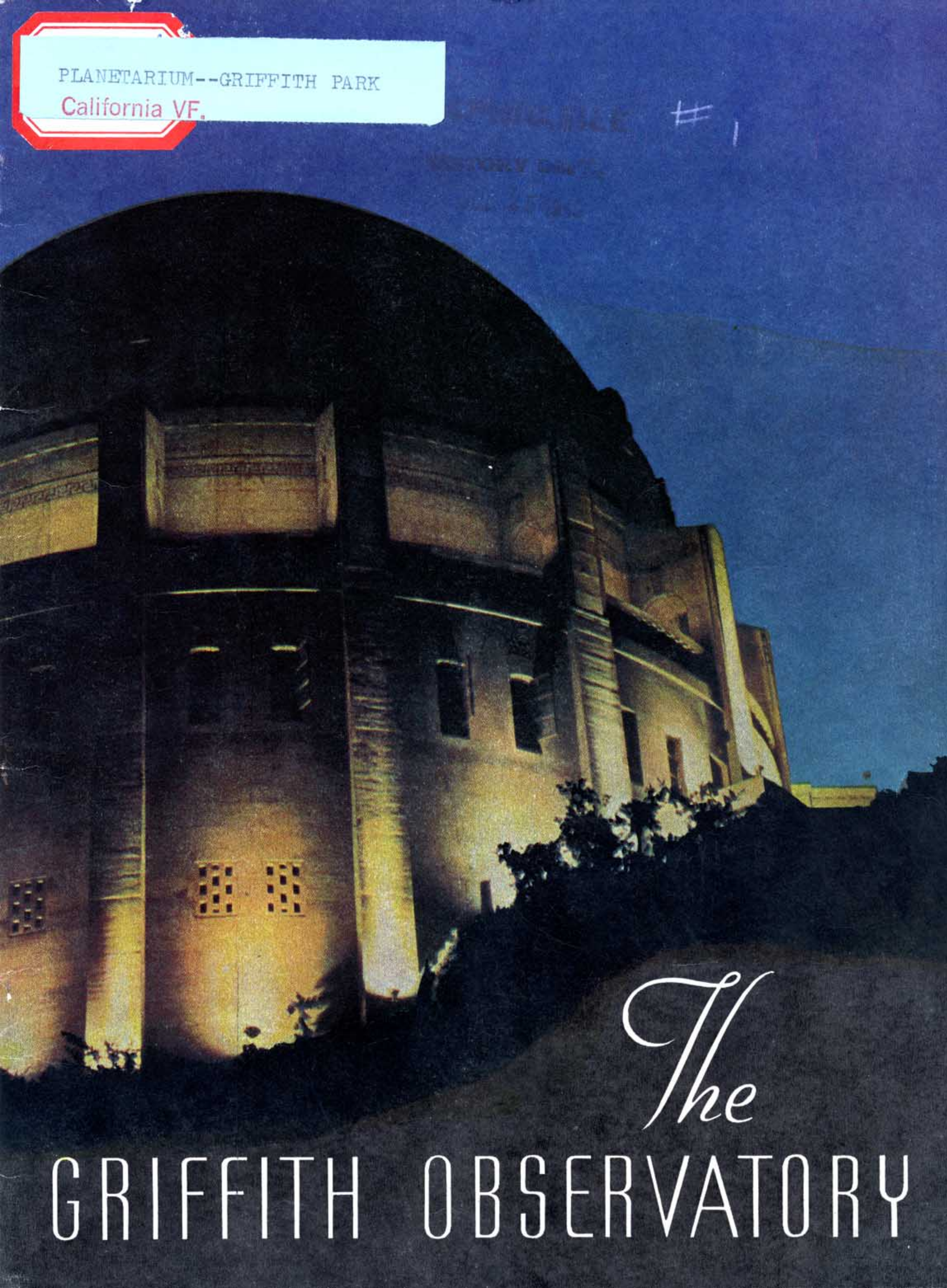

The GRIFFITH OBSERVATORY

THE STORY OF GRIFFITH OBSERVATORY AND PLANETARIUM LOS ANGELES CALIFORNIA

EXCURSIONS INTO THE STARRY HEAVENS

Operated by

Board of Recreation and Park Commissioners

City of Los Angeles

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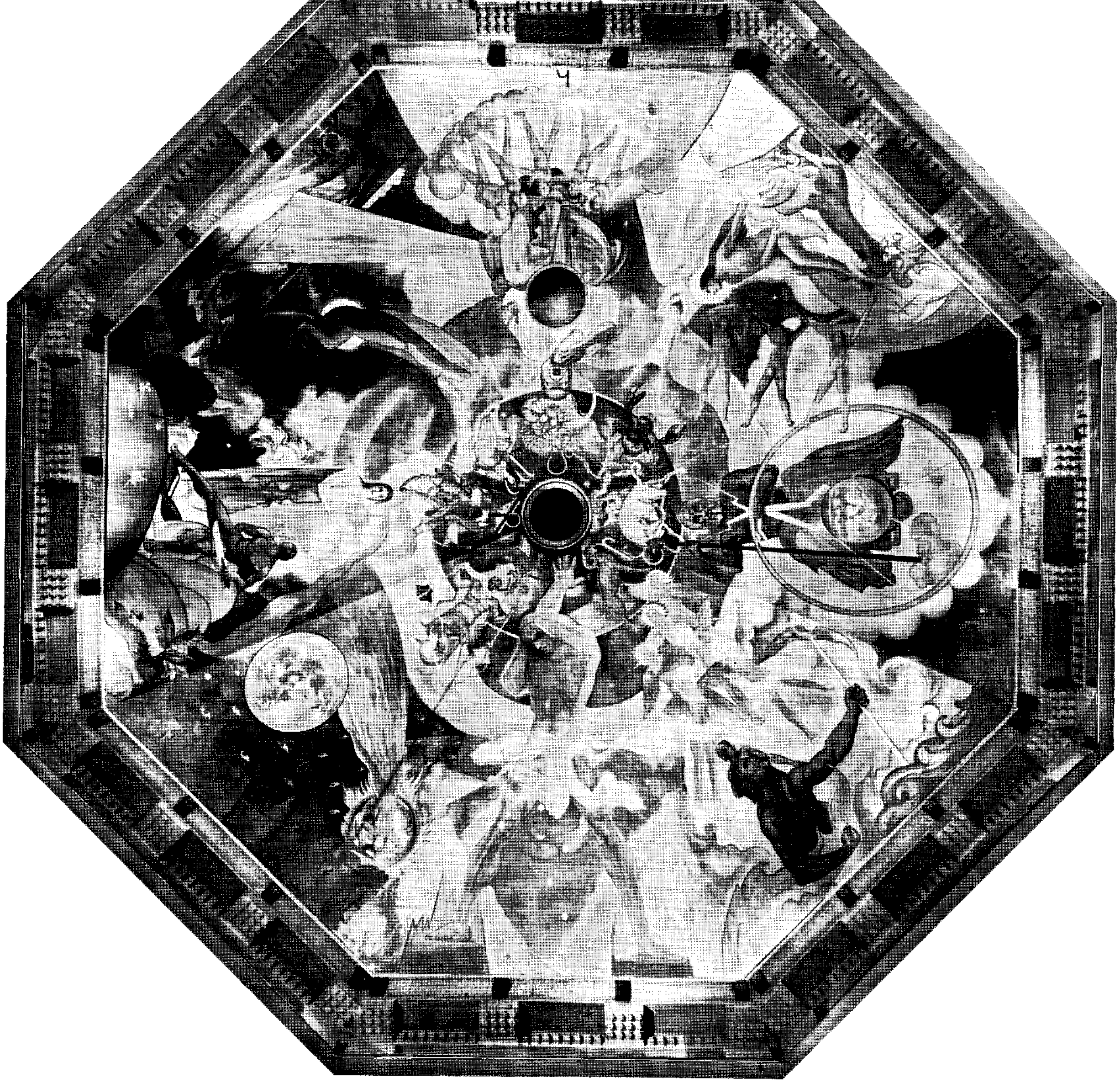
FOREWORD

THE GRIFFITH OBSERVATORY was a present to the City of Los Angeles, given by the will of Colonel Griffith J. Griffith. At the same time he provided for the Greek Theater. Previously he had presented Griffith Park to the City, in 1896.

