inches in thickness. As the average car body ranges from 50 to 70 feet in length, it is difficult to secure any other kind of wood in such sizes free from defect. The timbers are reinforced on their inner surface with steel plates totalling about an inch in thickness and of the width and length of the timber; this gives about as great strength as if the beams were of hardwood. These sills, as they are termed, form the outside of the backbone and are connected by transverse beams of the same wood placed at frequent intervals and fastened to the sills with steel bolts. To give additional strength, however, bolsters are attached to the under side of the beams forming supports for the car when it rests upon the truck. In the center of each bolster, which is made of heavy casting, is a steel pin about 1 foot in length and 2 inches in diameter, which fits into an opening in the top of the truck and connects the two portions.

In addition to the framework referred to, truss rods ranging from 1 to 1½ inches in diameter extend the full length of the car, passing through the end sills. Under the center of the framework is placed a partition of timbers, under which the rods are stretched. This forms a sort of bridge, and allows the rods to be tightened at the ends by the use of nuts and washers. Four are placed under each car and serve to distribute the weight more equally, preventing any bending at the center; the trusses are further reinforced by short rods extending across the car bottom at regular intervals.

With the foundation completed, the work of building the sides begins by setting the upright posts. Those at each corner are of steel, and they are so connected at the top that the end of the car is really a steel arch. At the sides oak or ash posts are used, and they are so reinforced and bolted together that a strain on any part is shared to a great extent by the entire skeleton of the car. Every joint is fastened with a bolt and a nut and practically no nails or spikes are used. This is true to a large extent of every part of the car, glue taking their places in the lighter work. As soon as the main uprights are in place, they are topped with heavy sills extending the length and breadth of the car and adding still further to the strength. The roof skeleton is built with the same degree of solidity.

The first operation in the interior work consists in laying the floors. The modern passenger coach has no less than three, which are required not only for strength, but also to inclose the steam and other indispensable pipes. The first floor, which is laid directly over the framework, is merely intended to cover it, and is composed of yellow pine planking fastened directly across the car body. Upon this are placed the pipes for steam, compressed air, water, and gas (if the latter is used for illumination). When the plumbers and gas fitters have completed their work the second floor is laid down to inclose the piping, but the strips are much narrower than those comprising the lower floor, and are laid diagonally from side to side, in order to give strength. Upon them is laid the top floor, the planking also being placed diagonally, but in such a manner as to cross that below it in the form of a letter X. It is partly due to this fact that passenger cars offer so much resistance in collisions. The invention of the vestibule, however, has been another safeguard in this respect, especially in the prevention of telescoping, while, as is well known, it is one of the greatest conveniences which have yet been invented to add to the comfort of the traveler. If a car is to be vestibuled, this addition is fastened to the platform while the interior work is in progress.

When the flooring is completed and the skeleton of the car body is fastened together, the work can be carried on very rapidly, for while the carpenters are inclosing the sides and putting on the roof, the machinists can be working underneath fitting the body with the air and other tanks, as well as the brake machinery. The siding of the ordinary day coach consists of two layers, of which one is usually poplar grooved and tongued and thoroughly seasoned so that it will fit tightly. With the siding put in place the door and window frames are set and the cornices placed in position. The roof skeleton is covered first with light wood, on which is fastened either tin or canvas.

With the completion of the roof the exterior of the car is ready for painting, and this is usually finished before the interior work is ended. Car builders believe in plenty of paint and varnish, and from ten to twelve coats are applied to the outside. As the first three or four coats are applied, each is thoroughly rubbed down with water and powdered pumice stone and another added. Recently compressed-air painting machines have been employed at some of the larger shops, the liquid being forced through nozzles and applied to the surface in jets, and this method has taken the place of the brush; but the finishing coats of varnish must be applied by hand, while the lettering, of course, is all done by specialists in this class of work.

As soon as the sides and roof are on the car, work on the interior begins. The finishing woods are attached directly to the skeleton timbers. Quartered oak, mahogany, yellow poplar, and cherry are frequently used in one car. They are coated heavily with varnish to protect them from the action of dust and cinders. Following this the lavatory cabinets are erected, and the heat registers, chandeliers, ventilators, windows, shades, and seats are placed in position. This completes the car with the exception of the tests and perhaps a few finishing touches.

