function of these springs is to keep the planks, before sawing, and the paving blocks, after sawing, pressed to the table. Near the end of the table where the combs and springs rise and abandon the blocks, the latter are held down on the table by a set of small wheels *M* mounted on springs. Each comb carries two little brushes which sweep all waste into holes at the sides of the table.

The circular saws protrude through slits in the table. There are 17 saws, about 25 inches in diameter, mounted on three shafts, of which two are in line with each other but not with the third, *P*. This arrangement was adopted in order to avoid the excessive vibration of a single shaft as long as the planks, bearing 17 saws and making 2,000 revolutions per minute. The long shaft could not be stiffened by intermediate bearings because of the small distance between the saws. It was therefore decided to distribute the saws among three short shafts not in the same line. Each shaft is mounted on ball bearings and is driven by two belt wheels, one at each end. The bearings rest on iron beams imbedded in masonry.

Directly under the saws, in the cellar of the building, is the main driving shaft, which carries six wheels connected by belts with the wheels on the saw shafts. The driving shaft is mounted so that it can be moved up and down, to loosen and tighten the belts. This adjustment can be made from the main floor.

The saw blade is made up of a number of hinged cast-iron plates, which can be turned back for examination and adjustment of the saws. The bearings have direct lubrication. The resinous kerf which the saws accumulate from pine wood is removed by fine jets of kerosene pumped from a five-gallon tank through 3 main and 34 branch tubes and occasionally thrown on both faces of all the saws, without stopping the operation of the machine, by opening the cocks of the three main tubes that supply the three sets of saws.

Each of the two sets of saws which are in line contains 5 saws and cuts from the plank a waste end or trimming and 4 paving blocks. These two sets attack the plank simultaneously. The middle portion of the plank passes on between them to the third set, which comprises 7 saws and divides the remnant into 8 equal blocks. The 16 blocks which are thus cut almost simultaneously from the plank continue to advance along the table, pushed by the teeth of the conveyor and held down by the springs *L* until they come under the spring wheels *M*, where they remain until they are pushed onward by the following set of blocks. Thenceforward the blocks advance by steps, as they are pushed onward by new arrivals. When they reach the end of the table they slide down two inclined planes, divided into 16 compartments by vertical partitions, to the three belts of a horizontal conveyor, from which they are picked up and thrown into cars by a crew of 8 workmen. The cars, when filled, are hauled over the Decauville railway tracks to the creosoting establishment, whence the creosoted blocks go to the storage yards.

The power which operates the saws is furnished by an electric motor *U* of 110 horse-power, which is installed in the basement and connected by two belts with the main shaft *P'*. This motor is controlled by a liquid rheostat *W*, with an amperemeter and a safety cut-off. Connected with a switchboard on the main floor are two additional interrupters, an amperemeter, a voltmeter, and the controlling apparatus of a 4 horse-power motor *U*, which supplies power to the conveyors. Finally, there is a traveling crane and windlass for the removal of the saws for resetting.

The Josse machine can saw 25 planks per minute. As each plank furnishes 16 blocks, the theoretical output of the machine in a day of 10 hours is $25 \times 16 \times 60 \times 10 = 240,000$ blocks.

In practice it is necessary to make some allowance for unavoidable stoppages, etc., but a small mountain of paving blocks can be turned out in a day with the aid of 20 men or less.

New National Forest in Arizona.

A new national forest, named the Verde, and consisting of 721,780 acres, has just been created in Maricopa and Yavapai counties, Arizona. The forest lies on the west side of the Verde River and constitutes a great part of its watershed. Jerome, where the United Verde Copper Mining Company has its headquarters, is in the northern part of the new forest reserve. To the west and southwest of Jerome are the Mingus Mountains. Most of the reserve is covered with brush that has no commercial value; but a small part has merchantable timber on it and, under proper management, will supply the neighboring mining camps. The protection of the brush-grown area is just as important as that of heavily forested land, the scrub being the only thing that conserves the water and saves the watershed of the Verde River from erosion. The protection of this watershed from damage by overgrazing and wasteful lumbering is necessary in the opinion of the officers of the Reclamation Service to the development of the irrigable lands of Salt River Valley.

Hitherto the forest has been damaged by large herds of goats, which will not be prohibited from grazing in future but will be under regulation. The protection of the brush will conserve the water, which swells the Salt River and its tributaries and will help to develop the Salt River Valley.

