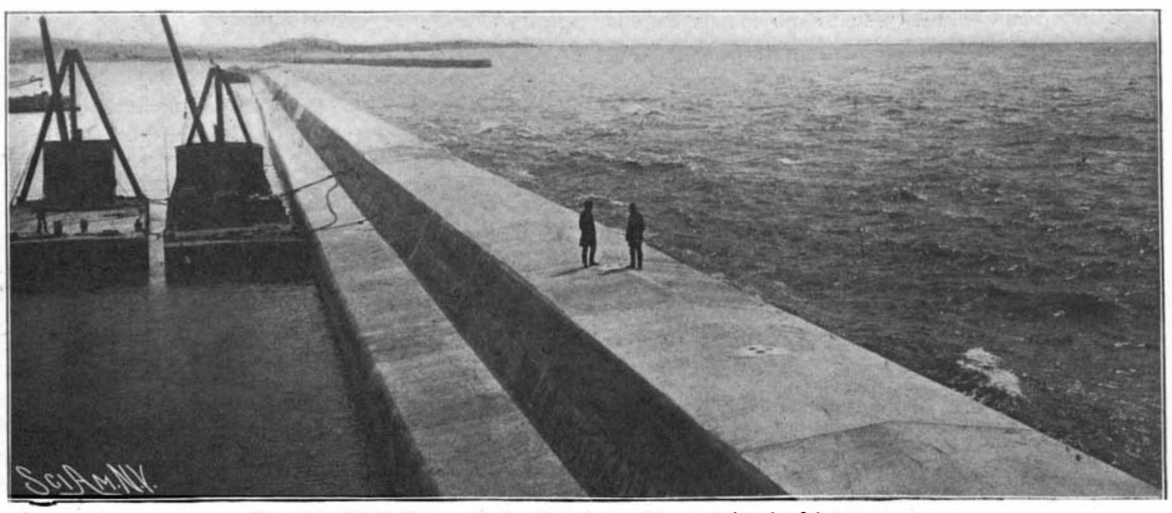
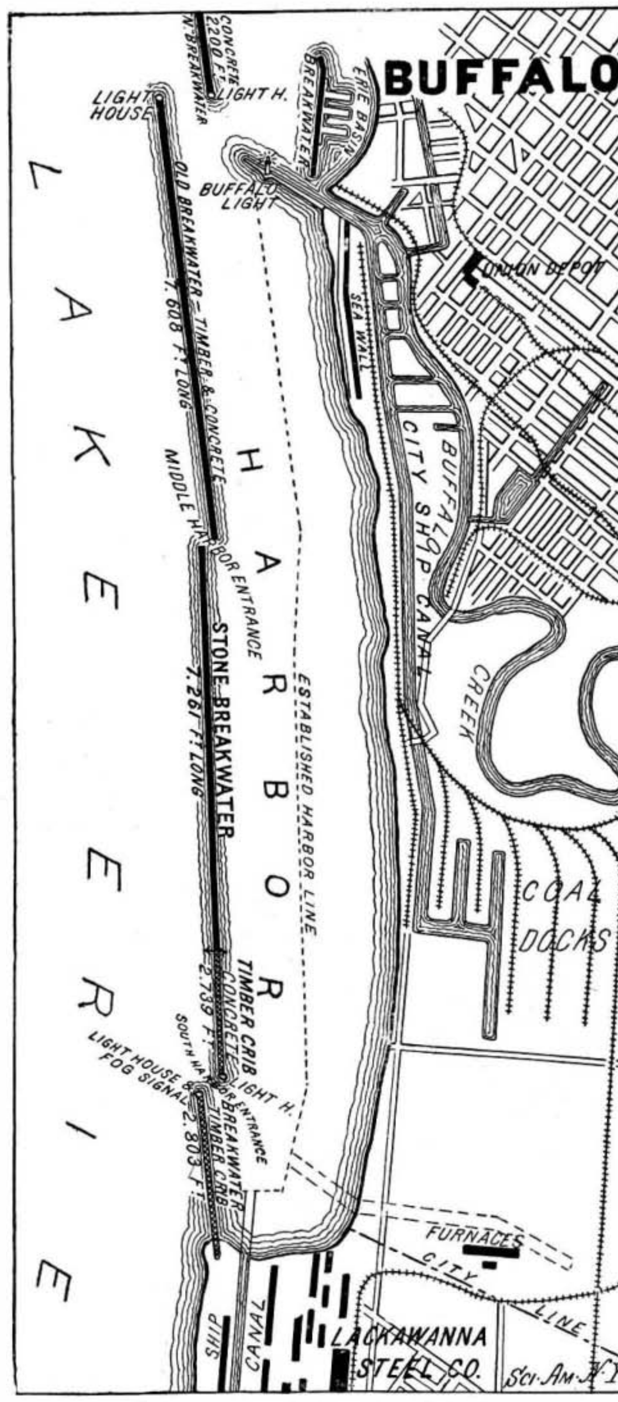
Original Crib Superstructure in Foreground; Concrete Reconstruction in Distance.

