what may prove to be new species of fishes, certainly new to Minnesota; collected a great many insects, some of them new, and a number of reptiles. Besides these, extensive data were secured concerning a number of fishes, valuable histological and embryological material was preserved, and a number of anatomical preparations were made. There is no better way, it seems to me, to study the fauna and flora of a river than by such a floating laboratory, and I wish to strongly commend the plan to any persons who are considering plans for such study.

The Megalops now lies anchored at Red Wing Minnesota, on the Mississippi River, and it will likely continue on down the river the coming season, after which it may become a part of the equipment of a permanent biological laboratory on the Mississippi, which it is hoped will soon be established by the University of Minnesota.

Tests on Some Ball and Roller Bearings.

By M. J. Golden.

These tests were made to determine the comparative friction of ball and roller bearings when used for shafts under ordinary shop conditions, so the simplest forms obtainable were used, and they were tested at such speeds as usually occur in shop practice. When used in shop practice two or more of these bearings are placed side by side and in this way an ordinary hanger or other such piece of apparatus is built up. In the test the unit of the maker was taken for the size tested and no effort was made to establish any relation as to comparative sizes.

The bearings selected were for shafts one and fifteen-sixteenths inches in diameter, and as the shaft turns in direct contact with the rollers, the spindle used was a piece of regulation, cold-rolled, shop shafting of this size. This piece of shafting broke down before the bearings were affected. The ball bearings, of which three were used, were of the form shown in fig 1. In this figure the full form for a shaft is shown. In the test the bearing at one end was used. This consists of an inner ring of case-hardened steel fitted closely to the shaft and having a V groove cut around the outside. The balls travel between this groove and a corresponding outer groove. The sides of the outer groove are separate rings that are held in a frame, one fixed and the other adjustable by means of a screw thread cut on the inside of the frame, and a corresponding one cut on the outside of the ring. Adjustment of the bearing to the balls is gotten by means of this ring. This gives a four-point bearing in which the balls travel in planes perpendicular to the axis of the shaft. The balls were .5 inch in diameter.

The roller bearings used were of the form shown in fig. 2, in which, however, is shown a bearing having four sets. In the test, only one set

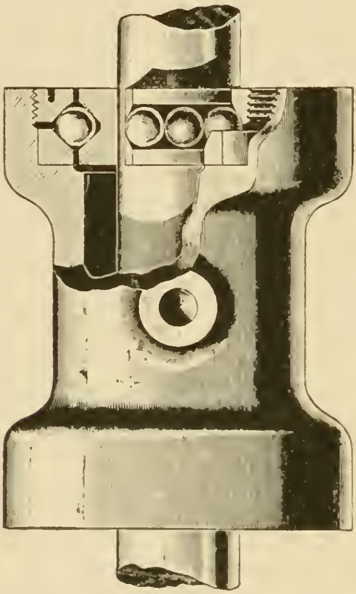
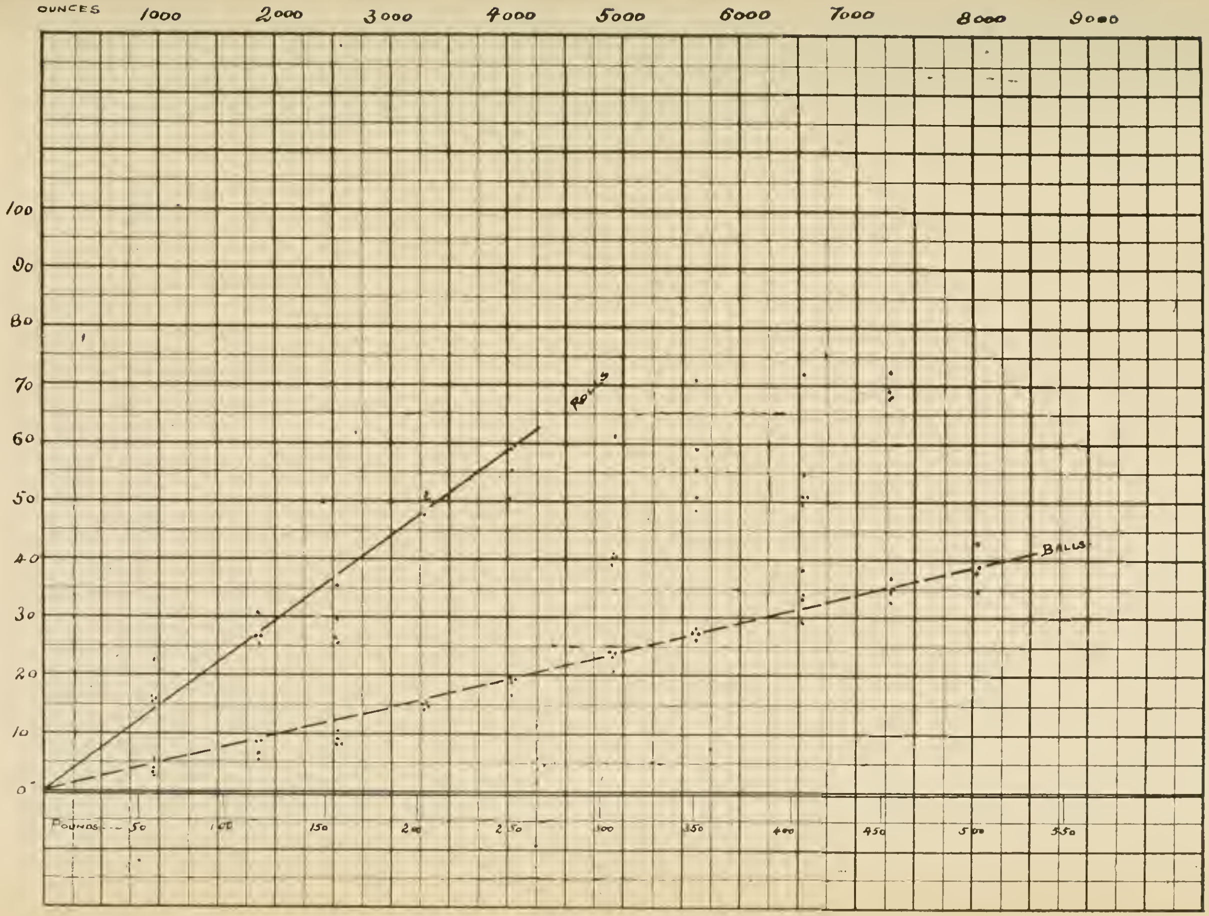


