

HOW YOUR EYEGLASSES ARE MADE.

BY C. H. CLAUDY.

No man ever had but one pair of eyes. Most men value them above all other senses. Yet is a man often careless of his eyes, neglecting the visit to the optician and the glasses which may improve and prolong his sight, and ninety-nine out of a hundred of him never think or ask, "Am I getting the best-made lens the market affords?" He takes what the optician gives him on faith. The hundredth man goes through a spectacle lens factory, and forever after he is extremely particular about his glasses. He finds out how difficult and how delicate an operation lens-grinding is. He knows how easy it would be to make an error.

First he sees the imported blank pieces of glass sorted by machinery before being ground—for greater accuracy. Then he watches a workman attaching them

highly glossy surface, perfectly polished. He will watch the "picker" detaching lenses from the pitch with a pointed tool and may perhaps ask to try it (it looks so easy) and may well break up several dollars' worth of lenses in attempting to imitate the skillful movements of the trained workman. He will watch the reblocking of the lenses, this time in the shell, or upon another block, if the lens is a double convex, see the whole range of operations repeated, and note

chines. To grind any glass evenly and truly requires more than one movement. While the shell or block revolves, the axis of the companion fitting it nutates back and forth and revolves also, so that each lens continually changes its angle with the grinding or polishing surface. With the cylindrical grinding machines there is no revolution of the grinding surface, but a constant shifting back and forth, which accomplishes the same purpose. One machine would not impress, ten would hardly get a curious stare, but thousands and thousands, all nodding and bowing, certainly command attention.

The visitor will hear something about the names and kinds of spectacle lenses. For instance, a periscopic lens is a meniscus, or a convexo-concave lens. Periscopic means "all seeing," and the use of this form in eyeglasses not only gives the eyes a wider angle of view than does the

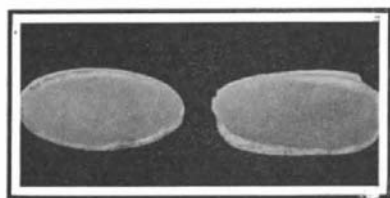


Fig. 1.—Fine grinding of a pair of eyeglass lenses.

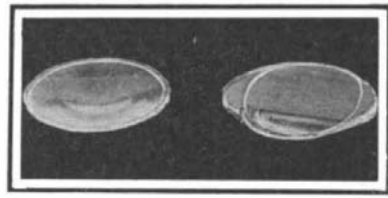


Fig. 2.—Lenses cut but outer rim not broken off.

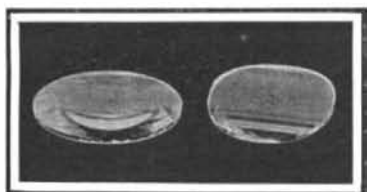


Fig. 3.—Centered lenses, showing center mark and reflection of this mark below it.

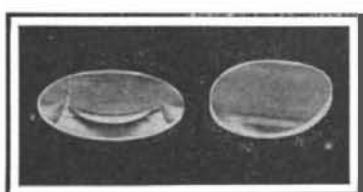


Fig. 4.—Polished and edged lenses of a pair of eyeglasses.

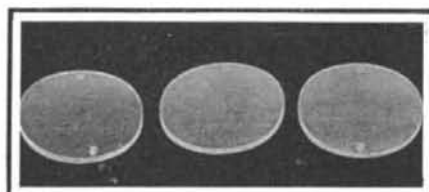


Fig. 5.—Lenses entirely finished, drilled, edged, and ready for the stock room.