▲ The Observatory was opened officially on the night of the 14th of May, 1935. It is divided into three main divisions. First is the Observatory proper. In this division the principal instrument is a Zeiss 12-inch refracting telescope. Other instruments are the three solar telescopes which are fed by a triple mirror system. One of these produces a large image of the sun on a screen in the Hall of Science. A second places the image of the sun on a 5-inch grating spectroscope. The third does the same for the revolving prism of Hale's spectroheliosocope.

▲ The Hall of Science, which is the second division, shows more than 100 exhibits from the most notable achievements of modern physical science. New exhibits are built and added from time to time.

▲ The third division is the theater of the heavens, with its Zeiss planetarium. The ceiling of this theater is a hemisphere 76 feet in diameter. On it the planetarium instrument in the center of the room projects the sky almost exactly as one would see it under the very clearest of conditions, from any place that he might choose in the whole world at any hour for thousands of years past or future. The capacity of the theater is 514 and at night demonstrations, especially during the summer months, it often is filled completely by those who for an hour find themselves in an artificial universe.



THE MURAL PAINTINGS

▲ The murals in the rotunda were painted by Hugo Ballin, and cover the domed ceiling and eight panels. The latter were copyrighted in 1934.

THE CEILING

▲ The large figure opposite the main entrance to the building is Atlas. On the sphere which he holds on his shoulders are the twelve signs of the zodiac, surrounding the opening from which hangs the Foucault pendulum. They are Aries, the Ram; Taurus, the Bull; Gemini, the Twins; Cancer, the Crab; Leo, the Lion; Virgo, the Virgin; Libra, the Scales; Scorpius, the Scorpion; Sagittarius, the Archer; Capricornus, the Sea-Goat; Aquarius, the Water-Bearer; and Pisces, the Fishes.

▲ In front of Atlas are the east and west winds. The winged figures near his shoulder are his daughters, the Pleiades. Below them is the blind giant, Orion, with Kedalion on his shoulders to act as guide.

▲ Above the entrance to the west gallery is Jupiter holding thunderbolts. The sphere in front of him is the planet named after him. The larger circle is a symbol of perpetual motion. The four falling children represent spring, summer, autumn and winter. Next to them is Venus, who was born out of the foam of the sea.

▲ Above the main entrance sits Saturn holding a cup containing the drink which caused him to disgorge his children, shown below him—Ceres, Pluto, Juno, Vesta and Neptune. He swallowed them, because he had learned that one of them would dethrone him. The next figure is Mercury, the messenger of the gods. He has wings on his hat and on his ankles. He holds the caduceus, a rod entwined with two serpents and surmounted by wings.

▲ Above the entrance to the east gallery a woman holds a star radiating a golden cross, symbolic of the Star of Bethlehem. The seated figure of the man represents an early observer of the heavens. Next to the right appears the moon, on which there is a heifer. Nearby are some of the eyes of Argus. In this myth, Jupiter fell in love with Io, and to protect her from the wrath of Juno, his wife, he turned Io into a heifer. Juno had 100-eyed Argus watch the heifer. Jupiter sent Mercury to kill Argus, which he finally succeeded in doing. The eyes were placed as ornaments on the tail of the peacock.

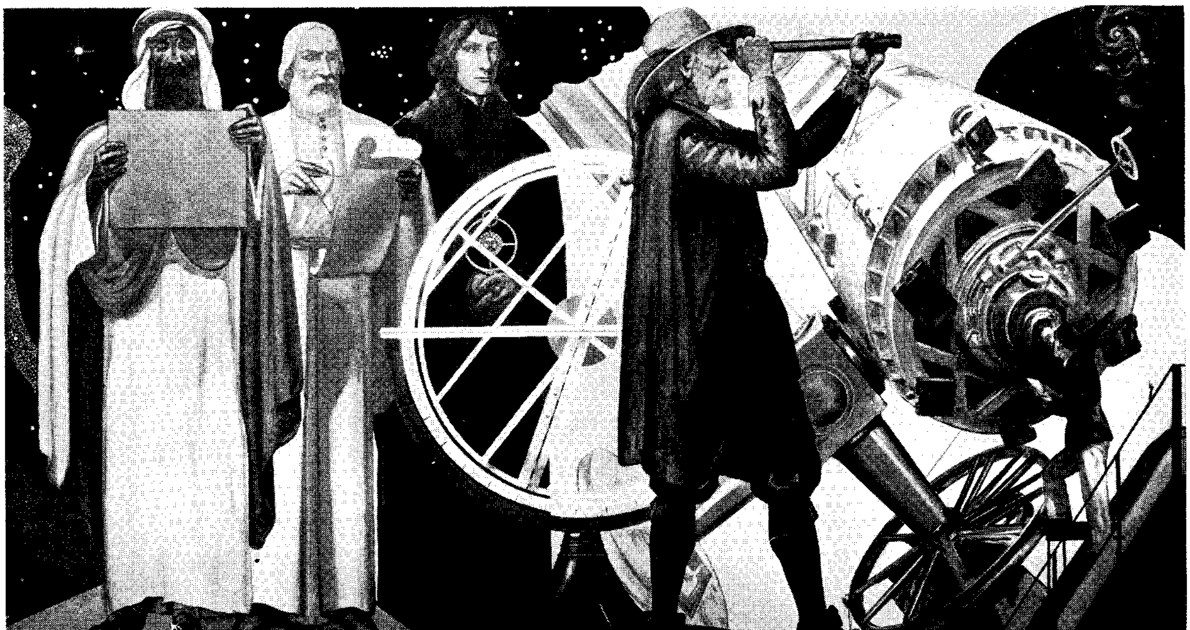
▲ The many-legged figure is the artist's conception of a comet. That brings us back to Atlas. Under him on four tablets are the symbols of the four largest planets, Jupiter, Saturn, Uranus, and Neptune. These are repeated over the main entrance and over the entrances to the east and west galleries. Under Orion are four tablets containing the symbols for Mercury, Venus, the Earth, and Mars. These also are repeated in three other sections.

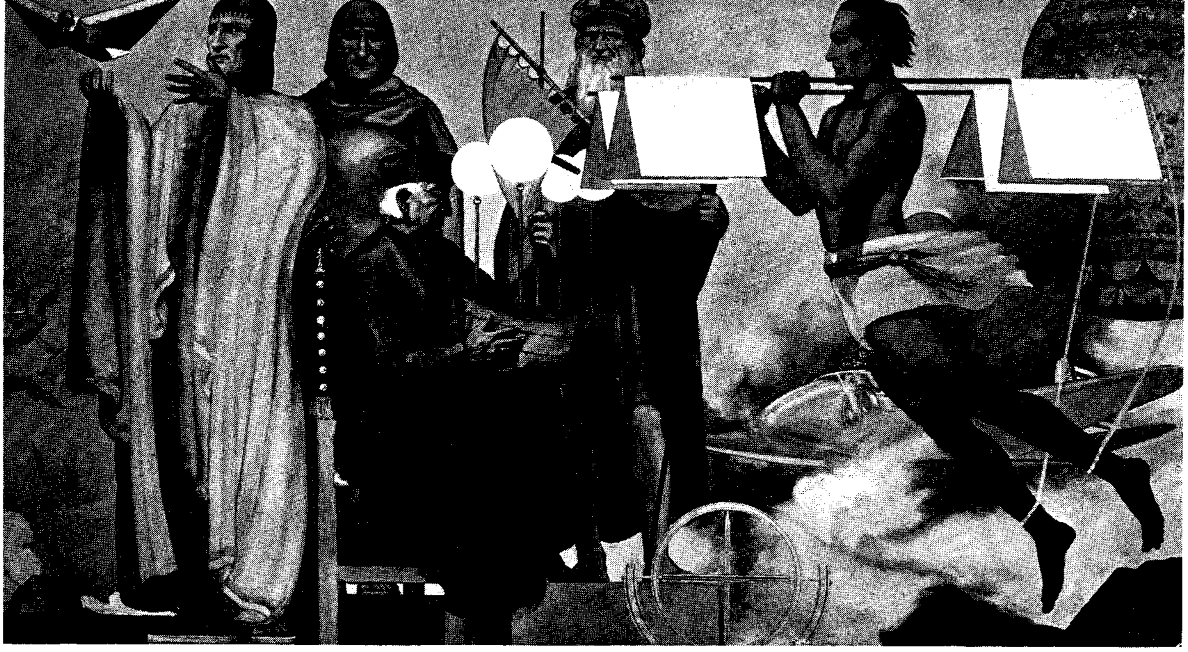
Panel No. 1 ASTRONOMY

▲ Opposite the main entrance to the building is a group of astronomers, standing against a black sky in which appear such familiar objects as the North Star, the Big Dipper, the Milky Way, and a spiral galaxy. On the left is Arzachel, who published in 1080 a volume of astronomical tables, known as the Toletan Tables, because they were calculated for an observer at Toledo, Spain. Arab astronomy was transported by the Moors to Spain, and these tables were the most important work produced there at that time, marking the dawn of European science.

