THE EXPANDING UNIVERSE

Mt. Palomar's Giant Telescope Opens New Era in Human Knowledge

Written for "The Listener" by Dr. C. M. Focken, Senior Lecturer in Physics, Otago University.

ASTRONOMERS and astrophysicists throughout the world are awaiting an event of the first magnitude in the long history of astronomy. Very soon now the giant 200-inch telescope situated on top of Mt. Palomar in Southern California will have undergone its final tests and be ready for service, and a crowded programme for extending man's knowledge of the universe has already been mapped out for it. The great eye of the telescope—the glass disc with an accurately ground concave paraboloidal surface—was transported up the mountain last November. There were sighs of relief when this precious piece of glass, insured at Lloyd's for £150,000, was safely lowered on to its massive supports at the base of the telescope tube. The completion of this telescope, probably the world's most costly single mechanism, crowns nearly 20 years of expert labour. Although the project was well advanced in 1939, all work on it was suspended during the war years. The last event of a comparable kind was the commissioning of the 100-inch telescope at the Mt. Wilson Observatory in 1917.

The year 1948 will most probably begin a new era in knowledge of the cosmos, a subject which has always had a peculiar fascination for mankind. It is no exaggeration to say that our information about celestial bodies has come to us on rays of light. We cannot experiment with these remote sources of radiation in the ordinary way. We can do nothing but observe, from an incredible distance, and reason on the results of our observations. The astronomer's instruments are therefore all concerned with light, principally with its collection and with its analysis into component colours (or wavelengths). Until aided by scientific weapons such as the telescope, the spectroscope, the photographic plate and the photoelectric cell, man's concepts of the universe were childlike. Physics and mathematics have played such a prominent part in advances of modern astronomy that it can more exactly be referred to as astrophysics.

Millions of Universes

Only four centuries ago men began peering through telescopes to find out what existed beyond the limits of unaided vision. During the present century accumulation of data has been rapid and extensive, and has led to a complete revision of all older concepts of celestial structure. It was not long ago that astronomers spoke of the "universe" as if it were one entity, namely, the galaxy which includes our solar system. Now they speak glibly of universes or galaxies. Our own Milky Way is one; the Andromeda Nebula another. It is known that there are millions more out in space and each one may contain several thousand million stars. How are these universes related? What changes have occurred and will occur in the future in their relationships? Surely there is some fundamental plan. If so it has not yet been discovered. Nor is it known whether there is life, in any way similar to ours, on any other celestial body. True, this question may not be of fundamental importance, but it does interest *us*.

How may the structure of the universe be described? Is it expanding or static, finite or infinite? Profoundly different hypotheses have been proposed by eminent astronomers. The answer to these problems will be sought beyond the present limits of exploration, inconceivably vast though these are. The Mt. Palomar Observatory has been designed and built to help solve the mystery of the universe.

Six Thousand Feet Up

This observatory has been most carefully planned and will possess when completed many valuable auxiliary instruments in addition to the giant telescope. It embodies the ingenuity, brains, and experience of the Mt. Wilson Observatory staff and other experts who were consulted. Liberal financial backing has been provided since its inception in 1928 by the Rockefeller Foundation of New York. The construction was undertaken by the California Institute of Technology. A plan of co-operative research with the staff of Mt. Wilson Observatory has been developed, which should be highly advantageous to both institutions—the equipment at the two observatories is largely supplementary. And these unrivalled facilities will be available for approved work to astronomers the world over.

Mt. Palomar was selected as the best site available within working distance of Pasadena, the common focus of the joint project. It is only 125 miles away, is unaffected by the lights of Los Angeles, which have been detrimental to certain work at Mt. Wilson, and has excellent atmospheric conditions. The mountain is about 6000 feet high with a large, relatively flat top.

The construction of a mirror to satisfy the exacting requirements was physically the most interesting of the construction problems. Years of experimentation with fused silica or quartz which had some admirable properties including non-expansibility, revealed that it was too difficult to cast in a large disc. It was also too expensive. Consequently a special pyrex (borosilicate) glass was decided on. The Corning Glass Works finally completed the unprecedented task after gaining experience by pouring several smaller discs and one unsuccessful 200-inch one. The back of the disc is cellular or honeycombed to save weight without sacrificing much strength.

