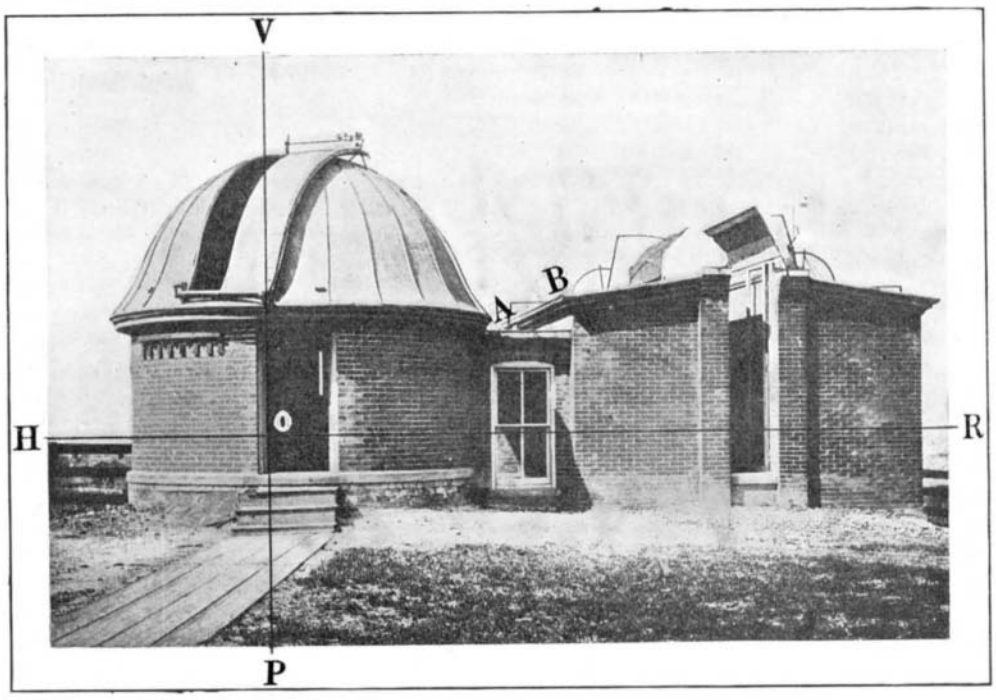
WHERE WAS THE CAMERA SET UP?

BY WILLIAM F. RIGGE, S. J.

In a former issue of this journal (September 24, 1904) I solved the problem as to *when* this photograph of the Creighton University Observatory (at Omaha, Neb.) was taken. In the present one I wish to find *where* the photograph was taken from, that is, to determine the exact spot at which the camera was set up. The solution of this problem is much easier than that of the first, and that in practice as well as in theory.

There are in general, I might say, two methods of solving the present problem, the physical and the mathematical methods. The physical method would consist in walking toward or away from the building, and by a careful scrutiny of the view it presents to the eye, to find the spot from which this view is identical with that shown on the photograph. This method might be capable of giving very good results. But as its principles are not evident, there is nothing to be learned from it. Moreover, the solution it offers would become impossible, when this access to the building for some reason or other becomes impossible.

The mathematical method makes use of the principles of perspective, and obtains its results from a few simple measurements executed upon the building and upon the photograph. In case it should be impossible to obtain these measures from the building itself, its plans, elevations, or at least the necessary specifications, must be supposed to be obtainable. To explain this mathematical method is the purpose of the present article.



WHERE DID THE PHOTOGRAPHER STAND WHO TOOK THIS PICTURE?

We begin our attack upon the problem by determining the position of the horizon line, *H R*, upon the photograph, that is, of the line which is on a level with the camera. As the equatorial room of the Observatory is circular in shape, each horizontal row of bricks and each mortar line is in reality a circle. But as the eye, or the camera, can be on a level with, or in the plane of, only one of them, this one alone must appear on the photograph as a straight line, while all the rest must appear to be more or less curved. For this reason the horizon line, *H R*, must not only run perfectly straight through a row of bricks or a mortar line across the whole building and across all buildings, whatsoever their shapes may be, shown on the same photograph, but it is also the only line that can be so drawn. In our case this horizon line runs through the middle of the seventh row of bricks above the water table of the equatorial room. Measurement upon the building then shows that the camera was 18⅜ inches above the level of this floor.