▲ The second figure is an early English astronomer, John Holywood, better known by the Latin name of Sacro Bosco, who died about 1256. He wrote an elementary text-book on the easier parts of current astronomy, and it was called "Sphaera Mundi." It dealt principally with the more obvious results of the daily motion of the celestial sphere. It was one of the first astronomical books ever printed, and it enjoyed great popularity for several centuries.

PANEL No. 1—ASTRONOMY





PANEL No. 2—AERONAUTICS

▲ The third astronomer is a Polish Monk, Copernicus (1473-1543), standing behind an early astronomical instrument known as an armillary sphere. He brought about a great revolution in thought by suggesting that the earth was not the center of the universe. He placed it in its true place as one of the planets revolving around the sun.

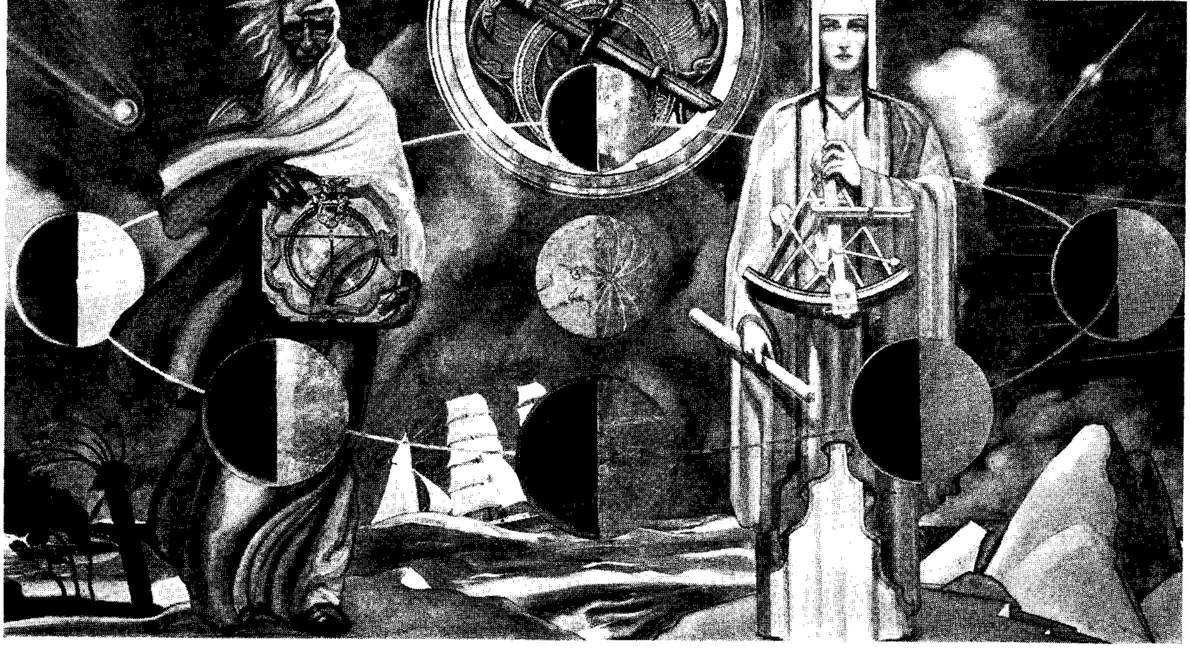
▲ The next figure is an Italian scientist, Galileo (1564-1642), looking through one of his telescopes, the first to be used for a study of the heavens. On the extreme right is a modern astronomer observing with one of the large reflecting telescopes of today.

Panel No. 2 AERONAUTICS

▲ The panel above the information desk is devoted to aeronautics. In 400 B.C. Archytas of Tarentum, Italy, is said to have made a wooden pigeon that could fly. Next to him stands Roger Bacon (1214-1292), celebrated English philosopher, with his floating ball. Seated in the foreground is Francesco de Lana holding a model of a flying boat which he conceived about 1650. The plan was to attach a boat with sails to four large copper balls from which the air had been exhausted. That he foresaw the evils of aviation is shown in his prophecy: "No city can be secure against such an attack (by air). Ships may at any time be placed directly over it, and descending, may discharge soldiers."

▲ In the center stands Leonardo da Vinci (1452-1519), the great Italian painter, sculptor, architect, engineer, musician, and natural philosopher. He is best known as an artist, especially because of his paintings, "Mona Lisa" and "The Last Supper," but much of his life was devoted to the study of aeronautics. He studied the flight of birds, and many of his drawings still remain as a testimony to his understanding of the fundamental principles of aviation. In his conception of a flying machine about 1500, the wings or oars were to be operated by a system of pulleys. Leonardo said: "If the accomplishment be not for me, 'tis for some other. The spirit can not lie; and man shall have wings, shall indeed be as a god." Experts say that if he had had at his disposal some power like that furnished by the gasoline engine, he would have successfully navigated the air.

▲ The first successful glider was made in 1678 by Besnier, a Frenchman. He placed two rods over his shoulders, and on their ends were frames of cloth which acted as supporting kites. In the upper right corner is an early Montgolfier balloon. The first known flight made by a lighter-than-air balloon was one filled, not with gas, but with heated air. In 1783 the two Montgolfier brothers inflated



PANEL No. 3—NAVIGATION

their balloon over a fire. It rose rapidly and remained aloft about ten minutes. On a later flight at Versailles, France, in the presence of Louis XVI and Marie Antoinette, three passengers, consisting of a cock, a duck, and a sheep were carried up in the air and landed safely two miles away.

▲ In the background is shown a modern airplane, and in the foreground is a gyroscope, which is used in such instruments as the turn and bank indicator, the automatic pilot, the gyro-stabilizer, and the gyro-compass.

Panel No. 3 NAVIGATION

▲ Above the entrance to the west gallery, the two figures are symbolical only. On the left is an old man, Wind, holding a sundial and a compass. On the right is Calm, with a modern sextant. Around these figures the moon is shown in different positions in its orbit, with the earth at the center and the sun's rays coming from the right. In the upper left is a comet and in the upper right a spiral galaxy seen edgewise. In the upper center is an astrolabe, an early astronomical instrument used for measuring altitudes. Below in the background is a ship sailing out of a tropical storm into the polar regions.

Panel No. 4 CIVIL ENGINEERING

▲ In the center of this panel are two powerful figures, symbolizing the contending forces within the earth which have caused the earthquake in the upper background. The two oxen at the upper left furnish power to pump water through the irrigation ditch to the tree at the

PANEL No. 4—CIVIL ENGINEERING

PANEL No. 5—METALLURGY AND ELECTRICITY

lower left. An Egyptian holds in his right hand the symbol of life and in his left hand a scepter in the form of a measuring rod and a flail, symbolic of driving men to work. Behind him is a pyramid, an outstanding engineering achievement of the ancient world. The star in the upper left corner is Sirius, the brightest of all stars. This was highly regarded by the Egyptians, because its appearance in the east just before the rising of the sun warned them of the annual overflow of the Nile.

▲ Modern engineering is represented on the right by Hoover Dam and a surveyor with a measuring rod and a theodolite.

Panel No. 5
METALLURGY AND ELECTRICITY

▲ The panel above the front door to the building is twofold in its character. On the left, devoted to metallurgy, is Saint Florian, of Austria, pouring water on fire. Behind him is a converter, used in the Bessemer process of making steel.