IS THE AXIS OF THE EARTH SHIFTING?

BY J. F. SPRINGER.

It has been known for hundreds of years that the axis of the earth is continually changing its direction. To be clear as to this, recall that there is a point in

Figs. 1 and 2.

the northern sky which we term the north celestial pole and which will remain unchanged in its position to-night, although all the stars are apparently moving from east to west. There is no visible star occupying exactly this position, although the North Star approximates it. But this pole of the heavens is continually passing through a change in location. The terrestrial

Fig. 3.

motions which give rise to the movement of the pole are technically known as *precession* and *nutation*.

But near the close of the last century, certain astronomers began to suspect that not only was the axis of the earth continually changing its direction relatively to the stars, but that it was undergoing changes in the body of the earth itself. That is, they

Fig. 4.

saw reasons to think that the geographical point on the earth called the north pole was shifting its position over the surface. This would mean, if true, that the latitude of New York city is not a fixed quantity. The reasons for entertaining suspicion in this matter arose from the fact that variations of such number and character came to light in redeterminations of the

latitudes of certain locations, that they could scarcely be explained on the theory of errors of observation due to defects in instruments or lack of accuracy in observers.

But before saying more on the aspect which the matter has now assumed, it will perhaps be interesting to glance a moment at the question of latitude as it appeared to the ancient Greeks. In the first place, certain of their philosophers distinctly taught the globular character of the earth. They were familiar, too, not only with the conspicuous daily apparent motion of the sun from east to west, but with his annual apparent motions north and south. They noted the day when he halts in the constellation Cancer, having accomplished the end of his northern journey. This is the summer solstice. An imaginary east-and-west line through a point on the earth immediately below this position of the sun they termed the Tropic of Cancer. It was said that a well in Syene was found to be such a point. Here at noon on the day of the summer solstice the sun shone down the tube of the well. Possibly it was from such an observation that Syene was supposed by them to be on the Tropic of Cancer. In this they did not make such a great error, as its true latitude, 24 deg. 5 min. 23 sec., does not differ two-thirds of a degree from the true latitude of the Tropic of Cancer. However, they estimated it at 24 deg.

Using the Tropic of Cancer as a reference line, they were able, by means of an instrument which may be termed a *hollow gnomon*, to determine latitudes north and south. This was a hemispherical shell having a rod directed radially from the lowest point of the interior of this cup-shaped piece of apparatus. This rod terminated at the center of the sphere, and consequently was of the same length as a radius. At noon on the day of the summer solstice, the north pole would—as we know—be directed toward the sun, as shown in Fig. 1. A line from the sun to the center of the earth would pass through the Tropic of Cancer, *C*. If it be desired to determine the latitude of a point *P*, the hollow gnomon is fixed in such position that its central rod is vertical; that is, is a continuation of a radius of the earth. Its shadow is observed at the moment of noon. It is the arc *PQ*. Since *T* is the center of the shell, this arc is the measure of the angle α . As the sun, *S*, is very far away, the lines *ST* and *SCO* are practically parallel. Consequently, the angles α and β are equal. The number of degrees, then, indicated by the arc *PQ* is the same as the number indicated by *PC*. But this latter arc represents the latitude of *P* from *C*. This instrument is supposed to have been used by the Chinese as early as eleven hundred years before Christ. Whether the Greeks obtained their knowledge of it indirectly from them, or whether they invented it anew, is not certainly known. By this means, Eratosthenes determined the latitude of Alexandria.

But they were not limited to this one instrument. Another form of gnomon had a plane base. Upon the days of the vernal and the autumnal equinoxes, the sun is immediately over the equator at the moment of noon. It is at such an instant that the observation with this instrument was to be taken. The line *SO*, Fig. 2, connecting the sun and the center of the earth, would pass through a point on the equator. With the gnomon set up at *P* having its indicator in line with a radius of the earth, the angles α and β would be equal, as before. But β determines the latitude of *P* from the equator. Consequently, by determining the value of α by means of the lengths of the indicator *PT* and the shadow *PQ*, we should arrive at the value sought.

If one desires to satisfy himself how closely they approximated to the values determined by the refined methods of modern science, let him compare the values indicated by a good atlas with the following latitudes as given by Hipparchus:

Athens	36 deg.
Syracuse	36 deg. 44 min.
Byzantium (Constantinople) ..	43 deg.
Massilia (Marseilles)	43 deg.