By the principles of perspective, all lines parallel to one another in space will meet, if produced upon the photograph, at a certain definite point, called the vanishing point. If the lines are horizontal, this point must be on the horizon line, *H R*. As we wish to find the distance the camera was set up in front, or south, as well as east or west, of the building, we select the horizontal lines running north and south. Unfortunately, the present photograph has only one such line to offer, but that one is well defined, and it is amply sufficient for the purpose. This is the line *A B*, the west edge of the roof of the transit room, the edges of the transit shutters not being judged sufficiently reliable for the present determination. We produce the image of the line *A B* on the photograph until it intersects the horizon line, *H R*, in the vanishing point, *O*, through which the vertical line, *V P*, may then be drawn. It is plain that the line drawn from the camera to the point, *O*, is also horizontal and due north and south and projected into the point, *O*, itself. Hence, if we measure the distance of the point, *O*, almost at the very edge of the door frame, from the middle of the door, which is due south of the center of the equatorial room, we can determine how far the camera was set up west of the center of the dome. This measurement may be executed either upon the door itself or upon its image on the photograph, since we know that here the scale gives us 18⅜ inches as the distance from the horizon line, *H R*, to the water table of the building. The result is that the camera was set up 15¼ inches west of the center of the dome. This is therefore our second co-ordinate.

The next part of the problem is to determine the distance of the camera from the front of the building. Let us imagine a plane drawn in space through the edge of the roof, *A B*, and the point, *O*. This will give us Fig. 2. *D* is the camera, that is, the optical center of its lens. *O* and *B* are the corresponding points *O*

How the Distance of the Camera from the Front of the Building was Determined.

and *B* on the photograph. *C* is the true place in space of the point, *A*, that is, of the north end of the edge of the roof, and *A* is its apparent place as seen on the photograph. The plane of the photograph is perpendicular to the line *O D* at the point, *O*, and hence *O D* is the distance due south of the optical center of the lens from the south end of the edge of the roof, *B*.

In Fig. 2 we have two similar triangles, *A O D* and *A B C*, and hence the proportion:

$$\frac{AO}{AB} = \frac{OD}{CB}, \text{ whence } OD = \frac{AO}{AB} CB.$$

As the ratio $\frac{AO}{AB}$ is the same on the photograph as it is on the building, the problem is thus very much simplified in practice, since all we need for its solution are the length of *C B* measured on the roof, and the lengths of *A O* and *A B* measured on the photograph on any scale whatever. The edge of the roof, *C B*, was found to be 17 feet 10¼ inches, and *A O* and *A B* on the photograph were found to be 11.31 and 2.96 respectively on a scale of fifths of an inch. Hence by proportion *O D* is equal to 68 feet 2¼ inches. As the cornice overhangs 7¾ inches, the distance of the optical center of the lens from the south front of the transit room was 68 feet 10 inches. By additional measurement we find that the camera was set up 72 feet 7 inches south of the center of the dome, which is the third co-ordinate, or 64 ft. 7 in. south of front door.

We can now also find the focal length of the lens. Knowing that twenty-five bricks at the front door measure 72¼ inches in reality and 1¼ inches on the photograph, we see that the photograph reduced the size of this object 57.8 times. Then on Fig. 2, where the triangle, *D E F*, has been enlarged ten times, we have a proportion similar to $\frac{AO}{EF} = \frac{OD}{DE}$, that is, we divide the distance of the camera by 57.8, and get $ED = 13.47$ inches as the effective focal length of the camera for this photograph. Erecting a perpendicular 13.47 inches long to the plane of the original photograph at the point, *O*, we are in a condition to reconstruct the whole observatory in all its three dimensions.

The solution presented in this article supposes that the plane of the photograph, the picture plane as it is called, was parallel to the front of the observatory, that is, at right angles to the line running from the camera to the point, *O*, instead of to the center of the picture, that is, the point half-way between *H* and *R*. As the latter position is the usual one for a plate, and was therefore most probably the actual one in this instance, the picture plane made an angle of about 8 degrees with the front of the observatory. Hence, all lines parallel to *H R* were shortened very nearly in the ratio of the cosine of 8 degrees, that is, about one per cent, a quantity too small to affect the results.