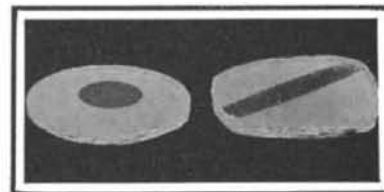


Fig. 6.—Improperly polished lenses, the black spot and band showing portion which has remained rough.

with pitch to "blocks" and "shells," concave or convex pieces of iron of exact curvature, which are revolved in their mates with abrasive, to do the grinding. He notices that the more powerful the lens is to be, the smaller the shell and block, and the less the number of blanks it will accommodate. Hence the increase in price of strong lenses over weak ones. Wandering through the labyrinthian corridors in the basement of a great factory, and seeing the thousands and thousands of pairs of shells and blocks used for spectacle-lens grinding alone, he stops to wonder at the science and the knowledge which devised this enormous number of possible curvatures. Here glass working and metal working join hands. The alliance is vital, since the curve of the lens depends on the curve of the shell and block, the perfection of which means the perfection of the original lathe.

The sightseer may walk through aisle after aisle of room after room, filled, in long, long ranks, with hundreds of grinding machines. He will see machine tenders, each with his set of machines to watch, keeping each set of lenses supplied with abrasive, changing blocks and shells from the rough grinders to the second grinders, from the second grinders to the fine grinders, and from the fine grinders to the polishing machines, where felt, carefully mounted on block or shell of proper curvature, and rouge, take the place of iron and emery, working out the last tiny abrasive mark and leaving the lens with a

the even greater care taken now; for it is no longer only glass which is being ground, but a partly finished lens, the cost of which has far exceeded the first cost of the raw materials. But he will not be able to watch any individual lens through all of its operations. Clock hands mark four and one-half hours for each of the rough, second, and fine grindings, and as long for polishing—more than two days to complete any one lens. Cylindrical lenses require even longer—five hours for each grinding and seven for the polishing.

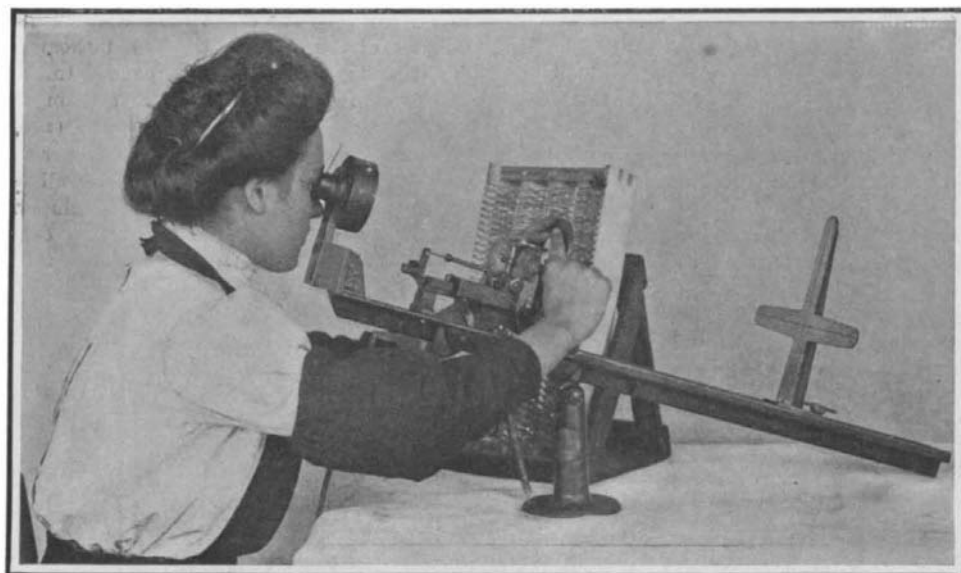
There is something uncanny about the grinding ma-

chine, but better accommodates the sweep of eyelashes, decreases reflections from behind, and, when the periscopic curve is deep, maintains all parts of the lens as nearly as possible equidistant from the pupil of the eye, no matter in which direction the eye itself be turned.

The ordinary two-curve or spherocylinder lens, used for the correction of hypermetropia or myopia and astigmatism at the same time, having one side of the lens ground to the section of a cylinder and the other side to the section of a sphere, obviously cannot be made periscopic if the spherical curve be convex, nor deeply periscopic if the spherical curve be concave. Yet the advantages of a deep periscopic glass are as great with the spherocylinder lens as with any other.