It will be observed that the ancients were able to use these methods only at certain particular moments. In modern times, latitudes may be determined at any time of the year. There are quite a number of methods. But the following is quite simple, and will be readily understood. *N* is the pole of the heavens, Fig. 3. *E* is a point on the equator. Consequently, *NO* is perpendicular to *OE*. If no great accuracy is desired, the north star may be considered as the celestial pole. The angle ϕ is observed with a suitable instrument. That is to say, the elevation of the north star above the horizon is taken. Now *OP* is perpendicular to one side (*PH*) of ϕ , and *OE* is perpendicular to the other side *PN* (*PN* being practically parallel to *NO* on account of the great distance of the star). That is, the sides of θ are perpendicular to those of ϕ . This gives $\theta = \phi$. But θ determines the latitude of *P* from *E*, the equator. So then, the elevation of the north star above the (astronomical) horizon is exactly the same as the latitude of the place.

If it is desired to know the latitude with extreme accuracy, the value obtained by this rule must be corrected for the deviation of the north star from the true celestial pole, for the observation and refraction of light, etc.

In the eighties of the last century, Dr. Küstner at Berlin, in seeking to apply a method for the determination of the constant of aberration, was confronted with apparent errors of observation which refused to be explained by ordinary methods. Finally, he announced that the determinations of the latitude of Berlin showed a variation of 0.2 sec. to 0.3 sec. in the course of not many months. If the latitude had really changed, this would mean that the terrestrial pole had shifted from 20 to 30 feet.

It was found that the theory of a shifting pole was suggested by other facts. Finally, it was determined to set this matter at rest by an expedition to the Sandwich Islands. These are located about 180 deg. west or east of Berlin. If observations here showed a receding pole at the same time that European ones disclosed an approaching pole, and *vice versa*, then there could be no reasonable doubt that the axis of the earth is not fixed relatively to the earth itself. The United States government sent an officer to participate in the observations in the Pacific. Concurrently with these, similar work was carried on in the United States, in Berlin, and other places. The result of this work was to confirm the suspected shifting of the axis.

About the time of these occurrences, Dr. S. C. Chandler at Cambridge, Mass., became aroused over the same subject. In examining a series of determinations of latitude, he found not only variations, but that these variations appeared to conform to some law. At first, he felt that while the discrepancies seemed to indicate a shifting pole, this was too startling a proposition to put forth without further confirmation. However, after an immense amount of labor, he established the fact that two periodic influences were at work, at times co-operating to shift the pole to a maximum distance, and at others to limit its variation to a very small minimum. One of these influences was a yearly one; the other had a period ranging from 12½ to 14½ months. The combination of these two influences produced a cycle of about seven years.

The amount of displacement to which the north pole is thus subject is about 30 or 40 feet from a mean position. Dr. Chandler's first announcement was made in 1891.

In 1893 the fact of polar variation was pretty well admitted. The International Geodetic Association undertook the task of carrying on the observations and reducing them to order. At times they established four observational posts at widely separated points, but within about 12 sec. of the same degree of latitude; that is, at about 38 deg. 8 min. N. These were at Carloforte, in the island of San Pietro; Mizusawa, Japan; Ukiah, California, and Gaithersburg, Maryland. The officer of the last-named station is an officer of the U. S. Coast Survey. Aside from him, the expense involved is about \$14,000 annually. Tschardjui in Siberia and Cincinnati, Ohio, have joined in the work. More recently, the association has added two more stations in the southern hemisphere—one in Australia and the other in South America.

Fig. 4 is a curve representing the polar movement. This covers a period of six years, divided into tenths from 1899.9 to 1906.0. These points of time are indicated by the numbers shown on the curve. By referring to the numbers shown on the margin, the extent of the movement may be accurately noted, remembering that 1 sec. of arc is equal to about 100 feet.

The discoveries and investigation of Dr. Chandler have removed a mass of discordant results in the national observations of Great Britain, Russia, and the United States from the field of unaccountable error to that of agreement with fact. Indeed, the accuracy of both instruments and men had been under suspicion.

These results are valuable. Thus, one method of determining the solar distance is by means of the constant of aberration of light. This in turn is affected by variation of the rotational axis in the body of the earth. The reason for this is that it is necessary to know the position of the observatory in order to carry on the calculations. This it will now be possible to ascertain with a very high degree of precision.

