What does a pen have to do to record on paper the vibrations generated by an earthquake?

An earthquake comes like a thief in the night, without warning.

It was necessary, therefore, to invent instruments that neither slumbered nor slept.

Some devices were quite simple.

One, for instance, consisted of rods of various lengths and thicknesses that would stand up on end like ninepins.

When a shock came, it shook the rigid table upon which these stood.

If it were gentle, only the more unstable rods fell.

If it were severe, they all fell.

Thus the rods, by falling, and by the direction in which they fell, recorded for the slumbering scientist the strength of a shock that was too weak to wake him, and the direction from which it came.

But instruments far more delicate than that were needed if any really serious advance was to be made.

The ideal to be aimed at was to devise an instrument that could record with a pen on paper, the movements of the ground or of the table as the quake passed by.

While I write, my pen moves, but the paper keeps still.

With practice, no doubt, I could, in time, learn to write by holding the pen still while the paper moved.

That sounds like a silly suggestion, but that was precisely the idea adopted in some of the early instruments (seismometers) for recording earthquake waves.

But when the table, penholder and paper are all moving, how is it possible to write legibly?

The key to a solution to that problem lies in an everyday observation.

Why does a person standing on a bus or train tend to fall when a sudden start is made?

It is because his feet move on, but his head stays still.

A simple experiment will help us a little further.

Tie a heavy weight at the end of a long piece of string.

With the handheld high in the air, hold the string so that the weight nearly touches the ground.

Now move the hand to and fro and around, but not up and down.

It will be found that the weight moves but slightly or not at all.

Imagine a pen attached to the weight in such a way that its point rests upon a piece of paper on the floor.

Imagine an earthquake shock shaking the floor, the paper, you and your hand.

In the midst of all this movement, the weight and the pen would be still.

But as the paper moved from side to side under the pen point, its movement would be recorded in ink upon its surface.

It was upon this principle that the first instruments were made, but the paper was wrapped round a drum which rotated slowly.

As long as all was still, the pen drew a straight line, but while the drum was being shaken, the line that the pen was drawing wriggled from side to side.

The apparatus thus described, however, records only the horizontal component of the wave movement, which is, in fact, much more complicated.

If we could actually see the path described by a particle, such as a sand grain in the rock, it would be more like that of a bluebottle buzzing round the room; it would be up and down, and to and fro and from side to side.

Instruments have been devised and can be so placed that all three elements can be recorded in different graphs.

When the instrument is situated more than 700 miles from the earthquake center, the graphic record shows three waves arriving one after the other at short intervals.

The first records the arrival of longitudinal vibrations.

The second marks the arrival of transverse vibrations, which travel more slowly and arrive several minutes after the first.

These two have traveled through the earth.

It was from the study of these that so much was learned about the interior of the Earth.

The third, or main wave, is the slowest and has travelled around the Earth across the surface rocks.

The rods of various lengths and thicknesses stood up on end like ninepins on a rigid table.

If there was a gentle earthquake shock, only the unstable rods fell over, but a severe shock would make them all fall over.

The direction in which they fell would also tell the scientist the direction from which the shock came.

This simple seismometer worked by rods, was unsatisfactory because it was not delicate enough.

The observation that a person falls down if a bus he is standing on starts suddenly.

This is because his feet move on, but his head stays still.

The three ‘elements’ are movement up and down, to and fro, and from side to side.

The third wave of an earthquake is the last to be recorded because it has traveled around the Earth through the surface rocks.

The tent was supported on a rigid metal framework, but it still blew over.

The nurse left when all the babies were slumbering peacefully in their cots.

She served us tea in delicate bone-china teacups.

‘Invite all the family to stay with us for the holidays?!’ he exclaimed. ‘What a silly suggestion!’

He signed his name legibly so that anyone could read it.

Heavy rains are an everyday occurrence here at this time of the year.

Apples generally tend to ripen earlier in this part of the country.

She walked slowly to and fro in front of the window as she talked to her husband on her mobile.

I’ve only hurt my hand slightly; I won’t have to go to the hospital or anything.

The pilot switched on the motor, and the helicopter blades rotated slowly, before gradually picking up speed.

The woman screamed as the worm that her daughter gave her wriggled in the palm of her hand.

We now have scientific instruments that can record the path described by a particle of energy.

There was a huge blue bottle flying around my bedroom and I knew I would never get to sleep.

The seismometer used for recording the horizontal component of earthquake wave movements works on a fairly simple principle.