Fig. 1.

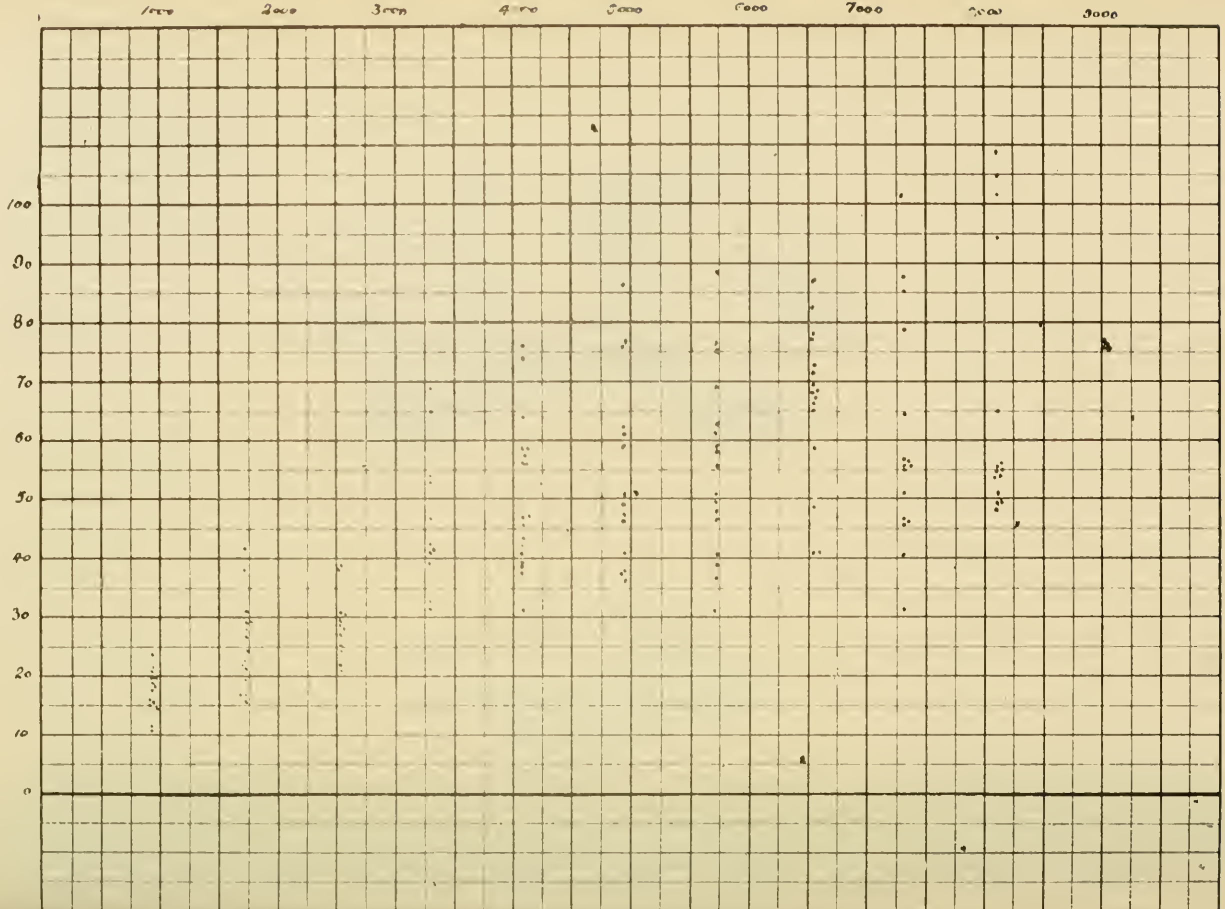
Fig. 2.