As already stated, the car body is usually mounted on a platform so that the trucks can be run under it and attached in a very short space of time. While it is under construction the truck makers are busy in the machine shop connecting the springs with the truck frames and attaching the latter to the axles and wheels. The trucks are so nearly completed when ready to be put under the car body that but very little work with the wrench and hammer is needed to make the coach ready for service. While a large number of the ordinary passenger coaches are equipped with four-wheeled trucks, recently the tendency has been to increase the number of wheels to six, following the example of the Pullman car builders. The advantage of the six-wheeled truck is to distribute the weight of the car body over a larger area and gives it more even motion when under way; but one objection to the six-wheel truck is that it is far more expensive in proportion than the four-wheeler. The wheels principally used at present are composed of cast centers fitted with steel tires. Entire castings of wheels are no longer favored and the era of the paper car wheel has also about passed away for use on standard-gage railroads.

It is interesting to note that in constructing modern freight cars where wood forms the framework and outside, the method followed is very similar to that in passenger coach building. First the backbone or bottom frame is built of reinforced timbers of sufficient size to bear the load which the car is intended to carry when full. Upon the framework is erected the wooden skeleton, but usually only a double floor is laid instead of three, as the freight car carries so little mechanical equipment compared with the passenger coach. Of course, there is no interior finish, with the exception of a few coats of paint, but the sides and roof of the modern box car are built about as strongly as if they were intended to carry passengers. The majority are equipped not only with air brakes but hand brakes as well, as a double precaution in case of accident.

The cost of building passenger coaches has increased rather than diminished with the progress which has been made in their design owing to the additional work which is required, also the many valuable woods which are utilized in their decoration and finish, as well as the upholstering. The standard day coaches in service on the larger systems of the United States seldom cost less than $6,000 and may range as high as $7,500. They are heavy vehicles, weighing from 35 to 40 tons when ready for service. The majority can seat sixty passengers, but nearly forty more can be crowded into the remaining space if necessary. One of the principal expenses attending the construction of these cars is the steam heating, lighting, and sanitary equipment. These features alone represent an outlay of from $1,200 to $1,500.

AN APPARATUS FOR MEASURING THE EARTH'S SPEED OF ROTATION.

BY OUR BERLIN CORRESPONDENT.

The classical pendulum experiment made by Foucault has borne out the fact that the law of inertia is satisfied for a space devoid of rotation with respect to the fixed-star sky.

Since this experiment is impaired by errors which render it possible to attain approximate results only, even if the utmost care be taken, it seemed desirable to make further experiments. It is true that Foucault himself endeavored to check his results with an experiment on a gyroscopic device, but on account of their inaccuracy these tests failed to aid him. Prof. A. Föppl, while engaged in a theoretical investigation of the gyroscopic device designed by Mr. O. Schlick for diminishing the rolling movement of a ship, described in these columns, employed a similar improved apparatus for carrying out experiments in which Foucault could not attain precision.

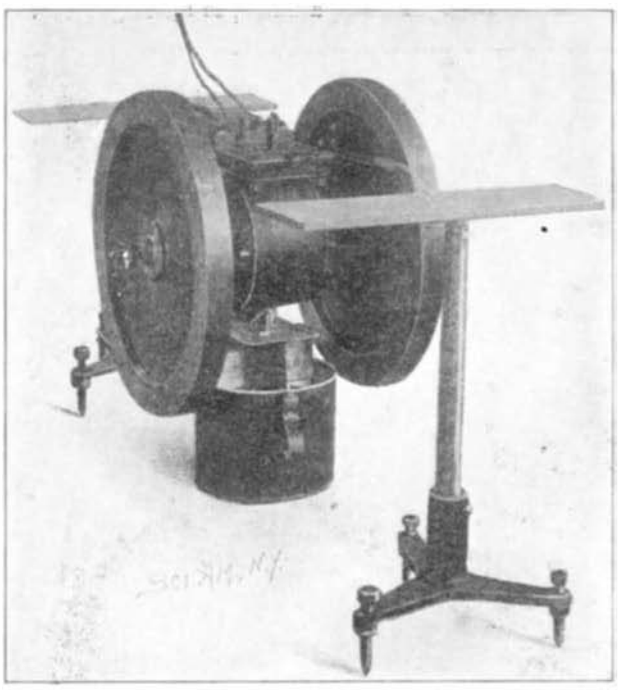


Fig. 1.

