Visible Space To Grow Thirty Fold

Astronomy

Telescopic power ten times as great as that given by the 100-inch reflecting telescope of the Mt. Wilson Observatory, now the largest in the world, will be at the disposal of astronomers when the 200-inch reflector of the California Institute of Technology is completed. It will penetrate three times as far into space as the 100-inch, and bring into view a globular region of space thirty times the volume of that reached by present-day telescopes.

Work on the new instrument is now under way. A model of the telescope, based on a design that has been accepted tentatively, but may be greatly altered after further study, is now on exhibition at the building of the National Academy of Sciences in Washington.

Two miniature figures, on the same scale as the model, indicate the size of the finished instrument if this design is finally accepted. It will be about 85 feet high when pointing near the zenith, about the same height as a seven or eight story office building. The tube is supported in a fork, so that it may be pointed to any part of the sky. The fork is arranged to turn in a direction parallel with the axis of the earth. A powerful clock drive will turn the instrument around this axis once a day, thereby keeping it pointed to the stars as they move across the sky. This arrangement is the same as in the usual equatorial mounting for astronomical telescopes.

Dr. George Ellery Hale, honorary director of the Mt. Wilson Observatory of the Carnegie Institution of Washington and chairman of the Observatory Council of the California Institute of Technology, describes in the current issue of *Harper's* the progress of the work on the telescope since it was started a year ago.

No actual construction work on the telescope proper has yet begun, but much necessary preliminary work has been accomplished. A tentative design for the telescope has been worked out. Plans have been completed for the astrophysical laboratory, on the Pasadena campus, of the California Institute, which will be the headquarters of the astronomers who will use the telescope, measure the photographs taken with it, and interpret them with the aid of laboratory experiments. Plans have also been made for the instrument shop where the smaller telescope parts and many accessory instruments will be constructed, and for the optical shop, where the huge mirror will be ground and figured. While these plans were being drawn, Mt. Wilson astronomers engaged in a survey of a dozen possible sites for the new instrument.

Dr. Hale emphasizes the importance of choosing the best site for the telescope.

"We observe the stars from the depths of a turbulent atmosphere," he says, "which not only scatters and absorbs much of the light that reaches its upper levels, but so irregularly refracts the portion transmitted that the rays falling on the various parts of a large lens or mirror are rarely or never combined into a sharply defined and perfectly steady image.

"By selecting a site of high altitude, above the denser and more disturbed portion of the atmosphere, in a region but little affected by clouds and storms, we may greatly reduce these difficulties. In fact, the conditions on Mount Wilson are so favorable that on a very large proportion of the nights in the year the 100-inch Hooker telescope gives us a gain in light-collecting power over the 60-inch telescope fully in proportion to its greater aperture.

"The use of the larger instrument has thus resulted in many fundamental discoveries beyond the range of the smaller one, and has more than justified our most sanguine hopes. Moreover, we have direct observational evidence that on Mount Wilson a 200-inch telescope could be depended upon to show a further gain, in keeping with its increased size. The probabilities now are that we can find a still better site within a short distance of Pasadena."

The type of mounting shown in the model is not final, said Dr. Hale. It represents one satisfactory solution of the problem, and justifies further work. Should any other kind of mounting be suggested which would be still more advantageous it will be adopted. The great mirror, however, still remains a problem, but one to which a satisfactory solution is fully expected.

"In the days of Herschel and Lord Rosse the mirrors of reflecting telescopes were made of speculum metal, a silver-like alloy of tin and copper, which takes a beautiful polish and retains it for many years," he states. "Subsequently, mirrors of glass, silvered on their front surface, were introduced and universally used. Glass is lighter than speculum metal, and silver reflects a greater proportion of blue light, though speculum metal is much more efficient as a reflector of the ultraviolet stellar rays. Moreover, as glass is a poor conductor of heat, the outer parts of large thick mirror discs change in temperature more rapidly than the interior as the air in the open dome grows warmer or colder from night to night. Thus their curvature is more or less affected, and this means that the stellar image, instead of being nearly a point, may often be expanded into a much less brilliant disc.

"The most promising means of overcoming this difficulty is to make the mirror of fused silica or quartz, which is not appreciably affected by change of temperature. Dr. Elihu Thomson and his associate, Mr. A. L. Ellis, had already solved at West Lynn, Massachusetts, many of the technical problems involved in the use of fused quartz, and our first step was therefore to secure their cooperation and that of the General Electric Company. President Gerard Swope immediately agreed to have the work done in the Thomson Research Laboratory at actual cost, with no charge for commercial or administrative expenses. The special methods required for producing large discs have since been developed, with every promise of success.

"The procedure adopted is to begin with the manufacture of mirrors of moderate size, then to undertake the 60-inch and larger mirrors needed for auxilliaries, and finally to make the 200-inch disc itself. A 20-inch disc has already been made, and the 60-inch stage will soon be entered. Some conception of the magnitude and difficulty of the ultimate task may be gained when it is stated that the fundamental problem is to construct a rigid concave mirror nearly 17 feet in diameter (200 inches), many tons in weight, whose surface is parabolically curved with an error less than two millionths of an inch.