was used, as this was the unit in building the bearing. This consists of a cage holding fourteen small rolls, of hardened steel, each .315 inch in diameter and .625 inch long. These are separated from one another in the cage by brass bars. During the operation of the bearing the only friction between the cage and rolls ought to be that induced by the weight of the cage. It was found that the heavier loads caused the cage to become badly worn where there was contact between the ends of the rolls and the cage. The cage and rolls are held in a cylinder of steel that is carefully bored,


OUNCES
1000
2000
3000
4000
5000
6000
7000
8000
100
90
80
70
60
50
40
30
20
10
0
POUNDS
50
100
150
200
250
300
350
400
450
500
550
BALLS

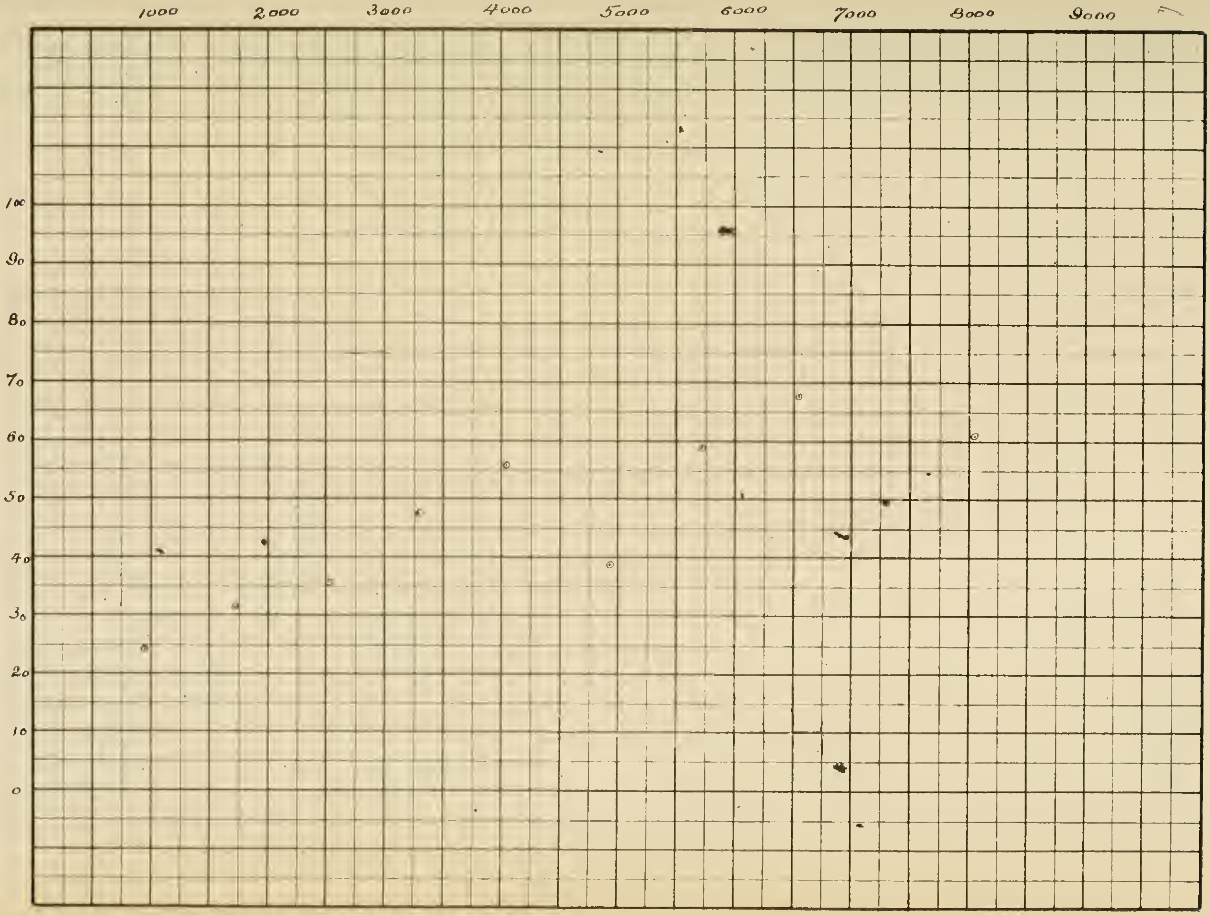
Sheet 2

Roller Bearing Test



Sheet 3-

Roller test... Speed = 1600 R.P.M



then case-hardened and ground. No further grinding or other treatment to produce a greater degree of accuracy was given to any of the bearings used. Four tests were made at each of four speeds for every load, so that sixteen tests were made for each load. With some of the roller-bearing tests, where the results varied markedly, a greater number were made. In the curve of tests showing the comparative friction, each point is the average of four tests, so the position of the line is the result of sixteen tests. The loads were varied from fifty pounds to five hundred pounds. It was found that while the friction increased with the load in a nearly constant ratio for the balls, for the rolls there was a great variation at and after three hundred pounds. This is shown by the points on sheet 2. An examination of the shaft showed that it was being torn away in small flakes under the 300-pound load, and this tearing increased as the load was made greater. At 500 pounds the shaft was torn away quite rapidly, especially at the higher speeds, and after a few minutes' operation, a ridge was formed on the outside edges of the path of the rollers. This ridge had to be filed down on one side before the cage and rollers could be removed from the shaft. Neither the rolls nor their hardened steel race were affected, though, as already mentioned, the sides of the cage were cut by the ends of some of the rolls. Of the fourteen rolls in one cage, this wearing occurred at both ends of four of them. In making measurements on the dynamometer, a scale reading to fractions of ounces was used, so in plotting curves the unit used was the ounce.