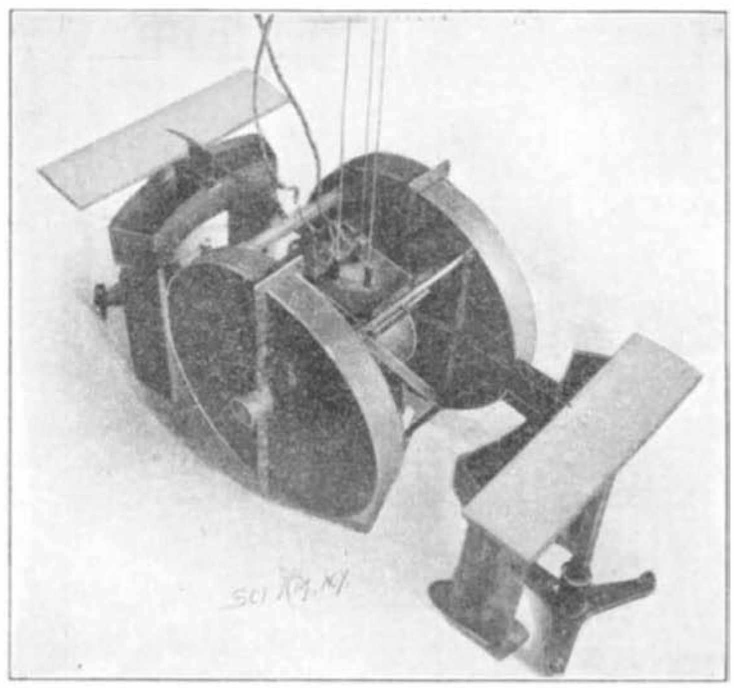


Fig. 2.

AN APPARATUS FOR MEASURING THE SPEED OF ROTATION OF THE EARTH.

As is well known, the deflection of the axis of a rotating top renders it possible to determine the speed of rotation of the earth, and any departure observed between the figure thus found and the astronomical earth rotation would contradict the results of the Foucault experiment. Moreover, there was the possibility of discovering a special influence of the rotation of the earth in the course of a gyroscopic experiment.

The apparatus designed by Prof. Föppl, as shown in the accompanying photographs, is a top consisting of two cast-iron flywheels, 50 centimeters in external diameter, each about 30 kilogrammes in weight and riveted to the other. These flywheels are mounted on the two ends of the shaft of an electric motor, having a speed of about 2,400 revolutions per minute. The motor is suspended by three steel wires from the ceiling of the room. The whole system can therefore rotate only about a vertical axis, and must overcome the resistance offered by the trifilar suspension. The motor is fitted with two crossed plates, dipping into an oil vessel placed below and serving to check the oscillations. On the top of the motor two indicators playing over scales may be seen.

In order to determine the speed of the top at any given moment, the wires leading to the armature are loosened from the external conductors and short-circuited by inserting the voltmeter, whereupon the electromotor will run for a short time as a dynamo and the angular speed of the armature can be figured from the voltmeter reading.

Experiments were carried out as follows:

The motor was started, speeded up to the desired point, and kept at constant speed for a quarter of an hour to half an hour. Since the top at the beginning of this period still had a certain precession velocity due to starting, it would oscillate very slowly (once in about 3 or 4 minutes) around the dead center. In order to ascertain that there had been no outside disturbance, the deflection of the indicator was read on both sides every minute, the mean value being plotted as ordinates with respect to an axis of abscissæ representing time. From this curve the position of equilibrium about which the oscillation occurs was ascertained.

The air current due to the rapidly rotating flywheel at first produced some disturbance of the oscillation phenomena. This was overcome by surrounding the rotating parts with a casing (see Fig 2). The top then began to perform quite regular precession oscillations, no departures between the astronomical earth rotation and that inferred from these terrestrial motion phenomena being noted. The minimum speed available for these experiments was found to be 1,500 revolutions per minute.

