechanism to give fresh impetus at stated intervals.

The pendulum always swings in a perfect arc, with the length of the string or rod as a radius. The shorter the rod, or in other words the smaller the circle, the greater will be the relative distance between the arc and its chord, (as shown by the heavy lines at *l* and *m* in Fig. 2), and the more directly can the force of gravity exert itself. It will be observed that *l* is much greater in proportion to the rest of the radius than *m* is in proportion to *its* radius. For this reason a short pendulum will vibrate faster than a longer one.

The effect is the same as in a ball rolling down an inclined plane as shown at the left hand side of Fig. 2. The steeper the plane the faster of course the ball will roll: and the rounder the curve the faster it moves when attached to a rod or string. We have now seen that the number of vibrations of a pendulum depends entirely on the length of the rod.

It will take just as long for a weight of one ounce to fall to the ground from a given height as it will one that weighs a ton. The force of gravity in both cases does its work in the same time. It will therefore be understood that all changes in the number of vibrations of a pendulum must be brought about by changing the length of its rod and not by altering its weight.

The strength of the impelling mechanism of a clock, the condition of its escapement, the amount of recoil and the influence of currents of air, or other disturbing causes to the action of which the pendulum may be exposed, are factors which must be considered when the proper weight of a pendulum is to be determined upon.

The number of times of vibration of different pendulums are as the square root of their lengths. Thus a pendulum in order to vibrate twice as slowly must be four times as long; and to vibrate three times slower must be nine times as long. The length for a given number of vibrations in a stated time varies slightly in different latitudes. This is due to the acceleration of the earth's axis. In the latitude of Greenwich the length of