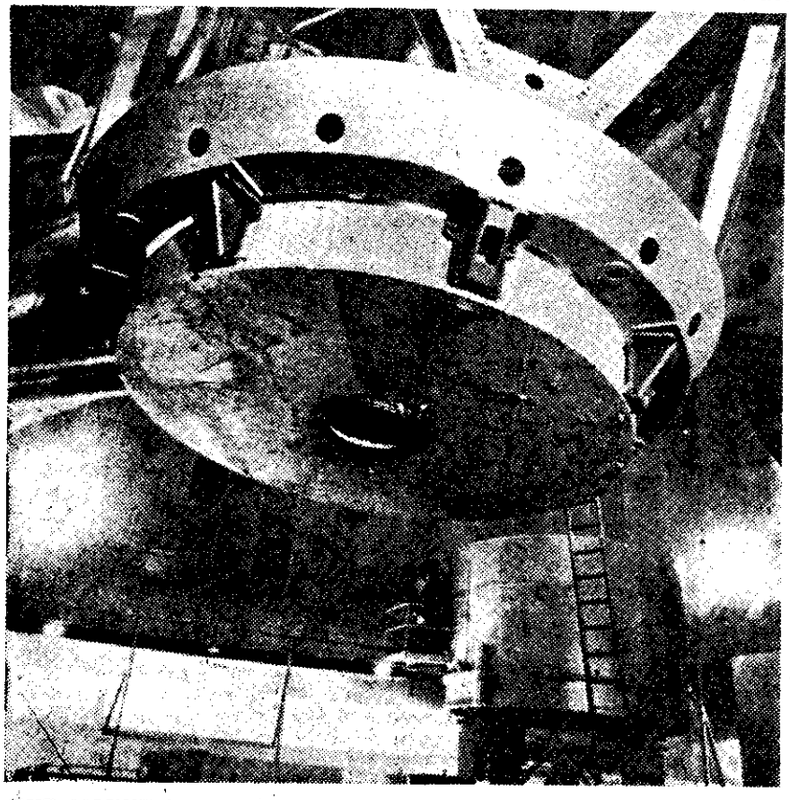
To remove all trace of internal strain the disc was slowly annealed during a period of 10 months. Rough grinding began in Pasadena in 1936 and was followed by years of polishing to bring the surface of the glass to that of a perfect paraboloid. This slimming and figuring reduced the disc by about five tons. Many people fail to realise that the light is reflected from the front surface of a telescope mirror, not from the back surface as in the case of the usual plate glass mirror. The glass, however, must maintain its shape to a high degree of precision under all conditions to which it is subjected. It supports the reflecting layer, a thin coating of aluminium which is sprayed on the surface of the disc. Aluminium itself, like silver, tarnishes in the air. But the film of oxide which forms has a composition like emery or sapphire and provides splendid protective film. When dirty with dust, as will happen in time even in the clear mountain air of California, the precious film can be washed with plain soap and water.

An electronic mechanism was devised to counteract automatically the earth's daily rotation. It enables a star to be kept exactly in focus as it crosses the sky. This is an essential requirement for the lengthy exposures extending over successive nights, which are necessary when photographing the faint messages from distant stars. The support for the disc, which must not introduce any distortion; the yoke type of equatorial mounting; the 60-foot telescope tube, and the 137-foot hemispherical dome mounted on concrete piers running deep into granite were all skilled engineering feats. Altogether the moving parts total 450 tons. The yoke holding the telescope tube is not on bearings, it is floating in oil.

Popular Fallacies

Popular misconceptions in regard to large telescopes are not uncommon. Since these telescopes are designed for photography, visual observations are incidental and generally brief. Gone are the days when an astronomer glued his eye to the telescope and swept the skies hoping for some undiscovered body to swim into his ken. Surely the largest telescope must have an immense magnifying power? Broadly speaking this, too, is a fallacy. The primary purpose is not high magnification, it is to collect more light than was ever collected before, and direct it all to a small, sharp, undistorted image of unequalled brilliance. Magnification is relatively easy—it is the main function of a small system of lenses or mirrors trained on the primary image. And the insuperable limitation to magnification lies in our atmosphere which is almost always turbulent. "Twinkle, twinkle little star" is the manifest evidence of atmospheric irregularities about which astronomers can do little else but cuss.

Neither rapid nor spectacular results are to be expected when work begins with the Mt. Palomar telescope. Investigations will be mainly directed to distant frontiers of space, not to neighbouring planets. So do not expect to



THE MOUNTING at the base of the telescope tube, to which the 200-inch mirror will be affixed. When this photograph was taken the reflector was being ground and polished, its place being taken by a massive disc of concrete of the same size and weight.