How is the problem solved? The solution was known long ago—the toric lens—but only recently has its successful manufacture been possible. A spherical lens has the same curvature measured in any meridian. A cylindrical lens has no curvature in one meridian, and its greatest curvature in the meridian at right angles to the first.

A spherocylindrical lens has a spherical curve on one side and a cylindrical curve on the other. A toric lens is one having two different degrees of curvature in two meridians at right angles to each other on the same side of the glass. These two curvatures have the effect of a spherocylindrical



Centering the lens. This operation is highly important; for on the ink spot placed on the center of the lens depend the mechanical and optical properties of the finished lens.



Making the oval cut with a diamond point on an oval swinging upright lathe.



Drilling holes with diamond drills for rimless glasses.

lens. The difficulties of the manufacture of toric lenses are enormous, as may be imagined, requiring special machinery to grind two curves at once on one side of one piece of glass. Only in recent years have such lenses been commercially possible. These grinding machines have meant the expenditure of thousands and thousands of dollars and of years and years of time.

Ground, the lenses go to the cleaning room, where, in wooden trays, they are soused and soused again in ten different baths, acid and water, and alkali and water, and soap and water, and repeat. Finally they are plunged in a bath of rouge, which leaves the wooden trays dyed the familiar red of the optical factory, and with a film of rouge on each glass for the final hand polishing and cleaning.

So far the glass has been merely glass, raw material in various stages of manufacture. Now it is a lens. Before it goes further in the tedious costly process of making raw glass into an aid to eye sight, it is rigidly inspected.

Inspection is for striæ (streaks), for air bubbles, for picker's scratches, for grinding scratches, for failure to "polish out," for too great thickness or thinness, for cracks, for breaks, for nicks, and for "target polishing," or polishing in rings. The girls who inspect for defects and for quality, who decide whether a lens is of first quality or not, become extremely expert. They see things in an instant which you may not be able to see even when pointed out. Every spherocylinder or cylinder lens must cut a circle thirty-nine millimeters. Its axis can then be ground at any angle for a normal eye. Larger lenses are supplied on order. In the spherical glasses, the inspection test must not show any defect within an oval thirty-nine by thirty millimeters, nor any serious defect, such as chip or striæ, beyond that size.

After inspection, a series of operations, bewildering in the dexterity with which they are accomplished, the lens is centered. A girl fits the glass on the centering instrument, takes a swift look through an eyepiece, sees that a cross hair behind the eyeglass and a cross hair behind the eyepiece of her instrument are in line, and "click," a little ink-spotted pointer has touched the center of the lens, the optical center. If the lens has a cylindrical curve, and consequently a major axis, three ink spots are made upon it, one for the optical center and one at each end to show the axis.

For axial determination, the instrument is accurate to within one-half a degree. The lenses are gaged for thickness, and sorted to size, and then gaged and sorted for actual area; lenses are "two eye," "one eye," "0 eye," "00," "000," "0000 eye," and finally "jumbo" in size, and each must be gaged to see what size it will cut.

Spherical lenses are usually finished at the factory, edge-ground and packed ready for use, and, since a spherical lens has no axis, it can be cut with the long axis of the oval in any direction to the shape of the ground and polished blank. But the cylindrical lens, the spherocylinder, or the toric, must be left unfinished as to edge, except for special order, since the angle the axis of the cylinder curve is to make with the astigmatic eye is important.

If the lens is to be edge-ground, the next operator upon it fits the lens over a size gage upon the table of a little machine, turns a handle, and behold, a tiny diamond cutter has oval-ringed the glass with a scratch the shape of the finished lens. Another girl breaks off the rough edges with pliers, and, perhaps, a rough pair of iron shears. To see her surrounded with splinters and tiny spikes of glass all over her lap and bench, you would imagine she was in imminent danger of injury, but cuts are rare even with the thickest and heaviest of lenses.