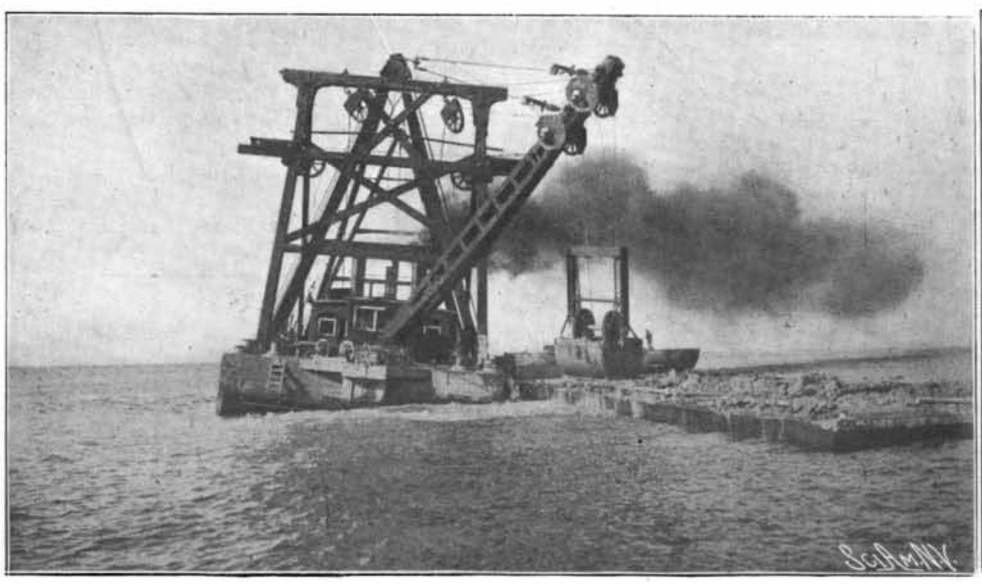
Finishing Off Stone Breakwater with Heavy Top Angle Stones.



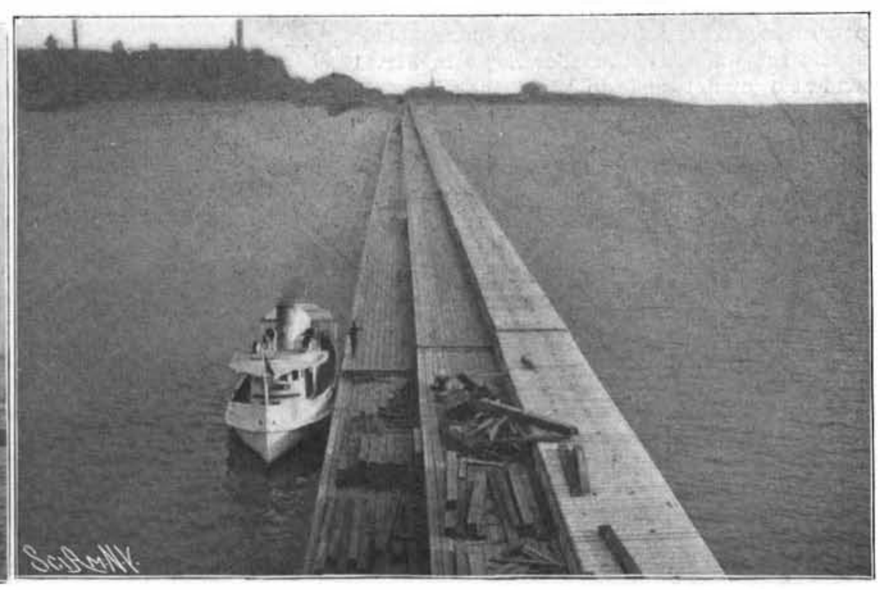
The Completed Concrete Breakwater. Stony Point in Distance.