The diagram of the friction curve for the roller bearings shows the points for the measurements taken at each load to be within spaces that increase slightly until the 250-pound load is passed, when the spaces between points increase in such manner as to show that the pull on the scale was due to more than the friction. It will be seen, however, that most of them seem to fall below the line made by the curve up to that point, if the line were produced. The points were so distributed that a curve drawn through the average position would not mean much. Why they fell so low in some cases I was unable to determine.

The diagram for the friction of the ball bearings shows the points within small spaces up to the 500-pounds load. How much farther this would continue with the kind of bearing used I did not determine, though I found on another test made on smaller balls and bearings, that both balls and bearings began to pit soon after the load exceeded 500 pounds, and that this pitting was very marked at 700 pounds. The small pieces torn from the balls and races were very different in shape from the flakes torn from the shaft by the rolls.

The diagram giving a comparison of the friction line of the two kinds of bearings shows the friction of the roller bearing to be more than twice as great as that of the ball bearing. Calculations from the figures taken during the tests gave the co-efficient of friction for the ball bearings used to be .00475, or less than one-half of one per cent., while that for the roller bearings was .014, or nearly one and one-half per cent. I have no doubt that if the shaft used was of steel, hardened and ground, as the rest of the parts were, that the friction would be reduced. As the shaft was torn by the rolls, new parts were brought into contact and a marked drop of the pull occurred.

Bearing-Testing Dynamometer.

By M. J. Golden.

In making some tests to determine the amount of power lost by friction in different forms of shaft bearings, so much trouble was experienced in separating the loss in other parts of the apparatus used from that in the part being tested, when the regular transmission type of dynamometer was used, that the apparatus described here was devised for that purpose. It was tried in various forms experimentally before the present form was adopted. One of the rougher forms was described here last year in connection with a report then made on some bearing tests. In such tests the whole friction is so small that it is difficult to separate the friction due to the part being tested from that of the rest of the apparatus.

The machine as now used consists of a cast iron frame, made heavy enough to be stiff and to absorb a large portion of the vibration due to the rapidly moving parts. To the top of the frame is bolted a cast-iron table with planed surface. On this table are bolted two carriages, shown in the illustration at (a), that are fitted with ball bearings, in which a spindle or shaft revolves. These bearings are used because of the ease of alignment with them, and by fastening a set collar on each side of