▲ The remainder of the panel is devoted to electricity. In the center, the kite and the hand drawing a spark from a key remind us of Benjamin Franklin's experiment in bringing electricity from the clouds. Below are the towering smoke stacks of the modern generating plant. The sphere and two pillars represent part of a high tension apparatus, from which a long spark is being discharged. On the right is Otto von Guericke, of Prussia, who constructed about 1663 a primitive form of frictional electrical machine. It consisted of a globe of sulphur fixed on a wand, and it was electrically excited by the friction of the hands rubbing against it. Behind him is a conventionalized dynamo, and in the lower right is a drawing of an internal combustion engine.

Panel No. 6 — TIME

▲ At the left an Aztec is pointing to the calendar stone of Mexico. The Aztec system was the same as the Maya, in which the year consisted of 18 months of 20 days each, with five supplementary days at the end. A circular band about half way out from the center of the stone shows the 20 day signs. In the extreme lower left is the head and gaping mouth of the feathered serpent, which was the Aztec's deity. Emerging from the open mouth is a human head, indicative of the Aztec notion of the relation between the human and the divine.

▲ In the upper center is the Chinese Emperor, Yao, who lived about 2300 B.C. and was especially interested in astronomy. The scene in the lower center is that of the beheading of the Chinese astronomers, Hsi and Ho. According to tradition, they were thus punished, because they were drunk and failed to predict an eclipse of the sun and perform the customary rites at such a time. On the right sits the Persian prince, Ulugh Begh, the grandson of the savage Tartar, Tamerlane. About 1420 he

PANEL No. 6—TIME

built an observatory at Samarkand, where he re-determined with unusual precision the positions of nearly all of the stars observed by Ptolemy.

Panel No. 7 GEOLOGY AND BIOLOGY

▲ This panel above the entrance to the east gallery deals with the earth and its life. A very old man symbolic of geology holds a card on which appear the various crystalline forms of minerals. Below him are snow-capped mountain peaks and behind are folded layers of rocks. In the center a biologist is looking into a microscope. Below him are the embryo of a chicken, a plant, and a crab. The figure on the right is symbolic of paleontology, that branch of geology which deals with the life of past geological ages. The skull of a saber-toothed tiger and the skeleton of an early type of fish are shown. The waves of water at the bottom symbolize the origin of life, while a man and a woman above are looking upward for an answer to the question of the meaning of life.

Panel No. 8 MATHEMATICS AND PHYSICS

▲ On the left is a Greek holding circles and a triangle. Behind him is an ibis which symbolized the Egyptian god, Thoth, measurer of time and inventor of numbers. The Arabian looking at a slab typifies the contribution of his race to mathematics. The man seated is representative of physics, and the figure above him is coming to the earth from the Infinite.

▲ In arriving at the law of gravitation, Isaac Newton developed the very important branch

PANEL No. 7—GEOLOGY AND BIOLOGY

PANEL No. 8—MATHEMATICS AND PHYSICS

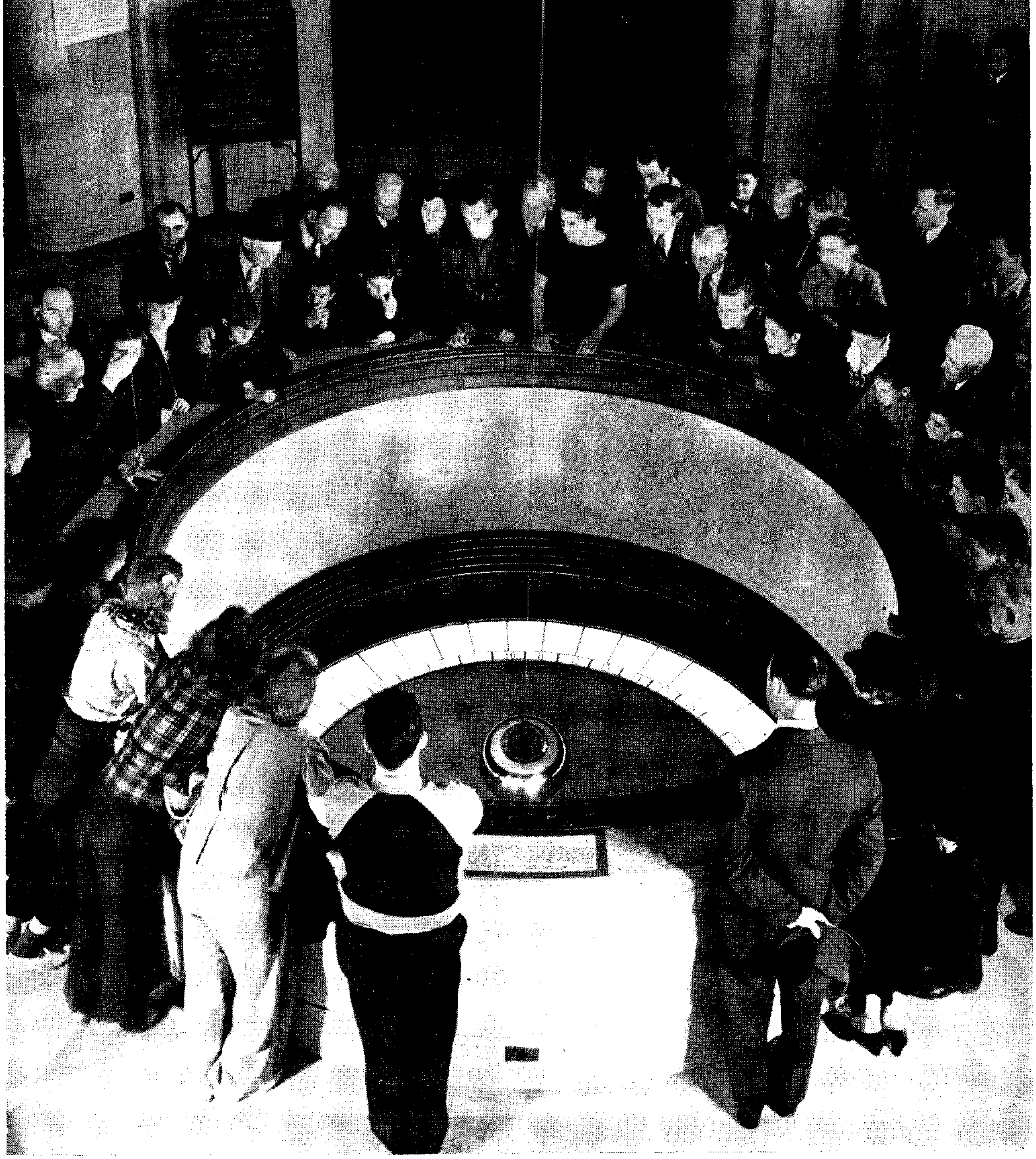
of mathematics known as the calculus. He is shown talking to three students. One holds a jar of water with a cloth in it as symbolic of capillary attraction. The second student illustrates gravity by dropping a ball. The third student holds a horseshoe magnet, and behind him is the magnetic needle.

FLUORESCENCE

▲ When light waves, especially in the ultra-violet region of the spectrum, strike the atoms of many minerals, liquids, dyes, and chemical compounds, energy is absorbed from the light waves by the atoms and then radiated as visible light of a longer wave length. This is called fluorescence. But if the substance continues to emit light after the stimulus is removed, the phenomenon is called phosphorescence.

▲ In this exhibit light from a quartz mercury vapor lamp source falls upon numerous mineral specimens, such as calcite, fluorite, franklinite, scheelite, and willemite. There are three different conditions of lighting: first, the minerals are seen in their natural drab color by ordinary white light of all visible wave lengths; second, under the mercury light they fluoresce in beautiful tints of green, rose, purple and blue; third, when all light is extinguished, some minerals continue to glow, thus showing the phosphorescent effect.

THE FLUORESCENT COLLECTION
Light invisible to the human eye causes these minerals to take on the most beautiful of color tints.