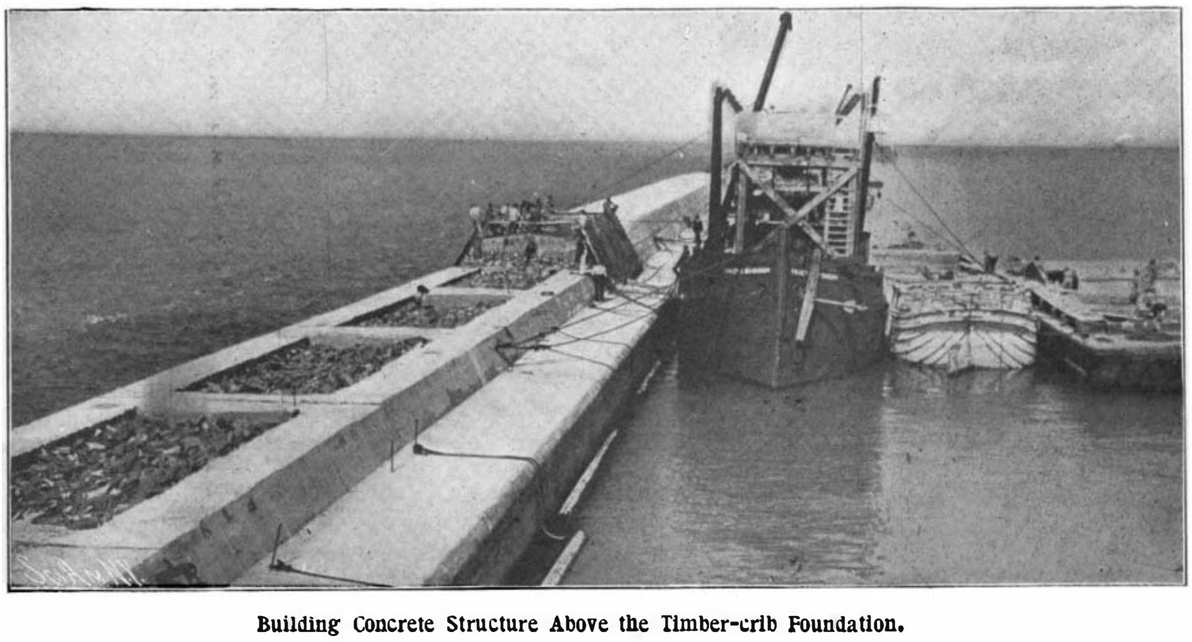
General Plan of Buffalo Breakwater.



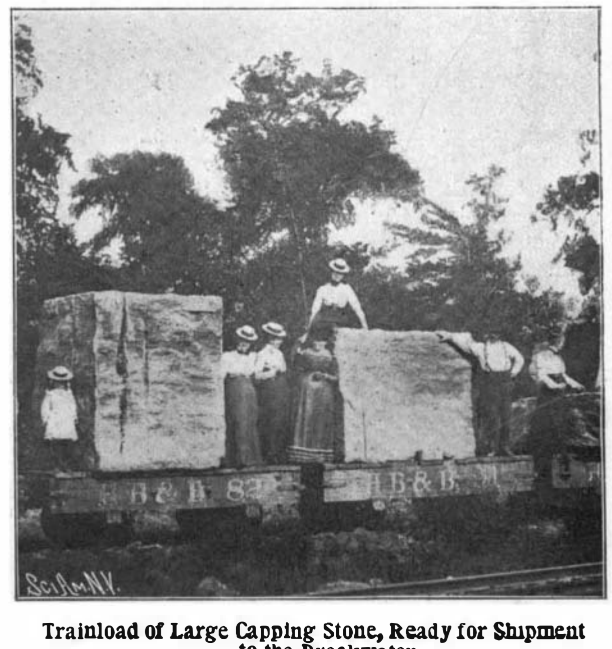
Dredging the Trench 70 Feet Below Water Level.



Bird's Eye View of Stony Point Timber-crib Breakwater.



Building Concrete Structure Above the Timber-crib Foundation.



Trainload of Large Capping Stone, Ready for Shipment to the Breakwater.

THE NEW BUFFALO HARBOR BREAKWATER.