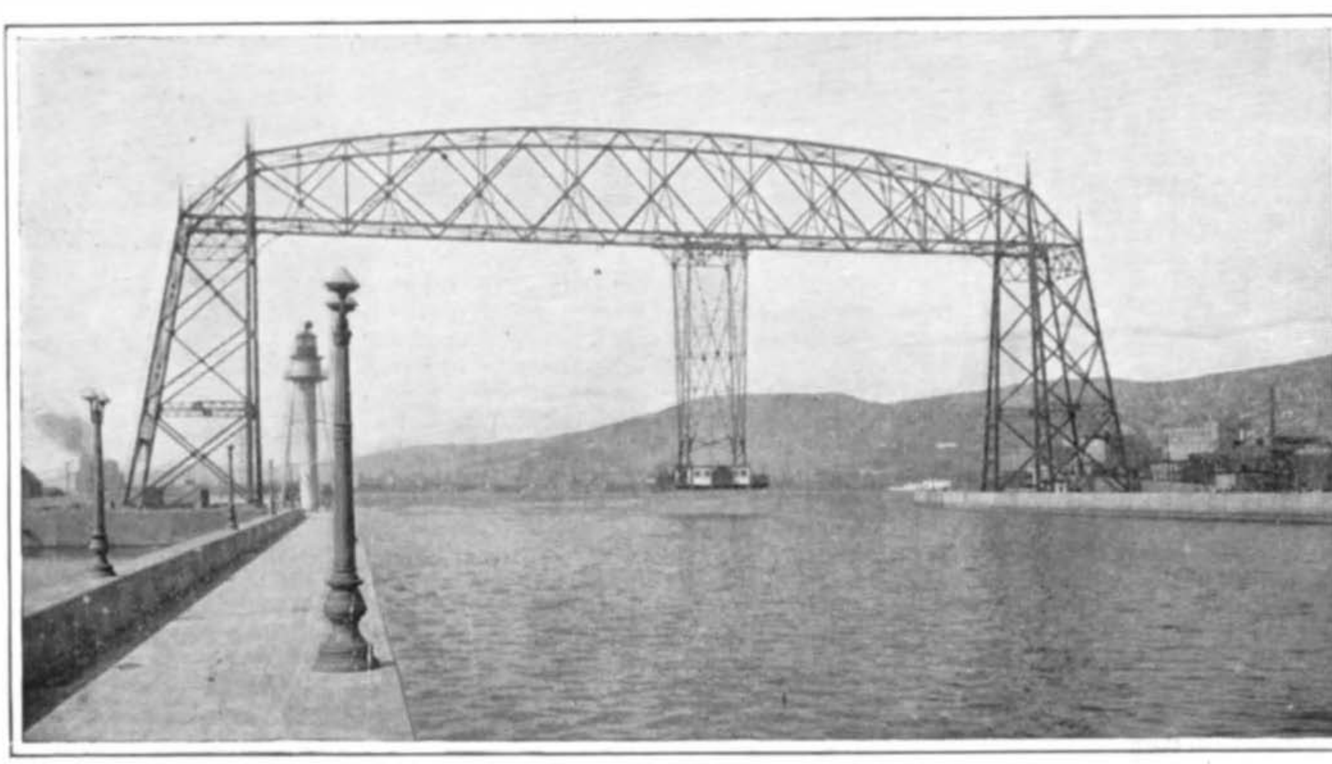
AN ELECTRICAL AERIAL FERRY.

BY FRANK C. PERKINS.

The aerial ferry at Duluth, the first structure of its kind in this country, has been completed and is now in operation.

The suspended ferry car has a normal speed of about four miles per hour, but the electrical motors and driving equipment are capable of propelling the car at twice that speed should it become desirable, and the passage of the canal can be made by the suspended ferry car in slightly over one minute.

There are two electric motors, each of 50-horse-power capacity, located under the floors of the car. These electric motors operate two drums, each of which is 9 feet in diameter, and on these drums are wound cables 1 inch in diameter, extending to the truss and then over idle wheels 9 feet in diameter through the inside of the lower chords to tower, where they are fastened, and thus produce the motion which causes the car to travel across the canal.



THE RECENTLY COMPLETED AERIAL FERRY AT DULUTH.

The canal was adopted by the United States government about four years ago, increasing its width from 240 to 300 feet, and constructing permanent piers of cribwork and concrete. Minnesota Point was converted into an island by the opening of the canal, and the city accepted the responsibility of providing the inhabitants with adequate communication with the mainland. A rowboat ferry was first maintained, and finally a steam ferry for the transportation of passengers and freight across the canal was substituted.