The theory of the experiment, as given by Prof. Föppl, in the Physikalische Zeitschrift (No. 14, page 419, etc., 1904), is simple enough, if the precession oscillation be at first left out of account. Let the moment of inertia of the rotating masses be denoted by θ, their constant regular speed by w, and the angular speed of the rotation of the earth (supposing that this agrees with the astronomical earth rotation) with u. Let further φ be the geographical latitude of the place of observation, ψ the angle formed by the equilibrium position of the rotating top with the east-west direction, and M the moment of the couple transmitted from the suspension to the top frame in a horizontal plane. M should be equivalent to the vertical component of the speed of variation of the impulse of the top due to the rotation of the earth. The speed of variation of the impulse of the top will be equal to the product of the impulse itself and the angular speed of the rotation of the earth, being considered as a vector. The following equation is obtained:

$$M = \theta\, w\, u \cos \varphi \cos \psi.$$

The moment of inertia is found by calculation to be $\theta = 26.7$ cm. kg. sec²; the geographical latitude was 48 deg. 8 min. 20 sec., and M practically proportional to the torsion of the suspended system with respect to the zero position when the top was at rest, thus equivalent to $c\ \chi$, χ being the angle of torsion, and c being 2.12 cm. kg.

The observations of the deflection of the top due to the rotation of the earth were relative only to the two cases when the zero position of the top at rest is either in the meridian or at right angles to it. In the first case there should be no deflection of the top's axis due to the rotation, provided the astronomical earth rotation also governs terrestrial motion phenomena. This was indeed brought out by the experiment.

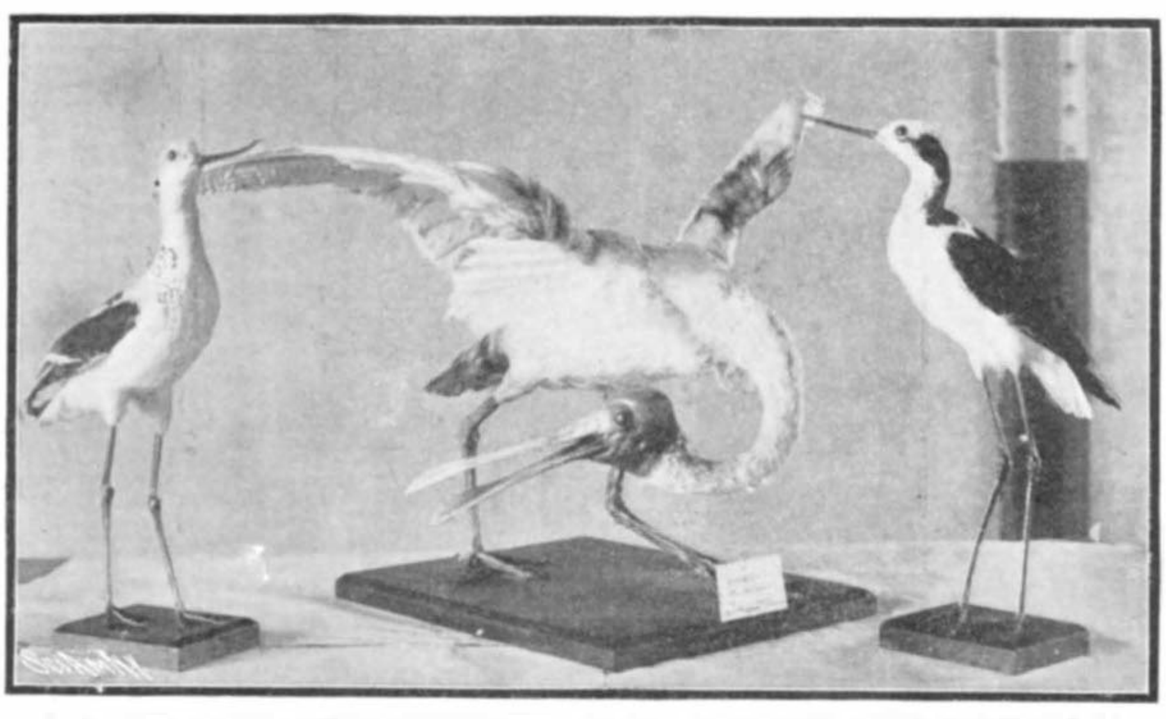
When the top's axis at rest is perpendicular to the meridian, the angle of torsion χ to which the moment M is proportional will coincide with the above angle ψ, the equation to be tested assuming the form:

$$c\, \psi = \theta\, w\, u \cos \varphi \cos \psi.$$

As an agreement within 2 per cent was found to exist between the angular speed of the rotation of the earth as derived from these terrestrial motion phenomena and the astronomical earth rotation, it seems likely that this agreement is as perfect as can be hoped. The experimenter hopes, however, to improve his apparatus and to ascertain whether some indications of possible departures are due to errors of observation.