THE NEW BUFFALO HARBOR BREAKWATER.

There has recently been completed at Buffalo a new stone breakwater, which forms the most important section of a long line of breakwaters that extend for 4½ miles to form the artificial harbor of Buffalo. The work just completed has been carried out under the charge of, and according to the designs of, Major T. W. Symons, whose long experience in similar classes of work in connection with river and harbor improvement has been used to excellent effect in the, in many respects, novel and unprecedented work just completed at Buffalo.

At the time that the present work was undertaken there existed the north breakwater, which is built of concrete and extends for 2,200 feet, with a light at its southerly end. Opposite this light and to the westward of it is the northerly end of what is known as the old breakwater, a timber and concrete structure which extends for 7,608 feet. There is a light at the northerly end of the old breakwater, with a harbor entrance between it and the southerly light of the north breakwater. To the south of the old breakwater is the new structure of which we are treating. It consists of a stone breakwater 7,261 feet in length, which connects with a timber and concrete structure that extends southerly for another 2,739 feet, with a light at its southerly extremity. Parallel with the previous structure, and slightly to the westward of it, is a timber crib breakwater 2,803 feet long, which runs northerly from Stony Point. It has a light on its northern extremity, and the opening between this and the last-named breakwater forms the south harbor entrance, the opening between the stone breakwater and the old breakwater being known as the middle harbor entrance. The 7,261-foot stretch of the new breakwater is of the rubble mound type, stone-topped, while the southerly end of it, 2,739 feet, is built of timber crib construction, to enable vessels to moor alongside of it inside of the harbor. The work was done by Messrs. Hughes Brothers & Bangs, of Syracuse.

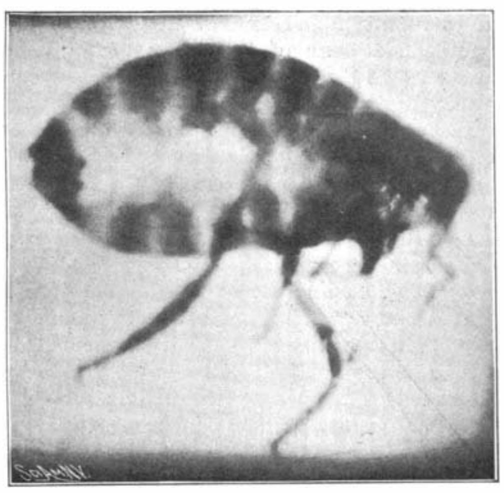


Fig. 2.—PHOTOGRAPH OF A FLEA MADE WITH THE CRYSTALLINE LENS OF A BULLOCK'S EYE

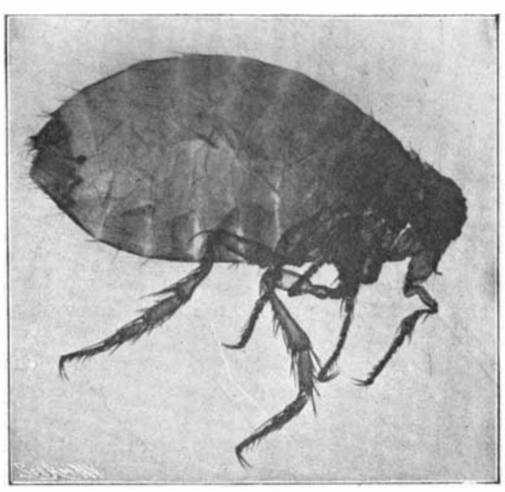


Fig. 3.—PHOTOGRAPH OF A FLEA MADE WITH THE USUAL LENS.

The new breakwater is built in the open waters of Lake Erie, parallel with the shore, 1,500 feet out from the pierhead line of the harbor, and in 30 feet of water. The first operation was to deposit two parallel ridges of small rubble on the lake bottom, one on the lake side and one on the shore side of the proposed breakwater, the intervening space being filled in with gravel. Another five feet of rubble ridges were added and again filled in with gravel, the mound thus formed being raised to within 10 feet of the surface of the water. The breakwater was then built up for the remaining 10 feet to the surface of the lake by dumping upon it large rubble stones. The slopes of the structure were covered with a revetment of large stones, which were lowered into place in close touch with each other, so as to completely cover the rubble stone, the object of these heavy quarried stones being to prevent displacement of the rubble by the action of the water. Then came the important work of covering the mound with large capping stones, which were quarried to prescribed dimensions, many of the stones measuring as much as 6 feet in thickness. These stones were carried out by five large floating derricks, each with a lifting power of 20 tons. The capping stones were laid snugly together, the finished top and side of the breakwater presenting a fairly even and true appearance. The photograph shows very clearly the way in which the top of the breakwater is finished, the heavy top angle stones serving by their weight and friction to prevent the heavy seas from taking hold of the rubble mound, loosening it and washing it away. A cross section of the breakwater as thus constructed shows it to be normally about 140 feet wide at the bottom and 14 feet wide at the top.