WEATHER VANE WITH ATTACHMENT FOR INDOOR READINGS.

(Concluded from page 272.)

the weather vane. To make the vane, procure the front hub of an old bicycle which contains all the ball bearings, a piece of galvanized iron rod, 6½ feet long, of the same diameter as the spindle in the hub to which the cones are attached, and a piece of brass tubing 4 feet long the inside of which will snugly receive the end of the hub by driving it in. First saw off a foot and a half from the rod, then take the spindle out of the hub, saving the cone *D*, which is tapped. Now saw the hub in two in the center. On the end of the 5-foot piece of rod *C* for a length of 1 inch cut a thread, corresponding to the tap in the

cone *D*. Measure half an inch from the end of the thread, and file a shoulder one-sixteenth of an inch all around; then measure 9 inches from the other end and drill a ½-inch hole. Take the remaining foot and a half of rod *A* and drill a hole 7 inches from the forward end which will fit over the filed end of the rod *C* down onto the shoulder. Take a half ball *M* from the end of an old curtain pole and fasten to the forward end of the rod. The tail of the vane must be made with two spreading boards on the sides, braced in the center, and nailed to a firm block into which the end of the rod is driven. After this is done melt up some lead and pour into the half ball *M* until the rod balances on the point where the hole has been drilled. Screw the cone *D* on the rod as tightly as possible, and after placing the vane down over the point onto the shoulder, rivet it on, being sure that it points in the same direction as the hole drilled near the lower end. Now drive the sawed end of the hub into one end of the brass tubing and the vane is complete (Fig. 1).

A contact table should now be made as follows: The table is a circular board 6 inches in diameter and ½ inch thick on which eight sheet brass segments or points of contact *J* are arranged as in Fig. 2 to form the eight points of the compass. A ½-inch hole should be bored through the center of the table. To connect the vane to the table in order to form a circuit a small brass pulley wheel *I* is used; this can be bought at any hardware store. The wheel should be about ¾ inch in diameter and have a long wood screw on the end of the brass yoke in which it revolves. The wood screw must be sawed off so that a piece of brass rod 3/16 inch in diameter and 2½ inches long may be soldered on in its place at right angles to the yoke and in the plane of the wheel. An annular shoulder half an inch from the end and a thirty-second of an inch deep must be filed in one end of the short piece of brass rod, the other end of which should be soldered where the wood screw was cut off as stated above. The rod should be threaded as far as the shoulder and a nut procured to fit the thread (Fig. 3).

To make the reading instrument or indicator procure eight single magnets 1 inch long wound with No. 24 single cotton-covered copper wire, also eight screws ¼ inch longer than the taps in the magnets, and eight copper burrs with holes in them large enough for the screws to slide through easily. Now make a board for the magnets to be placed on 6 inches square and ¾ inch thick, and eight wooden blocks 1 inch square by ¼ inch thick. Drill a hole in each of the blocks large enough for one of the screws to go through easily.

Describe a circle with a diameter of 1¾ inches in the center of the 6-inch board, and draw lines in it representing the eight points of the compass, viz.: N, S, E, and W, NE, SE, NW, SW.

Lay the magnets *N* radially around this circle, as shown in Fig. 4. Now at the other end of each magnet nail the little blocks which are set up on edge, and secure each magnet in place with a screw which has been run through a burr, to prevent the head of the screw from sinking into the block. Now connect all the inside magnet wires to a main wire *P* extending around the board about ½ inch from the ends of the magnets. Bore nine holes through the 6-inch board, one at the end of each magnet and one for the main wire to go through. Place the board and magnets in a box *K* with a glass cover which will exactly contain them. Now make a small wooden cone, insert in it a small steel needle and place it in the center of the circle around which the magnets are arranged. A small arrow-shaped piece of steel *O* must be balanced delicately on the cone after the manner of a compass needle. A paper face 6 inches square with a hole in the center 1¾ inches in diameter may be placed over the magnets. This may be as elaborate as desired (Fig. 5).

Set up as per diagram, being sure that the weather vane is a foot above the roof, and away from all trees, buildings, chimneys, or other obstructions.