Two Interesting Specimens in the Bird Collection of the Academy of Natural Sciences. On Left, Saddle-Backed Stork; on Right, Flamingo.

A Rare Pelican.



In the Center, a Roseate Spoon-bill of Tropical America; to the Right, a Black-Necked Stilt, the Longest-Legged Bird in the World for Its Size; to the Left, the Abocet.

A UNIQUE COLLECTION OF RARE BIRDS.

A UNIQUE COLLECTION OF RARE BIRDS.

BY HARRY DILLON JONES.

The Academy of Sciences of Philadelphia has always prided itself on possessing the most complete collection of birds in the world. Of late years Washington and New York have been struggling for supremacy in the ornithological world, and the Quaker City scientists have been quietly adding to their collection, in order to maintain the proud position allotted to them as long ago as 1857, when Dr. P. L. Sclater pronounced the collection of birds in the Academy of Sciences to be superior to that of any museum in Europe, and therefore the most perfect in existence. Prof. Witmer Stone, the famous authority on bird life, has about completed his work of cataloguing the collection in the possession of the Academy of Sciences, and about one-third of the specimens are now on exhibition in the museum of the institution. Two-thirds of the collection will remain in air-tight and light-tight cases, where they will be at the disposal of any scientist seeking to add to his knowledge of ornithological subjects. The reason these specimens will not be placed on public exhibition is that they are far too valuable to subject to the deteriorating influence of light and air. It has been found that about forty or fifty years is the duration of the life of specimens placed in cases for public exhibition. Those on exhibition therefore will be specimens of which there are duplicates or those that can be replaced without a great amount of trouble. The very rarest specimens will not be allowed to see the light of day unless the curator of the museum is asked to show them.

Among the rare specimens is one of the great auk, and one of the eggs of that famous bird. The eggs are even rarer than the birds, for according to Prof. Stone there are only two in America, and a valuation of $500 to $600 is placed on them by collectors. Another rare bird of which there is a specimen in the collection is the Labrador duck. This bird is even more difficult to find than the great auk, for there are not more than forty-two specimens, according to Prof. Stone, in the world. The Sandwich Islands have been hunted over for rare birds, and quite a number of specimens have been brought to the Academy of species that will soon be extinct because of the onslaughts on the forests of the islands and the consequent killing off of the birds of the district. One specimen in the possession of the Academy is absolutely unique, Prof. Stone being unable to give it any name, so extremely rare is the species. It is a bird very similar in appearance to the common American warbler, but has distinctive features that place it in a class by itself.

That exceedingly shy and scarce bird, the flamingo, is represented by some handsome specimens in the cases at the Academy. Once they were not particularly rare in America, but now there is practically only one flock of them, which is seen by venturesome explorers in the southern part of Florida. The specimens at the Academy were bagged in the Bahamas, where they are still living in sufficient numbers to be found without a long search. The few persons who have tracked these great birds to their haunts have found that they build big nests in uniform rows along the ground. While the female bird is sitting on the nest, the stately male mounts guard by her side. The sight is a remarkable one when an entire flock is seen in this pose.

Among the pelicans of the collection are some from Florida, where they are becoming daily more scarce because of the demand for their plumage for millinery purposes. So far have the birds decreased in numbers, that the United States government has taken a hand in the hunt, and has established a pelican island on the east coast of Florida, as a permanent reservation for the birds, where they can live free from fear of the hunter, and save themselves from extinction because of the greed of the feather collector. At one time the pelican, with his huge bag beneath the beak in which he stored fish for the young, was to be seen as far north as Sandy Hook. Now it is necessary to go to Florida to find him. But for the government's thoughtfulness in setting apart an island for his use, the pelican would probably soon be extinct.

A pheasant with the most wonderful wing development of any of the