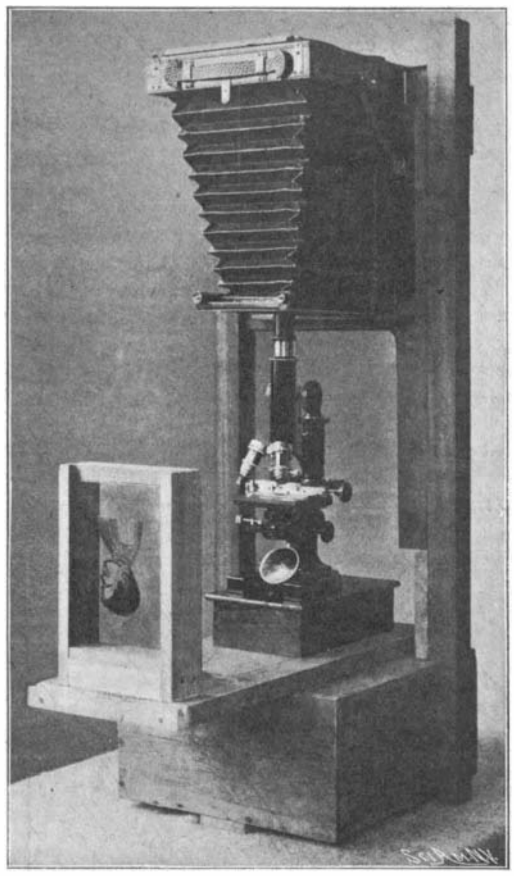


Fig. 1.—APPARATUS FOR MULTIPLE IMAGE PHOTOGRAPHY WITH THE LENS OF A BEETLE'S EYE.

While the masonry breakwater was being constructed, the work of building the timber-crib structure was also going on apace. As compared with the rubble mound type, the timber and concrete form has the advantage of being cheaper in construction. In building it the first step was to prepare a foundation and for this purpose a powerful clam-shell dredge built especially for the work was used to dredge a trench along the line of the breakwater in the bottom of the lake 95 feet in width, and 50 feet in depth through the clay. Then through the center of this trench another excavation was dredged out which was 50 feet in width and extended everywhere to solid rock. The next task was to fill in the trench thus formed with gravel which was brought to the spot in scows and dumped in, a bed of gravel, 30 to 40 feet in depth being formed in this way. Upon this was placed an embankment of rubble stone, 8 feet in height, which formed a foundation for the timber cribs. These cribs were built of sawn timber and were 36 feet in width, 22 feet in height and from 60 to 180 feet in length. They were towed to position over the foundation and sunk by loading with stone. The superstructure was built in three benches, the first 6 feet, the second 10 feet, and the third 12 feet above the mean water level of the lake. Each bench was 12 feet in width.

As shown in our illustrations, a certain portion of the crib breakwater, as finished, is of this construction; but the larger portion of it has been capped with concrete. This was done to strengthen the structure, the heavy gales of September 12 and November 21, 1900, in the latter of which the wind reached a velocity of 80 miles an hour, having loosened up and broken the above-water timber coping and finish. In repairing the ravages of the storm, the damaged superstructure was removed and the cribs were cut down to an elevation of 2 feet below the mean lake level. Upon this, concrete blocks, forming longitudinal and cross walls, were placed, and the pockets thus formed filled in with rubble stone, and roofed in with heavy concrete work, which was carried up to the level of the original breakwater. In place of the three benches of the crib superstructure, the reconstructed portion shows a parapet and a banquette. The parapet which is exposed to the lake side covers a width of 27 feet and its crest is 12 feet above mean lake level. The banquette is 8 feet in width and is uniformly 4 feet above the lake level. The new breakwaters have taken some six or seven years to construct, and the cost has been $2,200,000.