The imperative necessity of better communication with the Point at a less cost than was being paid for the steam ferry service resulted in the inception of the aerial bridge scheme.

The idea of the aerial bridge over the Duluth ship canal was received with favor by the United States War Department, and a bond issued by the city of Duluth for the amount of $100,000, the estimated cost of the structure, was sanctioned by the State legislature, and approved by the citizens, and a general specification and contract was prepared and let for the erection of the bridge about four years ago.

A most ingenious arrangement of the track has been provided to carry the car and hangers. It is inclosed on three sides within the box section of the lower chord, and therefore there is no danger in the winter of its becoming coated with sleet or snow. Within the chords there are four rails, two in each, with thirty-two wheels arranged in pairs rolling on the rails and carrying the truck, eight pairs of wheels being employed on each lower chord. The friction of all the working machinery is reduced to a minimum, as the bearings of these wheels as well as those of the drums and idlers are of the roller type. It is stated that the cost of operation of this electrically-operated aerial ferry bridge will not exceed $7,500 per annum, including the interest on the bonds, which will result in a saving of one-third the cost of the steam ferryboat service previously mentioned.

The four principal piers nearest the canal rest on grillage, which is secured on the tops of pilings, driven 35 feet below the level of the lake, while in the foundations of the bridge there are 730 tons of concrete in the eight piers which extend below the water level of Lake Superior. The towers are held in position by twenty-four anchor bolts, each of which measures 2 inches in diameter, and fastened by large washers to the bottom of the pier. There is a clear height above the ordinary stage of Lake Superior of 135 feet, the height of the bridge being fixed by the Lake Carriers' Association to permit the passage of the highest masts. The total height of the highest part of bridge above the water is 186 feet, and the depth of the truss at the center is 51 feet, while the width center to center of the trusses is 34 feet, the clear span being 393.75 feet.

It is stated that the car will carry a loaded double-truck street car, 350 passengers, and two loaded wagons with teams, which is equivalent to about 63 tons, with perfect safety. The car platform measures 50 feet long and 34 feet wide, and contains two inclosed cabins finely finished, 30 feet long and 7 feet wide, in addition to the space for two wagons and a street car. The bottom of the car is elevated above the United States government piers a height of 6 feet, and it rests entirely overland when at rest at either end of the bridge, so that there is no obstruction or menace in any way to navigation. In the construction of this bridge 1,400,000 pounds of steel were required. Before the last 45-foot piece of steel was to be placed in position, it was found that the opening was 3 inches too narrow. The workmen stood guard with tape lines at a height of 135 feet, while both halves of this massive structure were tilted back to enlarge the opening.

Opening of Lewis and Clark Centennial Exposition.

The Lewis and Clark Centennial Exposition was telegraphically opened by the President of the United States. There were present representatives of the State of Oregon, House of Representatives and Senate, the army and navy, and various Western States.

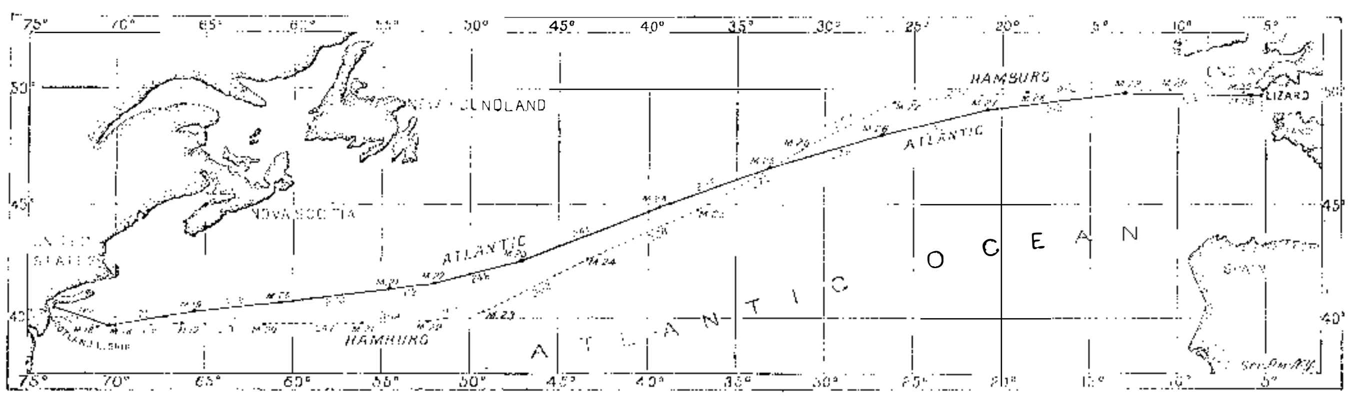
The prelude to the actual opening ceremonies consisted of a military parade, a pageant of federal and State troops, led by Vice-President Fairbanks, the Congressional party, visiting governors, and other dignitaries and the exposition officials.