Someone standing on a bus will fall over if the bus starts suddenly; that’s because his feet move while his head stays still.

To illustrate this, a weight tied to a long piece of string and nearly touching the ground will not move even though the hand holding the string moves to and fro.

Attach a pen to the weight, its point resting on a piece of paper (flat or round, a rotating drum), and you have a seismometer.

When the drum is still, the pen draws a straight line; when it is shaken, the pen draws a wriggly line.

The day was hot, unusually hot for the time of year.

My family and I had gone to the island for our annual holiday for the third time in three years, and my parents had chosen early June because the weather was normally just right then.

We could all swim in the sea and sunbathe, but we did not have to stay indoors for an hour or so at midday as we would have to if we went to the island in July or August.

We were having breakfast outside on the patio, all in shorts, T-shirts and sandals, ready to rush away to the beach straight afterwards.

“**I think it’s going to be very hot today,**” my father said, “**so I suggest we all come back to the villa for lunch. That way, if the sun’s too hot to sit outside, we can have lunch indoors.**”

We all nodded d agreement and began to help Mother clear the table.

Suddenly, there was one of those strange pauses when everyone stopped talking or doing things.

It was odd, but what was even odder was the fact that there was silence.

“**Listen,**” my mother said slowly, “**the birds have stopped singing, and I haven’t heard any cicadas for a few minutes either.**”

Usually, there was an almost constant noise of cicadas chirping in the background.

We all stopped and listened.

Everything did seem unusually quiet.

Then we all felt something.

We weren’t sure what it was.

My father, who had his elbows on the table at the time, said later that something had slid along the table and he gently rubbed his elbows.

I felt someone move the seat of my chair very slightly.

My brother and sister, who were sitting on a bench seat, both felt the seat move a little.

We all looked at each other.

No one said anything.

Then the silence was broken by the sound of the bell in the local village church tower.

It rang just once, as if on its own, and the table began to move, and the patio under our feet, and the sensation was horrifying.

Suddenly, it felt as if the patio was a boat on water and we were passengers with no way of steering it.

And as the ground began to shudder beneath us, the bell from the church began to ring almost regularly, and we heard the noise of stone against stone, concrete against concrete, and the sound of smashing glass, as walls collapsed in nearby buildings.

By now, there was a general angry rumbling all around, as if some prehistoric monster was beginning to wake up.

There was a loud crack, and from where I was lying—we were all lying on the ground now—I looked over the edge of our heaving patio to see the small donkey path below crack open like an egg.

Suddenly, with a splintering crash, all the tiles on the roof of our villa flew and slid off onto the roof of the villa below.

Then, just as suddenly, the ground stopped moving.

There was a pause of about fifteen seconds, a pause of almost absolute silence, before we heard the first cries of people from the nearby streets and villas.

We all looked at each other again, as we had done when the first tremors had hit us, but this time with relief.

“**My God, an earthquake,**” said my brother. (One of us had to say it.)

“**Yes,**” said my father, “**and we’re all alive. But let’s go and see what damage has been done to the villa. After that, we’ll see how we can help in the village.**”

The juice extractor is a practical household device.

He has devised a scheme for earning more money.

She travels to London at least three times a month.

I'm just back from a business trip.

The company has persuaded the workers to adopt more flexible working practices so as to increase efficiency.

Our Geology teacher has adapted an old washing machine so he can use it to polish gemstones.

What are your main exports? Oil and Wool

They have always exported a lot of oil to neighboring countries.

Oil is this country's most important import.

Many of their cars are imported from Japan.

Our neighbors sell their own produce in the market.

When children are learning to play the violin, they produce some strange noises!

That boy's conduct is excellent.

I'd love to conduct a large orchestra.

Even a primitive instrument with rods can indicate roughly how strong an earthquake is and its direction.

In a more sophisticated instrument to measure an earthquake, the pen remains still while recording the irregular movement of the paper beneath it.

The instrument, consisting of a pen and paper moving around a rotating drum, does not provide a comprehensive record of an earthquake.

Instruments have been devised that will give a comprehensive record of an earthquake more than 700 miles away.

Falling rods recorded a shock that was not strong enough to wake up the scientist.

Instruments of far greater delicacy were needed.

Where did the key to that problem lie?

Provided all was still, the pen drew a straight line.

While I write, my pen moves, but the paper does not.

It will be found that the weight moves only slightly.

The graphic record shows three waves arriving irregularly.