Our thanks are due to Major T. W. Symons for the illustrations and particulars in the above description of this important work.

PHOTOGRAPHIC EXPERIMENT WITH NATURE'S LENSES.

BY PROF. W. F. WATSON.

The eyes of animals possess various devices for the refraction of light and the formation of images upon the retina. The crystalline lens and the cornea appear to be the most important of these devices. When first removed from a large eye, as that of a bullock, the crystalline lens is a beautiful, clear, double-convex lens, about three-quarters of an inch in diameter. But it is quite soft and delicate, and must be handled with great care to prevent its being injured. Fig. 8 shows a crystalline lens which has just been removed from an eye and transferred to a round opening at the center of a square of pasteboard. It is covered with a bell-jar to protect from dust. Figs. 2 and 4 show the results of experiments which were made in attempting to produce photographs by using this natural lens in the camera in place of the ordinary camera lens. The method of making the photograph of the flea shown in Fig. 2 may be described as follows:

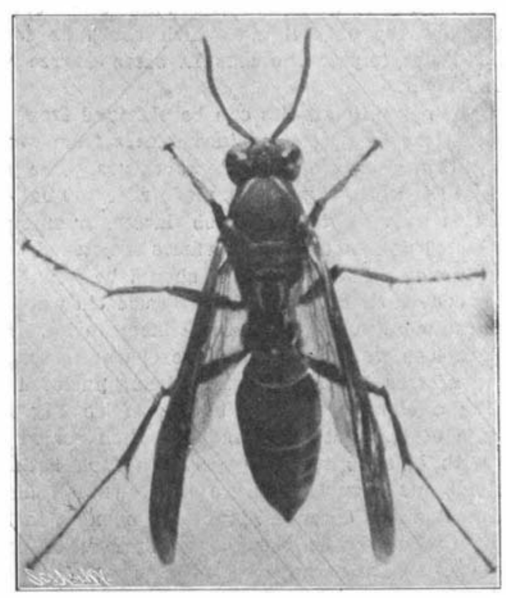


Fig. 4.—PHOTOGRAPH OF A WASP MADE WITH THE CRYSTALLINE LENS OF A BULLOCK'S EYE.

In the center of a pasteboard square a round hole is cut for the reception of the lens. This square is supported in a horizontal position by a wire frame. Its central opening must be less than three-quarters of an inch in diameter, so that the lens will be supported in it but will not drop through. The hole may be cut evenly in the pasteboard either on a microscopist's turntable or with a cork-borer of suitable size. Considerable skill is required in dissecting the eye without injury to the delicate lens, and also in transferring the lens, which must be done with a camel's-hair brush which has been dipped in aqueous humor. The lens is next

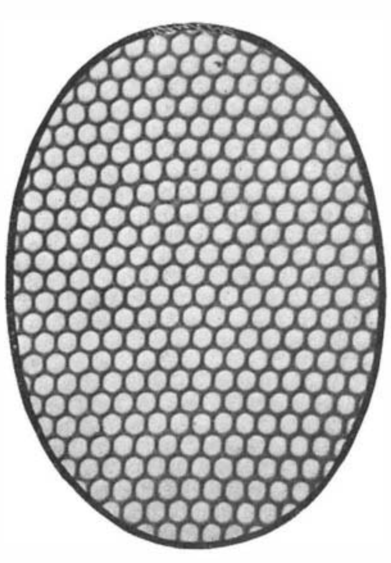


Fig. 5.—PORTION OF THE EYE LENSES OF A BEETLE, USED IN MAKING THE MULTIPLE-IMAGE PICTURE SHOWN IN Fig. 6.

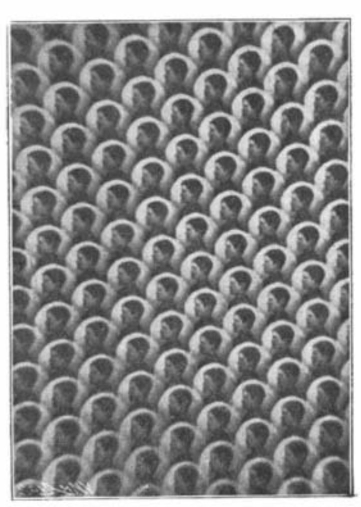


Fig. 6.—PART OF A MULTIPLE-IMAGE PICTURE MADE WITH THE LENS OF A BEETLE'S EYE.