For rimless eyeglasses or spectacles, the lens must have holes drilled in it. It goes to a girl with a drilling machine and diamond-pointed drills. As the tough material is bored, a steady stream of cleanly odorous camphorated turpentine plays upon the glass and the drill, and the little automatic machines, each with its impassive feminine watcher, turn out lens after lens with one or two tiny smooth-edged holes at the ends, ready for the next operation.

More washing and cleaning follow, and then edge grinding, a matter of wonderfully ingenious machinery, by which the rough-chipped edges are made smooth and the lens, so far as working the glass is concerned, is finished.

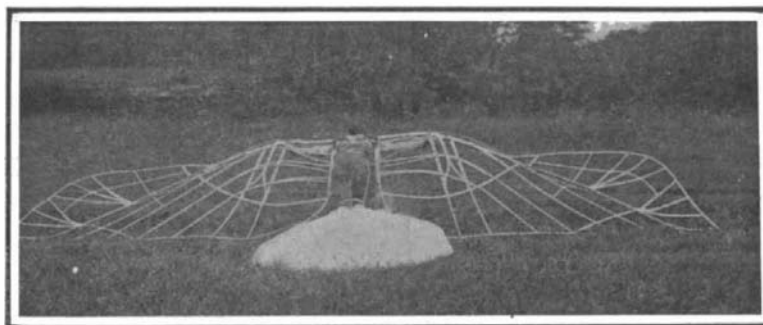
Then this product of many operations is focused, much as the elements of a photographic lens are focused, by a girl with a special focusing camera,

wiped again, packed, labeled, and stocked. Two hundred and twenty-five gross pairs, or sixty-three thousand lenses, are so finished every day in one big factory.

Nearly a million pounds of optical glass are made into eyeglasses in this one factory every year. It takes thirty tons of emery to grind, and twenty tons of rouge to polish this product. It requires five thousand yards of toweling every year to wipe it clean. For every unedged lens, there are forty-nine operations; for every edged lens, sixty-eight operations. A spectacle lens is simple to look at, but after you have visited the factory, you will know it for what it is—a very complex thing.

FLIGHT WITH FLAPPING WINGS.

Human flight by flapping wings is impossible for several reasons, chief among which is that Nature has failed to furnish us with the anatomy or the mus-



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Rear view showing the wing framing and the tail.

cular strength which are necessary for flight of this kind.

It is evident that the motive power for the machine herewith illustrated is to be furnished by the arms of the operator, and the movements when the body was in horizontal flight, would consist of a vertical oscillatory movement of the arms when stretched to their full extent. The power for lifting and propelling the man and the machine, whose weight would be at least two hundred pounds, would therefore have to be furnished entirely by certain muscles of the chest and shoulders, which are rarely brought into strenuous use, and are feeble compared with other muscles of the body.

Furthermore, with the slow rate of oscillation of the wings of which a man would be capable, their area would have to be very large, and their weight



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The frame is of aluminium and covered with balloon cloth. There is no motor. The designer hopes to fly by man power.

FLIGHT WITH FLAPPING WINGS.

would of course increase rapidly in proportion. Prof. Langley pointed out that the difficulty of flying with flapping wings increases rapidly with the increase in size and weight; this being due to the mathematical law that the area in bodies increases as the square of their dimensions, while their weight increases as the cube. He pointed out that "the larger the creature or machine, the less the relative area of support may be (that is, if we consider the mathematical relationship, without reference to the question whether this diminished support is actually physically sufficient or not), so that we soon reach a condition where we cannot imagine flight possible. Thus, if in a soaring bird, which we may suppose to weigh 2 pounds, we should find that it had 2 square feet of surface, or a rate of a foot to a pound, it would follow from the law just stated that in a soaring bird of twice the dimensions we would have a weight of 16 pounds and an area of 8 square feet, or only half a square foot of supporting

surface to the pound of weight, so if flight is possible in the first case, it would appear to be highly improbable in the second. The difficulty grows greater as we increase the size, for when we have a creature of three times the dimensions we shall have twenty-seven times the weight and only nine times the sustaining surface, which is but one-third of a foot to a pound. This is a consequence of a mathematical law, from which it would appear to follow that we cannot have a flying creature much greater than a limit of area like the condor, unless endowed with extraordinary strength of wing."