THE FOUCAULT PENDULUM
This exhibit demonstrates and proves the rotation of the earth on its axis

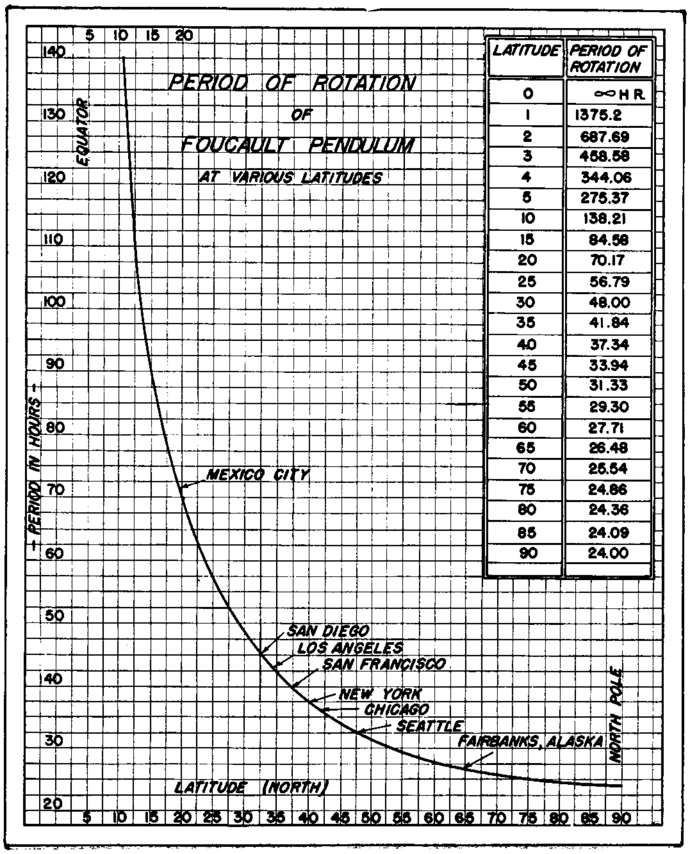
THE FOUCAULT PENDULUM

▲ The first exhibit which one sees on entering the Hall of Science at the Griffith Observatory is an extremely long pendulum. The steel wire is 40 feet long and the brass ball weighs 240 pounds. The ball swings slowly back and forth near the bottom of a pit. Around the pit is a scale which divides the circumference into 42 parts. If the observer watches the pendulum for perhaps a half hour, he finds that apparently its direction has changed and that it is vibrating in a different direction from what it was when he entered the building. After an hour or so he observes that this apparent change in direction takes place at such a rate that after approximately 42 hours the pendulum would be sweeping once more between the same scale numbers that it was at first.

▲ The Foucault pendulum was an invention of Jean Foucault (pronounced Foo-ko), a French physicist of the middle of the last century. In 1851 he suspended a very heavy iron ball from a wire more than 200 feet long, fastened to the dome of the Pantheon in Paris. At the bottom of the ball was a little wire which scratched a record of the pendulum's motion in sand which had been sprinkled on the floor. To insure as perfect as possible a vibration in one plane, the pendulum was started by drawing it to one side with a cotton cord and allowing it to hang in this position until all vibrations had ceased. When this occurred, the cord was burned, in order that it might swing without having any sidewise motion imparted to it. At Paris, it was found that the pendulum appeared to change direction at such a rate that it would make a complete circuit of the compass points in 32 hours.

▲ A clock pendulum is actuated by a force transmitted to it through the escapement. A force must not be given in this manner to the Foucault pendulum, because it would impart a definite direction to the swing. Foucault devised a magnetic control which had no sidewise component but, nevertheless, excited the motion enough to compensate for the friction of the air which otherwise, after a comparatively short time, would have brought the pendulum to rest.

▲ It is quite easy to see what happens to such a pendulum if set up at the north pole of the earth. The earth turns under the pendulum and, therefore, turns the support and twists the wire. However, this twisting of the wire does not affect the direction of motion of the bob. One may prove this for himself very nicely by suspending a pendulum from a piece of board and then turning the board slowly in a horizontal plane. He finds that the pendulum does not change its plane of vibration. At the north pole of the earth, the pendulum must remain vibrating in exactly the same plane that it was started, and the earth turns under it at a rate to make a complete revolution in 24 hours.



LATITUDE	PERIOD OF ROTATION
0	∞ HR.
1	1375.2
2	687.69
3	458.58
4	344.06
5	275.37
10	138.21
15	84.58
20	70.17
25	56.79
30	48.00
35	41.84
40	37.34
45	33.94
50	31.33
55	29.30
60	27.71
65	26.48
70	25.54
75	24.86
80	24.36
85	24.09
90	24.00

▲ For places other than the poles, the derivation of the law of the Foucault pendulum is quite complicated. Both the earth's surface and the pendulum change direction. The result is that the farther we go from the poles the longer it takes the pendulum to make an apparent revolution. By the time we get as far south as Paris, it requires about 32 hours, in Los Angeles 42 hours and at the equator there is no change in apparent direction.

THE MOON MODEL

THE MOON MODEL

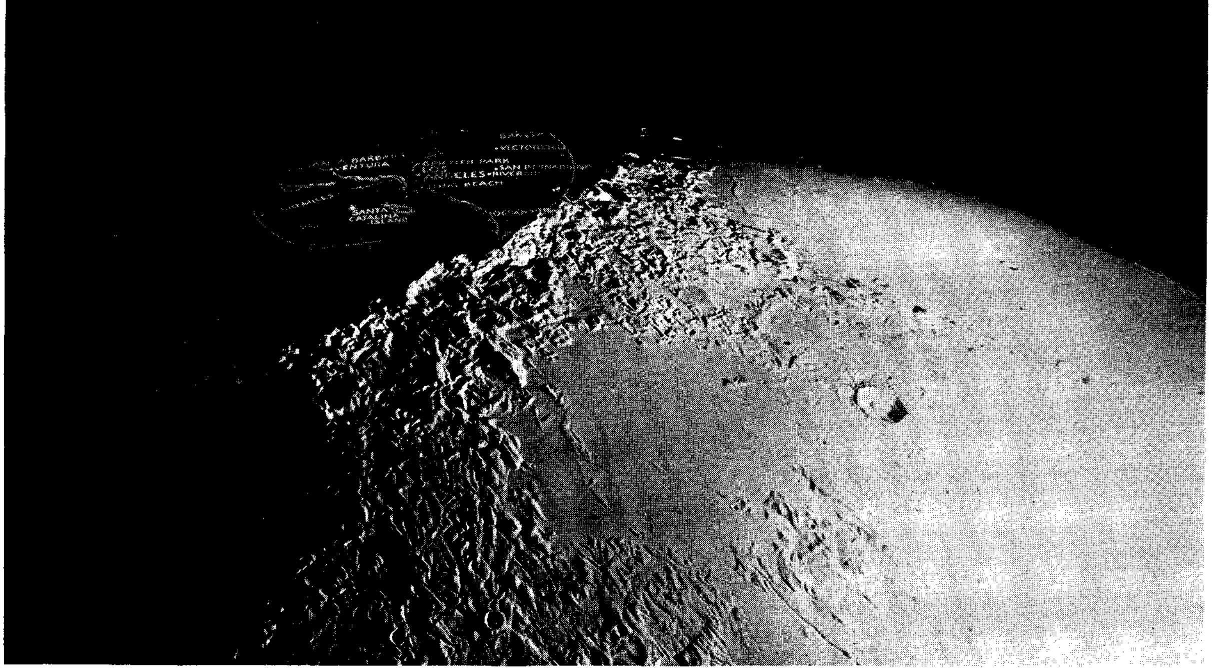
▲ By means of the moon model, the visitor sees how a portion of the moon would appear if he could view it from a space ship about 500 miles above the moon's surface. The mountains, craters, and other lunar features have been faithfully reproduced from photographs of the moon taken with the 100-inch telescope of the Mount Wilson Observatory.

▲ The model shows how the moon appears as different portions of it are lighted up by the sun. In nature the moon revolves around the earth about once a month, and it rotates on its axis in the same time, thus keeping the same side turned toward the earth. The moon is invisible at the time of new moon, because it is between the earth and the sun, and the side facing us receives no direct sunlight. After two or three days the moon has moved far enough around the earth so that a part of its earthward side is lighted by the sun. It can be seen just after sunset, low in the western sky, as a thin crescent. About one week after new moon, half of the side turned toward the earth is lighted. The moon has gone one-quarter of the way around the earth, and this phase is first quarter.