Portland is rather hurrying her celebration. Lewis and Clark did not come out upon the Pacific coast until November 7, 1806, so that the fair is opened more than a year ahead of time. The Lewis and Clark expedition was the necessary sequel and corollary of the Louisiana Purchase. That purchase carried the western boundary of the United States to the summit, the watershed, of the Rocky Mountain range.

THE FINISH OF THE OCEAN YACHT RACE.

From whatever point of view we look at it, the ocean yacht race for the cup presented by the German Emperor must be regarded as a brilliant success. Not only was the record for the eastern passage broken, but the winning yacht also broke the record for the longest day's run. The "Atlantic" won the Emperor's cup in brilliant fashion, crossing the ocean in 12 days, 4 hours, 1 min. in spite of the fact that she was subjected to an exasperating delay by running into what was almost a flat calm near the finish, in which she took eleven hours and forty-one minutes to sail forty five miles. Had the wind held true, so that this last stretch could have been sailed at her average speed of 10.5 knots per hour, she would have made the run in 11 days and 21 hours. As it was, the performance is an extremely brilliant one and reflects the greatest credit on her talented designer, Mr. William Gardner, of this city, and upon Capt. Barr, of "America" cup fame, who was engaged specially for the race. The single day's run of the "Atlantic" of 341 miles made on May 24 is, indeed, a most extraordinary performance, for she thereby surpasses the previous record of the schooner "Dauntless," made in 1887, by thirteen hours. As the yacht was sailing against the sun, the time from noon to noon was, of course, less than twenty-four hours, and her average speed works out at over 14½ knots an hour. The best previous record over the course sailed by the "Atlantic" was that of the "Endymion," which in favorable winds sailed from Sandy Hook lightship to the Needles in 13 days, 20 hours, and 36 minutes. The "Atlantic," after passing the stakeboat at the Lizard, sailed on to Southampton, which she reached on the afternoon of May 31, well within the "Endymion's" figures.

We stated in our description of the start of the race that the positions of the yachts a few hours after the gun were probably prophetic of their positions at the finish, and with the exception of the "Ailsa" and "Valhalla," which have changed places, this proved to be true. The "Ailsa," which was first over the line, seemed, after a couple of hours sailing, to hold the third position with ease. But she evidently could not compete with the more sturdy cruisers under their own conditions, and fell to the rear, while the "Valhalla," which started something like an hour behind her competitors, surprised the yachting world by working her way through the fleet and finishing in third place.



Won by the "Atlantic" in 12 Days, 4 Hours, 1 Minute, Which is the Record for This Course.

COURSE SAILED BY THE "ATLANTIC" AND "HAMBURG" IN THE OCEAN CUP RACE.