The main wire is soldered to the piece of brass tubing *B* and run to the batteries *H*. Thence a line *G* runs to the main wire *P* of the reading instrument *K*. A wire *L* should be soldered to each of the segments on the table *J*, and at the reading instrument should be connected with the corresponding magnet, i. e., the segment pointing north should be connected with the north magnet, etc. It will now be seen that if the weather vane points north it will turn the iron *C*, to which the brass wheel *I* is attached, to the north segment, thereby closing the circuit with the north magnet in the reading instrument. That magnet will become magnetized and will attract the steel needle around to it.

There are many valuable woods in Colombia. Where required, they are used locally, but difficulties of transport, and the phenomenal weight of some of the most useful kinds—e. g., guayacan and diomate—almost preclude export to other countries.

Correspondence.

Automatic Fire Valves.

To the Editor of the SCIENTIFIC AMERICAN:

With reference to article written by Mr. Frederic Bradlee Abbott in your issue of January 25, the writer cannot agree with Mr. Abbott for several reasons. First is that it has been positively proved that in a fire panic, persons have absolutely neglected to use any safety precaution, either for the safety of themselves or building they may be in, when a fire occurs. Depending on some one to turn a valve or allow water to enter the perforated pipes, as Mr. Abbott mentions, is out of the question.

In the second place, if the valve should be opened by a person, thousands of dollars of damage might occur before some one could get to the valve to close it. It would be left to the judgment of the occupants whether or not the fire might be of sufficient magnitude to warrant turning on the water and wetting everything in the building, and possibly causing ruin to the entire building. My opinion is that the sprinkler system, uncharged with water, is the safest and best protection that can be given for the immediate extinguishing of fire, together with the protection of lives and property. An automatic valve placed below the frost line or in the boiler room of a building, in connection with the sprinkler system, is in my estimation the best protection thus far afforded.

Chicago, January 24, 1908.

J. E. OSMER.

Hammer Blow of Poorly Balanced Locomotives.

To the Editor of the SCIENTIFIC AMERICAN:

I read with interest the retrospect for the year 1907 given in your valuable paper. The one that appeals to my mind as of the greatest importance, in relation to the unsafety of railway travel, was the special report of the Railroad Commission of the State of New York. The report says that in the winter months of 1907 nearly three thousand broken rails were removed from the tracks in that State alone. It seems to me that it is about time for the State to apply the remedy which is not far to seek. It has been shown from numerous experiments made by Prof. Goss that the counterweight in the locomotive driving wheels strikes a blow of 25 tons at each revolution—enough to break any rail under proper conditions of cold and frosty weather. They can remove at once this element of destruction, which is a relic of a prehistoric age, and make the conditions the same upon both sides of the center of revolution, thus eliminating this blow and bringing the locomotive into perfect balance. Who ever heard of a rail breaking under a locomotive at rest upon the rail? Neither will it break under a high rate of speed, if properly balanced; nor leave the rail by centrifugal force, as they frequently do without any apparent cause, leaving destruction all along the line.

Another reason for the removal of this relic of the past ages is the inefficiency of our locomotives produced by it. There are few machines that I have any knowledge of—in fact, I cannot recall any—whose transmission of power through frictional contact is as great as the locomotive engine. It is also well known that this contact must be constant to produce the best results. Let us look for a moment and see what occurs; in the downward movement of this counterweight we have the stress or blow; in its upward movement we have the lift from centrifugal force, a constant making and breaking of contact of the wheels with the rail, thereby losing its efficiency.

It is not only our locomotives that are off the track (owing to their construction), but our builders seem to think that with a tremendous boiler and cylinder capacity they have a tremendously powerful locomotive, without one thought as to the transmission of that power through the small frictional contact. The earning power of the locomotive lies in its contact of the wheels with the rail, and not in its boiler capacity.

In closing let me make a suggestion or two:

1. Balance up the locomotive and avoid that blow, and keep it in constant frictional contact, thus increasing its efficiency.

2. Reduce the size of the locomotives 20 tons and do the same work. This can be done if the friction is constant.

A locomotive constructed as I suggest will be much more safe at high speed, and there will be a great many less broken rails and accidents.

HENRY F. SHAW,

Mechanical engineer of the old school.

176 Corey Street, West Roxbury, Mass.

[Much attention is being paid to the question of locomotive balancing. The best results have been obtained by the use of four cylinders, with the adjoining cranks set in pairs at 180 deg. There can be no doubt that insufficient or intermittent adhesion, due to imperfect balancing, accounts for much loss of hauling power in some locomotives, when they are running at high speed.—Ed.]