▲ About two weeks after new moon, we see the moon fully illuminated. Full moon occurs when the moon is on the opposite side of the earth from the sun. When the moon has gone three-fourths of the way around the earth, the phase is last quarter, and the moon looks like the first-quarter moon turned around. At the end of about a month, the moon is again invisible as it passes between the sun and the earth.

▲ The moon's phases are simulated in the model by means of an electric lamp, invisible to the observer, which moves in a circular path and illuminates varying portions of the model. This moving lamp reproduces the changing direction of the sun's rays and throws the features of the lunar surface into greater or less relief as the shadows lengthen or shorten.

▲ The main features of the moon's surface are the plains, the mountains, and the craters. The plains are the large dark areas which are visible to the unaided eye. Formerly they were supposed to be large bodies of water, and they still bear the watery Latin names which were given to them. An example is Mare Imbrium, the Sea of Rains. It is now known that the moon has no water. Also it has no air.



MAP OF SOUTHERN CALIFORNIA SUPERPOSED TO SCALE ON THE MODEL OF THE MOON

▲ The lunar mountains are much higher in proportion to the moon's diameter of 2160 miles than terrestrial mountains are to the earth's diameter of 7900 miles. Some lunar peaks reach a height of about five miles. A conspicuous range shown in the model is the Apennines, which rises like a wall from Mare Imbrium. The names of the principal lunar features are projected at intervals on the model. Also a projector throws on the model a circular map with Los Angeles at the center and with a radius of 100 miles.

▲ The visible craters on the moon exceed 30,000 in number. They are of all sizes from about 150 miles in diameter downwards. It is not known how the craters were formed. Many of them may be the result of volcanic eruptions. If so, they must be ancient formations, because there is no evidence of present volcanic activity. Some craters probably have resulted from the fall of large meteorites. Terrestrial craters caused in these two ways are represented by models in an adjoining case. That of Crater Lake in Oregon illustrates volcanic origin and that of Meteor Crater in Arizona shows the result of a fall of a large meteorite.

▲ The moon is a dead world. The lack of air and water make life impossible there and produce conditions surprisingly different from those on the earth. There are no clouds, no wind, no rain, no snow, and no sound. Without air to scatter the sun's light, the sky is black instead of blue and the stars are visible all the time. Since the moon turns on its axis only once a month, sunlight lasts continuously for about two weeks, followed by about two weeks of darkness. This combined with the absence of a protective blanket of air results in a range of nearly 450 degrees in temperature on the Fahrenheit scale. During the long days the lunar rocks reach a maximum temperature of over 200 degrees above zero, about the boiling point of water, but during the equally long nights the temperature must reach nearly 250 degrees below zero Fahrenheit. The moon lost whatever atmosphere it may have had because its mass is not large enough to hold the rapidly moving molecules of gas. Gravity at the moon's surface is only one-sixth as great as that on the earth's surface. A man weighing 150 pounds on the earth would weigh only 25 pounds on the moon. He could jump high enough to raise the center of gravity of his body six times as far as he could raise it on the earth. A six-foot man jumping over a bar six feet high on the earth raises his center of gravity three feet. On the moon he would be able to raise it 18 feet, and thus he could jump over a bar 21 feet high. A baseball batted 450 feet on the earth would travel half a mile, if hit with the same force on the moon.

FRAGMENT FROM THE CANYON DIABLO METEORITE
This 268-pound metallic meteorite, a part of the one which formed Meteor Crater in Arizona, may be handled by the public.

METEORITES

▲ Meteorites are masses of solid matter which fall to the earth from outer space. They constitute our only tangible source of knowledge of the universe beyond the earth. Our knowledge of the sun, moon, planets, and stars has been derived from a study of the rays of light which come from them. Meteorites, however, can be handled, examined, and analyzed in the same way as terrestrial substances, and they yield information from regions of space beyond the earth.

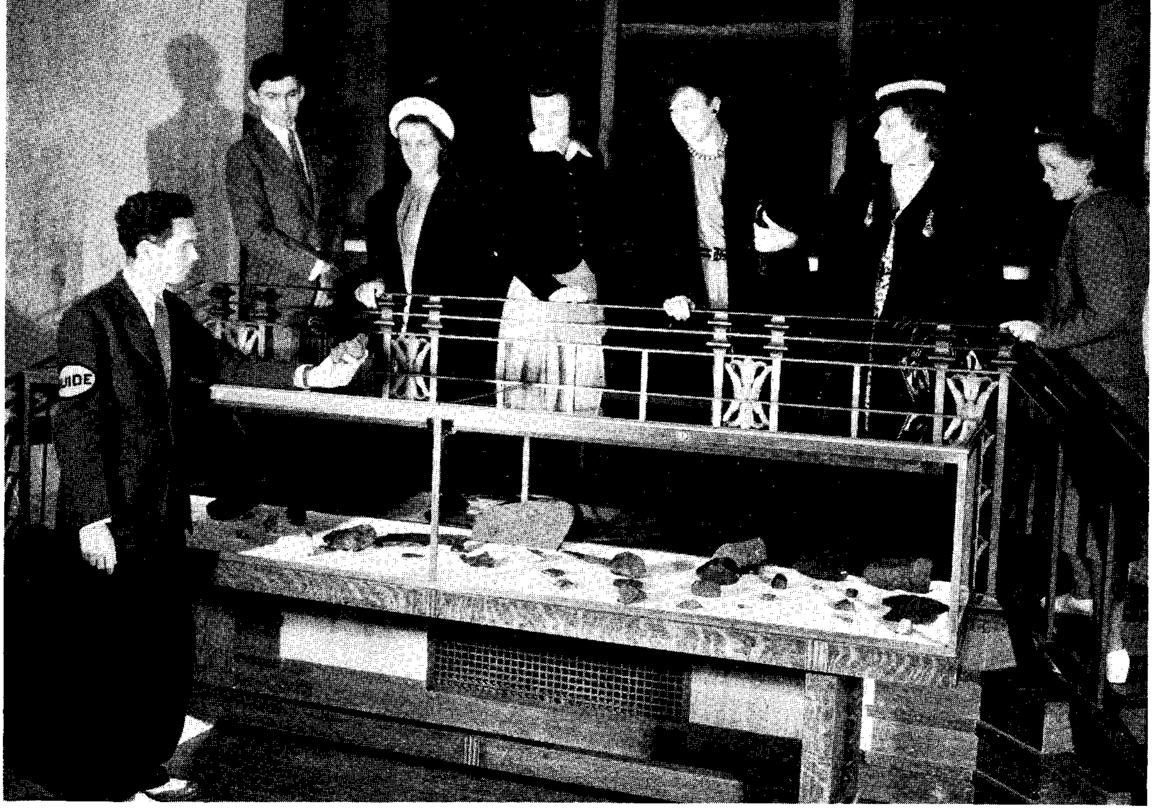
▲ When one of these celestial visitors passes through the earth's atmosphere, it produces a display of light, the intensity of which depends principally on its velocity and size. Most of the objects with which the earth collides are probably no larger than grains of sand, but they are heated enough by friction with the air to become vaporized and visible at a height of about 75 miles above the earth's surface. They are the familiar "shooting stars" or meteors. If a body is large enough, it can survive its passage through the air and reach the ground, with the production of considerable light and sound. Specimens have been preserved from about 1400 different falls, and of these the Griffith Observatory has a representative collection, ranging in weight from less than an ounce to 268 pounds.

▲ Meteorites may be divided into three broad classes:

1. The irons, called siderites, are composed of nickel-iron alloy, containing 5 to 15% nickel and 85 to 95% iron.

2. The stones, called aerolites, are similar to rocks of the earth, but usually contain metallic iron particles scattered throughout the mass.

3. The stony-irons, called siderolites, are composed of a sponge-like mass of iron with the spaces filled with rock materials.



THE GRIFFITH OBSERVATORY COLLECTION OF METEORITES
Polished sections of the iron and stone from space intrigue the visitor. Guides explain this collection.

▲ Iron meteorites are rough, angular, and irregular in shape, and have a pitted outside surface. Those of recent falls are black, but those of old falls are rust-brown. They show beautiful markings in cross section, due to the crystalline structure of nickel-iron alloys. These Widmanstetten figures, as they are called, are brought out by acid etching a polished surface.