To fly with the machine herewith illustrated would call for an expenditure of horse-power far beyond that which the strongest man on record ever possessed. It is doubtful if the average man is capable of exerting more than a quarter to a third of a horse-power continuously. It is true that, in supreme moments of effort, and for a very brief period, athletes may exert as high as one horse-power or a little over. The motorless aeroplane, or glider, is the only successful medium of human flight. Flapping wings are clumsy, difficult to construct, uneconomical in operation, and, according to present knowledge and experience in the subject, they form a wholly impossible means of human flight.

Depth of the Gulf Stream.

In Lieut. Pillsbury's examination of the Gulf Stream at various points from Hatteras southward, he found that the stream reaches to the very bottom in some places and tabulated its velocity at different depths. His results, as well as a review of the whole field of Gulf Stream investigation, are found in appendix 10, report for 1890, of the United States Coast and Geodetic Survey. It must not be inferred from the foregoing that all ocean currents extend to the bottom of the sea. Many instances are at hand of ocean currents extending to great depths. For example, Admiral Erminger, of the Danish navy, found that the northwesterly current in latitude 25 deg. 04 min. N., longitude 65 deg. 41 min. W., prevailed to a depth of 200 meters; Commander John R. Bartlett, United States navy, found a current in the Windward Passage to the depth of more than 800 fathoms (1,460 meters), and concluded that it reached to the bottom; between Key West and Havana the stream was measured in 1860 to a depth of 600 fathoms (nearly 1,100 meters), and was found to be only 10 per cent less than at the surface.

It is well established that the Gulf Stream loses in depth, temperature, and velocity, and gains in width, especially after passing Cape Hatteras, until the 40th meridian it becomes a drift current, reinforced on its right flank by the powerful Bahama current. Various measurements for temperature show that the Gulf Stream is shallower than its northeastern extension beyond the 40th meridian. Thus Commander Chimmo, R. N., commanding H. B. M. S. "Gannet," during the summer of 1868, found the warm water of the Gulf Stream to be less than 50 fathoms deep in latitude 44 deg. 03 min. N., longitude 48 deg. 07 min. W. Ten degrees to the eastward the warm water had deepened to 100 fathoms or more and in latitude 43 deg. 43 min. N., longitude 37 deg. 47 min. W., the warm water was found to extend down about 250 fathoms. Observations made on board H. B. M. S. "Porcupine," during the summer of 1869, showed remarkable depths in the Gulf Stream drift, as follows: In latitude 59 deg. 35 min. N., longitude 9 deg. 11 min. W., the warm water was found to extend to the very bottom of the sea, 767 fathoms (1,400 meters); at Rockall the warm drift was found to reach down 900 fathoms below the surface, and similarly again in latitude 47 deg. 38 min. N., longitude 12 deg. 08 min. W. At the last-mentioned observation spots

the warm water was found to be underlain by a polar current at depths of more than 900 fathoms. A similar phenomenon is often observed near the Grand Banks where the Labrador current dips under the Gulf Stream at comparatively shallow depths, 50 to 100 fathoms.

Daniel's Comet.

The comet discovered by Mr. Daniel of Princeton Observatory has received considerable attention throughout the country. Dr. H. C. Willson of the Goodsell Observatory, and Prof. E. B. Frost, Director of Yerkes Observatory, have both sent communications on the subject to Harvard College Observatory. Furthermore, Dr. Ebell of Kiel has computed an ephemeris. From the photograph which has been made at Yerkes Observatory it seems that the comet has no stellar nucleus; a short tail is suspected.