"The process consists of fusing a mass of nearly pure silica sand in a circular electric furnace which constitutes the mold. The disc thus obtained, whch contains innumerable small bubbles, is ground to the approximate curvature of the mirror desired and then (*Turn to next page*)

Babies Take Own Time to Develop

Psychology

Psychologists studying the behavior of young children have at last found a way to "have your cake and eat it too." That is, they have succeeded in giving a baby training that would alter the course of its development and yet they have been able to see what the youngster would have been like if it had never been trained.

This magic has been brought about by the Yale Psycho-Clinic, where Dr. Arnold Gesell and Dr. Helen Thompson have observed identical twin girls from the age of one month up to the age of eighteen months. Reporting their experiment in the Genetic Psychology Monographs, the psychologists say that it is doubtful if prolonged search could have secured for comparative study twins more extensively and profoundly alike than these. The blue-eyed blonde babies respond with remarkable similarity of behavior to almost any situation. In refusing or objecting, each twin's gesture is to turn the body slightly to the right and bend the left arm across the chest. when placed back to back and observed for several hours, their manner of handling a bell, spoon and other objects was strikingly similar.

For six weeks the psychologists gave one twin girl, T, a chance to practice climbing a set of five steps every day. Meanwhile, the other twin, C, had no such opportunity to learn the new activity. In the first three weeks of climbing lessons Twin T had to be frequently assisted. At the end of six weeks, when she was 52 weeks old, she climbed the steps in 26 seconds and was an enthusiastic climber. Yet when Twin C was introduced to the steps at the age of 53 weeks, she proceeded to climb the staircase without training or aid, taking only 45 seconds. At the age of 56 weeks T was climbing the steps in 11 seconds and C in 14.

Twin T was also given practice in handling cubes, the psychologists report, but her added early experience did not give her any advantage when Twin C was presented with three little blocks to bang with and to pile on top of one another.

The experience of the twins shows, according to Dr. Gesell and Dr. Thompson that a child begins to climb and to build towers with his blocks when his nerve structures are ripe for such activities. Exercise may not even hasten the actual appearance of such reactions in a young child. The experience gained by early practice tends to be supplanted or modified by the process of the child's maturation. If it were not so, the infant could scarcely grow, they point out.

Twins identically alike offer a promising field for psychologists to study the difficult problems of human growth, the investigation indicates.

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New Magic

Electricity

The busy housewife who prizes the last few minutes of her morning rest may now turn on the current for the electric percolator by a mere wave of her hand. This and many other modern "magic" tricks are made possible by the electric grid-glow apparatus now available commercially. The apparatus is so constructed that when the hand approaches it a slight current is started. This can be used to turn on other electrical appliances.

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200-Inch Telescope—*Continued*

coated to a sufficient thickness with perfectly transparent quartz, free from bubbles. This crystalline quartz, in finely ground form, is sprayed on to the hot disc by means of an oxy-hydrogen flame; and the development of multiple burners needed for coating large surfaces without flaws has been one of the principal difficulties overcome. On this transparent face of water-clear quartz the final grinding, polishing, and figuring will be done. Finally, a thin coating of pure silver will be chemically deposited on the finished surface, just as is done periodically in the case of such glass mirrors as that of the 100-inch Hooker telescope on Mount Wilson."

While quartz seems to offer the most advantages, there are still other possibilities.

"Everything depends upon the success of the mirror, and we are therefore considering as possible alternatives several entirely different methods of construction, some of which are very promising," says Dr. Hale.

Probably the large disc could be made out of special forms of glass, such as pyrex, used in cooking utensils and laboratory glass ware.

The concentration of light by a telescope, and the speed with which photographic exposures can be made, depends on the ratio of the focal length to the diameter of the objective. It has been decided to make the focus of the 200-inch mirror only 55 feet, or 3.3 times its aperture. This would give it a speed of F.3.3, about the same as that used in lenses for motion picture cameras. If still greater speed is wanted, a special correcting lens, designed by Dr. F. E. Ross, can be used, which will increase the ratio to F.2. The ratio of the 100-inch telescope is F.5.

"During our own time spectrum analysis, initiated by Kirchhoff's study of the sun, has revealed the unity of terrestrial and celestial substance and provided the means of tracing the evolution of stars and nebulae and the systems in which they are grouped," Dr. Hale says, in pointing out some of the possibilities of the telescope. "Moreover, it has served as our guide to the true nature of matter and the advancement of the fundamental sciences of physics and chemistry.

"The first harmonic series of spectrum lines and the first ionized atoms (lacking one or more electrons), vital clues to the modern theory of matter, were found in the sun and stars. Quickly, with the aid of powerful telescopes the vast experiments performed for us in these celestial laboratories have added to basic knowledge. The three most vital tests of the Einstein theory can be made only with the telescope. Matter two thousand times as dense as platinum has been found in the companion of Sirius. Oxygen and nitrogen in 'forbidden' forms have been detected in the excessively rare gases of the Great Nebula of Orion.

"The transformation of mattter into radiation, predicted by physical theory, is attested by stellar observations. And now we may hope that the problem of the curvature of space will be settled by celestial measures. Can one doubt that a telescope powerful enough to carry all these studies far beyond our present possibilities will prove profitable, not merely to the astronomer but to all who utilize the results of science in the many-sided problems of modern life?"

Science News-Letter, November 2, 1929