▲ Stony meteorites have a burnt pebbled crust, which is black on recent falls and rust-brown on old falls. A good test is to hold the stone in question against a revolving emery wheel for a few seconds. If iron particles are revealed to the unaided eye or under a magnifying glass, the stone is fairly certain to be a meteorite. The stones are heavier than ordinary rock due to the iron which runs from about 10 to 15%. They are always solid masses, and are never porous or like cinders. The specimen from Holbrook, Arizona, fell on July 19, 1912, and is one of about 15,000 stones which spread over an area three miles long and half a mile wide. This is a good example of a shower of meteorites, which results from the bursting of a large mass during its passage through our atmosphere. The total weight of the pieces which have been recovered from this shower is about 500 pounds, and the largest individual weighs 15 pounds. On May 2, 1890, 500 stones weighing 268 pounds fell near Forest City, Iowa, and on June 30, 1918, several stones totalling about 200 pounds fell near Richardton, North Dakota.

▲ The surface of a stony iron is pitted, and is black on recent falls and yellow-brown on old falls. One of the commonest types is pallasite. The cross section shows a sponge-like matrix of iron with the spaces filled with rock. Due to their structure, these meteorites are more easily broken up. Several thousand masses were recovered in 1885 from the fall near Brenham, Kansas. The date of the fall is not known. This type of meteorite is the rarest of all, less than 75 falls being known throughout the world, as compared with about 800 for the stony meteorites and about 500 for the irons.

▲ Between ten and fifteen tons of iron meteorites have been found in the vicinity of Meteor Crater, Arizona. The largest specimen weighs about 1500 pounds and is in the Colorado Museum of Natural History in Denver. The Griffith Observatory has a piece weighing 268 pounds and several smaller ones. They are referred to as the Canyon Diablo meteorites, named from a gorge located about three miles west of the crater, which is about 24 miles west of Winslow and 45 miles east of Flagstaff. A small model of this crater is in the Griffith Observatory near the entrance to the planetarium chamber. The crater is 4250 feet in diameter, nearly 3 miles in circumference, and about 600 feet deep. The rim of the crater rises 135 feet above the plain, and is covered with fragments of rock ranging in size from boulders as large as a family garage to tiny particles of sandstone, known as "rock flour." Explorations by means of shafts and drillings prove that, except for its content of crushed rock which has fallen in during and subsequent to the blow which produced it, the depth of the crater would be about 1400 feet. The amount of rock dislodged and partly thrown out of the crater has been estimated at over 300,000,000 tons.

▲ How large a mass produced this crater and when it fell are not known. The amount of weathering and other evidence in the bowl indicate that it was formed probably several thousand years ago. Close study of the layers of rock indicated that the meteorite had come in at a low angle from the northeast, and that it should therefore lie beneath or beyond the southwestern rim. A thousand feet below this part of the rim, a drill encountered hard bodies containing iron and nickel. At about 1400 feet the drill became stuck, and could not be removed. The condition of the meteorite and the amount of it buried there still remain a mystery.

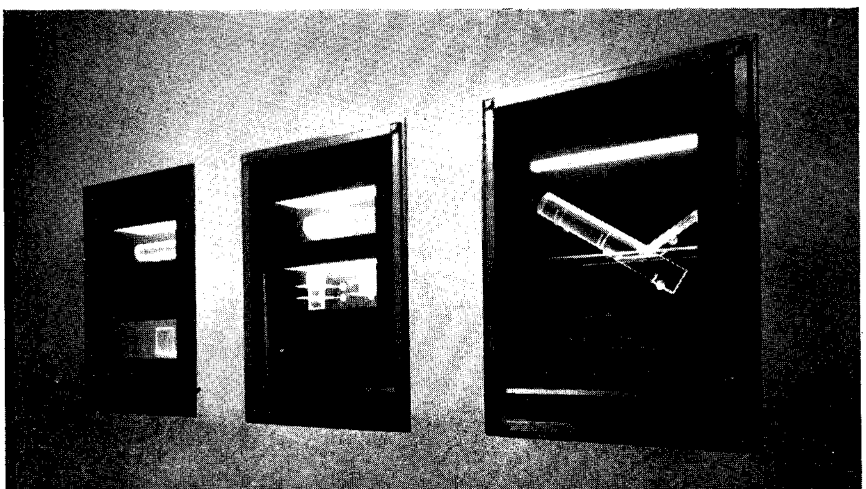
THE ALCOVE OF POLARIZED LIGHT

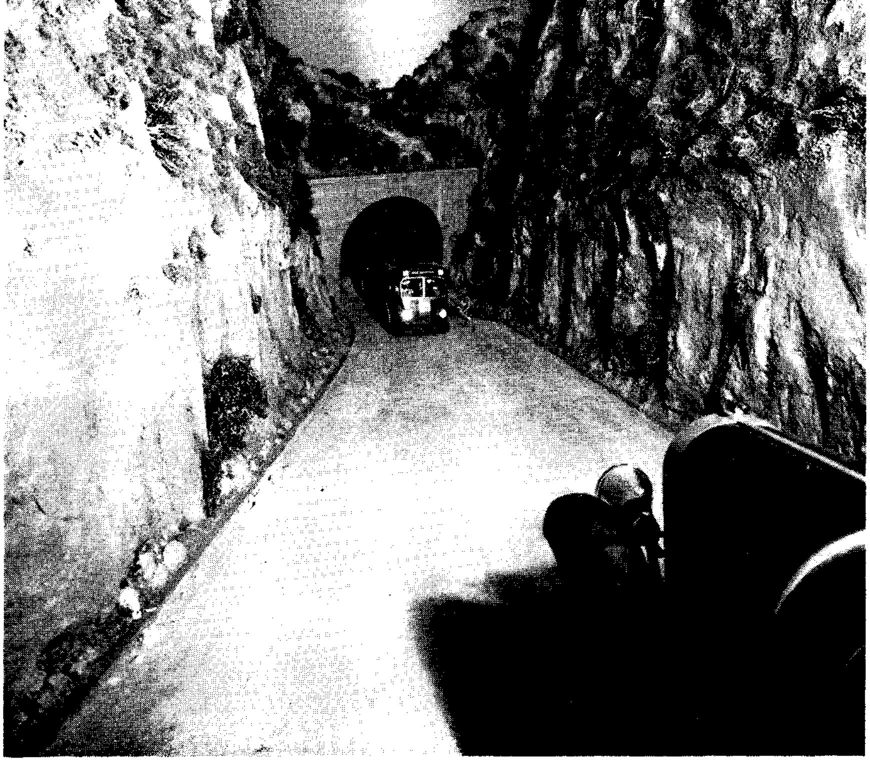
▲ When light is passed through certain crystalline mineral substances, it is changed in form. However, the eye cannot directly discover this fact. After it has been changed in this way, it will not again pass through these same substances unless they are turned in a proper direction. Light which has been so changed is called polarized. It can also be polarized by reflection and by other methods.

▲ This type of light is attracting rapidly increasing attention from the public, due to the numerous commercial applications made of it in recent years. As a result, a whole alcove containing seven exhibits tells, in the simplest manner possible, the story of this modification of light.

▲ The first three exhibits are schematic models, mainly in illuminated transparent material, to give a mechanical explanation of this form of light, and of the way in which it is produced.

MODELS TO EXPLAIN POLARIZED LIGHT





POLARIZED LIGHT EXHIBIT

This realistic scene demonstrates most clearly how polarized light soon will make driving safe.