The performance of the single German entry, the schooner "Hamburg," was exceedingly meritorious, as will be seen by a comparison of her log with that of the "Atlantic." Although the full log, giving the weather encountered by the two yachts, is not yet available, a dispatch sent by one of the guests on the "Atlantic" shows what splendid work the "Hamburg" was doing during the first day of the race. It seems that about half-past five o'clock on the evening of the 17th, and in a freshening wind and roughening sea, the "Hamburg" was about a third of a mile astern of the "Atlantic" and "holding on like a bulldog." By six o'clock she had gained until she was just abeam, and had weathered the port side of the American yacht. "Every stitch of canvas was set that could be spread and sheets trimmed flat. The water was boiling in our lee scuppers," says the same authority, "and the crew in oilskins and sou'westers were lying close up to the weather rail. We felt then that it was nip-and-tuck." At nine o'clock the "Hamburg" was a third of a mile to windward and a little ahead, from which it is evident that to windward, in a roughish sea, the Watson schooner proved rather more than a match for the "Atlantic." As soon, however, as the wind drew around to north and west, and sheets were started, the greater length and large sail spread of the American boat began to tell, and as the logs of the two vessels show, the "Atlantic" drew steadily away from her German rival and made steady gains to the end of the course. The first day out the "Hamburg" ran 142 miles, the "Atlantic" 166 miles. The second day the "Hamburg's" run was 216 knots, that of the "Atlantic" 212 knots. With the exception of the 22d, on which the "Atlantic" encountered light airs and a period of calm, making only 112 knots, her day's runs were all between two and three hundred knots; and on three days she made respectively 308, 313, and 341 knots, this last being the world's record. The "Hamburg" also on three days exceeded 300 knots, making 303, 306, and, on the 29th, 312 knots in the twenty-four hours. The "Hamburg" sailed the longer course, and this is due to the fact that while the "Atlantic" followed approximately a great circle starting from latitude 42 north, the "Hamburg" held a more southerly course, probably to avoid the ice, being in longitude 50 about 120 miles to the south of the course sailed by the "Atlantic," then crossing that vessel's course, until in longitude 26 she was about 80 miles to the north of it.

Although for the greater part of the race the yachts had a fair wind and were sailing with started sheets, they seemed to have experienced every variety of weather from a calm to a full gale. On the "Atlantic" on the day when the great run of 341 miles was made, reefs had to be tied down, as the wind steadily increased to a gale, and on the following day oil bags had to be put over the bow to keep the seas from breaking aboard. The ship made excellent weather, although the foam was knee-deep at the wheel. On May 26 a whole gale was blowing; two steersmen had to be lashed to the wheel to keep them from being washed away and three oil bags were carried over the starboard side. The "Atlantic" finished at 9.16 P. M. on May 29, the "Hamburg" at 7.22 P. M. on May 30, and at eight minutes past eight on the following night, May 31, the full-rigged ship "Valhalla" passed the finish line. Her time for the whole voyage was 14 days, 2 hours and 53 minutes. She was followed an hour and a half later by the schooner "Endymion," whose time was 14 days, 4 hours and 19 minutes. Close at her heels came the "Hildegarde," 14 days, 4 hours, and 53 minutes; then the "Sunbeam," 14 days, 6 hours, 25 minutes, and the "Fleur-de-Lys," 14 days, 9 hours and 33 minutes. The yawl "Ailsa" finished on the morning of June 1, at 4.25 A. M., and she was followed by the three-masted auxiliary schooner Utowana at 5.06 A. M. The "Thistle" crossed the line at 12.44 P. M. on the same day. The last to finish was the big bark "Apache," which evidently did not meet with winds strong enough to suit her very moderate rig.

A new variety of sweet potato having great economic value has been acclimated in the experimental gardens of Bordeaux. It is a native of Dahomey and very prolific. The leaves of the plant can be used as a substitute for spinach, and the tubers, containing a higher percentage of sugar than beets, are fine flavored and make exceptionally good food for live stock. At present the authorities have only a limited quantity of tubers, and as these are to be used wholly for reproduction it will not be possible to obtain samples for American experimenters until next year. A few hundred "sprouts" have been distributed among French agriculturists. A box containing ten of these "sprouts" has been placed at the disposition of the American consul, as the representative of the Smithsonian Institution, but as the young growths are extremely fragile and very susceptible to changes of temperature it is feared they may not survive transit to the United States, however well they may be packed.—Albion W. Tourgée, Consul, Bordeaux, France.

A New Tool Steel.

A new tool steel has been placed on the market by a firm of Sheffield makers. Among its advantages it is stated that for hardening the steel only requires to be heated to a bright red, and allowed to cool in the air, when it is ready for use. It can be reannealed, according to the makers, simply by heating the tool to a cherry red, allowing this to become a dark red, and then plunging into water. It then becomes quite soft. In a test with twist drills, this steel drilled 49 holes in steel of 0.49 per cent carbon, each 1.53 inches diameter and 1⅞ inches deep, at an average speed of 25 seconds each, and after the test was still in good condition.

Erratum.

Through an error the article published in the Scientific American for May 27 on "Placing of Printed Matter on Finished Lantern Slides" was credited to Mr. J. A. Honeking. The author of the article is Mr. J. A. Stoneking.