mediately compensated. The moment the escape-wheel moves on again, one of its teeth meets the projection, P_1, and the balance-wheel receiving this fresh impulse goes on to complete its swing. Then it returns and swings in the opposite direction, this time without acting in any way on the detent. When the balance-wheel made its first swing and the point P_2, met the projecting end of the spring, the latter could then only bend from the end of the arm with which the detent is provided and against which the point B_2 forced it. But on the return swing the spring is found capable of bending from the more distant point of its attachment to the shank of the locking-piece. It is therefore easily pushed aside; there is no change in the position of the detent, nor is any resistance offered to the motion of the balance-wheel, which goes on to complete its swing. Then another tooth is caught, the escape-wheel is again locked, and again released by the lifting of the detent. So the action goes on, the teeth of the escape-wheel being constantly detained and as constantly released by the action of the point B_2. The balance wheel, it will be noted, receives its impulse only at every alternate swing, whereas in the clock the pendulum receives its impulse at each vibration.

Time then can be divided down to the 1-10th of a second, or as we expressed it, down to the 864,000th part of a day, not only by a clock, but also by this chronometer. Having obtained this 1-10th of a second by these instruments, the question arises as to whether it be possible to get a still finer division. It will be seen that a very much finer division than this can be obtained, the 1-100th part of a second being a measurable quantity; not that such a small fraction of time as this is ever necessary in astronomy, nor will it be until the present astronomical methods have ceased to exist. If it were possible to get all observations made by photography, then it would be worth while recording with such minuteness, because photography would always behave in the same way, whereas two observers never have the same idea as to the time of occurrence of any phenomena which they observe. Yet, although so great an accuracy as this is not attempted, it will be quite worth while to consider the means by which this exquisite fineness of the division of a second of time has been arrived at. We shall see that just in the same way as an appeal to mechanical principles resulted in an improvement in the construction of our clock, so this fineness in the division of time has been obtained by an appeal to the principles of electricity. Let it be assumed that the seconds pendulum of our clock swings with perfect accuracy and with absolute uniformity from second to second, in spite of changes of temperature and other perturbing influences; and having assumed this, let us see how electricity can be made to aid in the measurement of time. The instrument used is called a chronograph. It consists of a metal cylinder revolving by clock-work and covered with cloth, over which a piece of paper can be stretched. Below the cylinder and parallel with it is a track along which a frame carrying two electromagnetic markers or prickers is made to travel uniformly by the same clock that drives the cylinder. Wires connected with a battery lead from one of these magnets to a clock and from the other to a key, which can be depressed whenever an observation is made, and a current so sent to the magnet. The effect of this is to cause it instantaneously to attract its iron armature and cause the pricker with which it is connected to make a mark on the paper above.

The connection of the chronograph with the clock is as follows:—The bearing shown in the middle of the diagram (Fig. 22) is a continuation of the bearing on which the seconds hand of the clock is supported, and there is a little wheel which does its work quietly at the back of the clock in exactly the same way that the seconds hand does its work quietly in front of it. What that wheel does is this. Every time that each of its teeth—and there are sixty of them—comes to the top of the wheel it touches a little spring. That little spring then makes electrical contact, and a current is sent flowing through parts of the apparatus already described. Now the teeth in that wheel, being regularly disposed around its circumference, always succeed one another after exactly the same interval of time, and there is no difference or distinction from second to second, or from minute to minute. But suppose that before the clock is started one of these teeth is filed off, and so filed off that when the seconds hand points to o seconds, and the minute hand to a completed minute, this part of the wheel shall be at the top, and there shall be no electrical contact established, for the reason that the tooth of the wheel is not there to act on the spring. In that way it is easy to manage matters so that the beginning of each minute shall be distinguished from all the other fifty-nine seconds which make up the minute. Let the cylinder, covered with paper, revolve once in a minute. In that case, the electrical current will make a hole or a mark on that paper every second, and as matters are so arranged that the prickers shall be travelling along at the time that the dots are made upon the revolving paper they are thus made along a continuous spiral, and since we have supposed the cylinder to revolve once in a minute, the beginning of each minute will be in the same line along the spiral. Then, according to the length of the cylinder, a second of time will be obtained written in dots, sixty of them round the cylinder representing sixty seconds. Suppose now that a man with a perfect eye makes an observation, recording it by sending a current through the apparatus and making a dot on the paper. He will then have an opportunity of observing on the paper the precise relation of the dot which represents the time at which the observation was made to the other dots which represent the various seconds dotted out by the clock, and not only the exact distance of the observation prick from the nearest *second*, whether it be ½, or 1-10th, or 1-100th of the distance between that second and the next, but the omission of the record of the first second in the minute will give the relation that observation has to the nearest *minute*.

For the sake of simplicity the case of one observer making one observation has alone been considered; but if the work be properly arranged, then not only one electromagnet, but two or three, or four, may be at work upon the same cylinder at the same time, each making its record, and that is how such work is being done at the Greenwich Observatory.

This power of measuring and dividing time then having been obtained, we seem to have reached our subject, "The movements of the Earth." Yet even now there are one or two other matters which require to be discussed before we consider the movements themselves. The first of these is the important fact that the earth is spherical in its form. There have been many views held at different times as to the real shape of the earth, but the only view we need consider is that stated. In going down a river in a steamboat, or, better still, in standing upon the sea-shore at some place, such as Ramsgate, where there are cliffs, and where, consequently, one may get from the sea-level to some height above it, it is observed that when any ship disappears from our view by reason of its distance it seems to disappear as if it were passing over a gentle hill.

It does this in whatever direction it goes. This familiar fact is a clear proof that the earth is a sphere, and is so obvious that it may seem unnecessary to mention it, but it was well to do so for a reason which will appear shortly. Besides this argument in favour of the spherical shape of the earth there is the argument from analogy: the moon is round, the sun is round, all the known planets are round. The stars are so infinitely removed from us that it cannot be determined whether they also are spherical, but doubtless they are as round as the earth. This point of the tremendous distance of the stars is an important one to bear in mind. Their distance cannot be conveniently stated by thousands, nor even by millions of miles, it is something far greater than that. It may be asked why it is that such a statement can be thus positively made. For this reason: the stars have been observed now for many ages, and the historical records of ancient times show that the chief constellations, the chief clusters of stars visible in the heavens now, were seen then. In the Book of Job, for instance, there is a reference to the well-known constellation of Orion, and there is very little doubt that for thousands and thousands of years that constellation has preserved the familiar appearance of its main features, the constellation called Charles's Wain, or the Great Bear, was also known to the ancients. If the stars were very near to the earth this could not be. If they were close to us the smallest motion either of earth or star would at once change their apparent position, and would prevent this fixity of appearance, and the skies would be filled, not with the constellations with which we are so familiar, but with new and ever-changing clusters of stars. This constancy of the constellations, not only from century to century, but from era to era, clearly proves then that the stars of which they are made up must be at an infinite distance from the earth.

Let us consider the question of distance a little further. If two pieces of wood (see Fig. 23) joined together by a cross-piece be taken, a moment's thought will make it obvious that the angles which A B and C B make with the cross-piece A C, will vary with the distance of the body, which can be seen first by