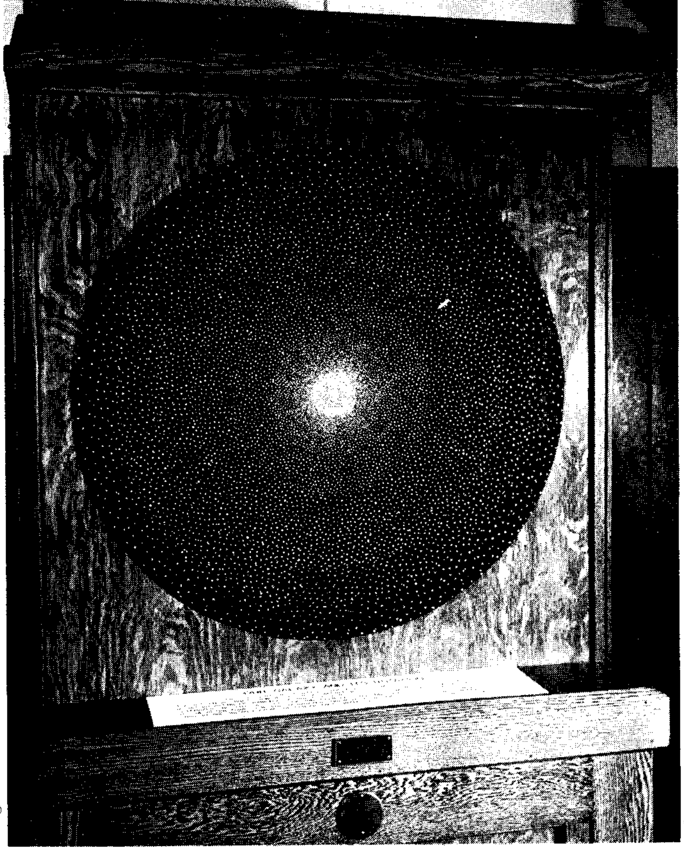
▲ The last four exhibits show actual uses of polarized light. The first of these four is an exhibit of a canyon road approaching a tunnel. A bus is seen emerging from the tunnel. Its headlights blind the observer to detail on the road. However, the lights do come through a piece of **polaroid.** When the visitor, by turning a knob, properly lines up a second piece of polarizing material, the glare dims, and a child who has fallen from a bicycle in the road at the side of the bus becomes visible for the first time.

▲ Another exhibit permits the visitor to melt some crystals of resorcinol. The crystals have been placed under a compound microscope so arranged as to project on a screen a much enlarged view of the crystals. The thickness of the various crystals determines the color. The melted resorcinol does not affect the light, but as it cools and the crystals form, they appear on the screen in a wonderfully beautiful pattern of many colors. Never twice will the formations be the same.

▲ In the last exhibit a hundred-pound weight is caused to rest on a piece of glass. This produces strains in the glass which the polarized light shows as a colored pattern. The pattern disappears as soon as the weight is lifted.

THE ROTATION OF OUR GALAXY

▲ Our sun is merely a small star — one out of a hundred thousand million stars that compose a system or galaxy. This galaxy is one from approximately 100 million galaxies within the range of the 100-inch telescope at Mount Wilson. The 100,000,000,000 stars of our own galaxy are scattered across a space so big that it takes light 100,000 years to cross it, traveling at the rate of 186,000 miles each second. The distance is approximately six hundred quadrillion (600,000,000,000,000,000) miles.



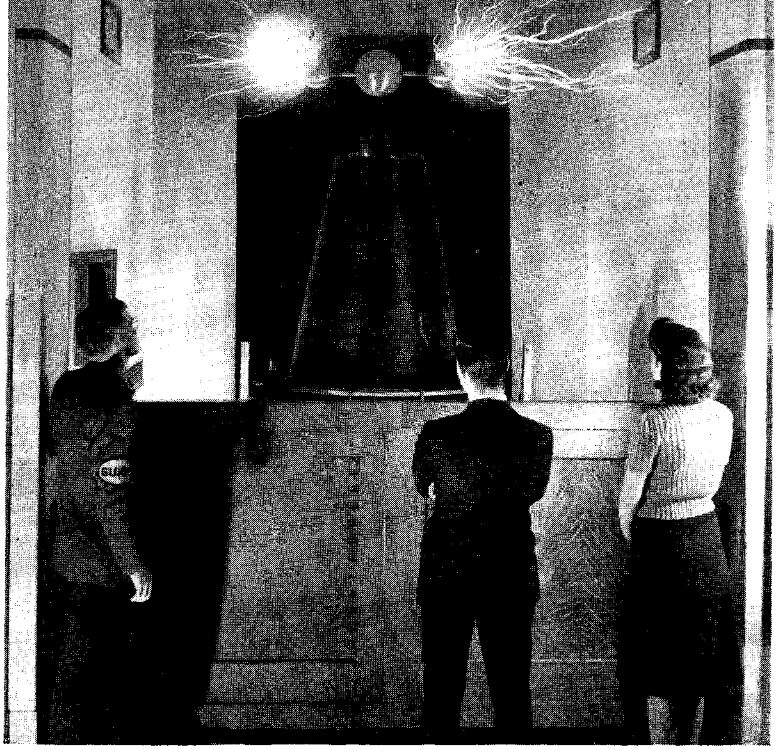
MODEL SHOWING HOW OUR GALAXY ROTATES

▲ The stars of the system form a cloud which is shaped somewhat like a pancake that has a big bubble blown in its center. Our sun is approximately half way from the center of the pancake to the rim, and the cloudy path of our Milky Way is the appearance resulting from our position within the plane of the pancake. When we look along this plane we see many more stars and more distant stars than in any other direction. Perpendicularly to the plane we find the last star of our system at perhaps not more than a tenth as far away as is the last star in the plane.

▲ The bright part of the Milky Way marks the "bubble" which is at the center of our system. In it the stars are somewhat more closely packed together. If it were not for large masses of cold gas and dust in space, our Milky Way would be so bright that it would make the night much brighter than does the full moon. Such a sky would be wonderfully beautiful, but its brightness would have the disadvantage of hiding from us all the other galaxies of space and the many faint objects that are studied by astronomers.

▲ The stars of our galaxy move rather loosely in paths around its center, somewhat as the planets move around the sun. It is estimated that the stars at our general distance from the center require about 200 million years to complete their paths.

▲ The exhibit shows this revolution. The stars nearest the center move fastest, just as the planets nearest the sun move fastest. Narrow concentric metal rings contain the stars. Each ring moves more slowly than the smaller ones. The rings are narrow enough and perfectly enough fitted together that at a distance of a few feet their boundaries merge and the galaxy seems to be a swarm of moving points. Watching it, the observer sees distant stars gradually approaching the sun, finally becoming close enough that they are within naked eye range, then passing us and receding until again they are lost in the host of faint objects. This close passage is the same sort of thing that we observe today in the very bright star Arcturus. 500,000 years ago Arcturus was barely close enough to be visible to the naked eye and at present is almost at the closest that it ever will be. During the next few thousand years it will begin to move away and at the end of another 500,000 years, once more will be invisible to us.



THE HIGH VOLTAGE COIL

HIGH VOLTAGE COIL (Tesla Coil)

▲ From the earliest records we read of man's wonder at and fear of lightning. Zeus, of the Greeks, who became Jupiter to the Romans, carried lightning in his hands. His northern equivalent, Thor, carried a hammer, the thunderbolt, which would return to him like a boomerang after he had cast it at his foes. Benjamin Franklin, of a more scientific turn of mind than the earlier story tellers, demonstrated that lightning is identical with the toy, electricity, which intrigued men of his day.

▲ Very early in the development of electrical apparatus men were able to get a short spark with a sharp crackle which suggested the experiment carried out by Franklin. Two generations ago this spark had become a foot or more in length and the crack almost deafening if heard in a closed room.

▲ Man, however, could not create the tremendous electrical pressure (voltage) necessary to obtain the bolts many feet long that have been supplied so prodigiously by nature. Only during the last two decades with millions of volts available has he been able to produce very minor lightning strokes.

▲ This coil, with an electrical pressure of more than a million volts, produces sparks several feet long which bear a great resemblance to natural lightning.

▲ In changing electricity at ordinary voltage to that which produces these long sparks, there is no creation of energy. Merely the pressure is increased. It is somewhat similar to the use of a lever. A small pressure at the end of the long arm enables one to exert a pressure on the other end great enough easily to lift an automobile. The coil increases electrical pressure enough that the electricity presses its way through several feet of air.

▲ The electrical discharge of the exhibit differs from lightning, however, in that it reverses its direction of flow with tremendous rapidity. From this characteristic it loses most of its danger to man. Indeed, one who knows what he is about can receive the spark on a metal rod held in his hand and yet experience no discomfort. The innocent appearing primary coil at the base, on the other hand, is death dealing.

▲ At frequent intervals guides operate the coil and give explanatory talks.

ELECTRICAL DISCHARGE THROUGH GASES

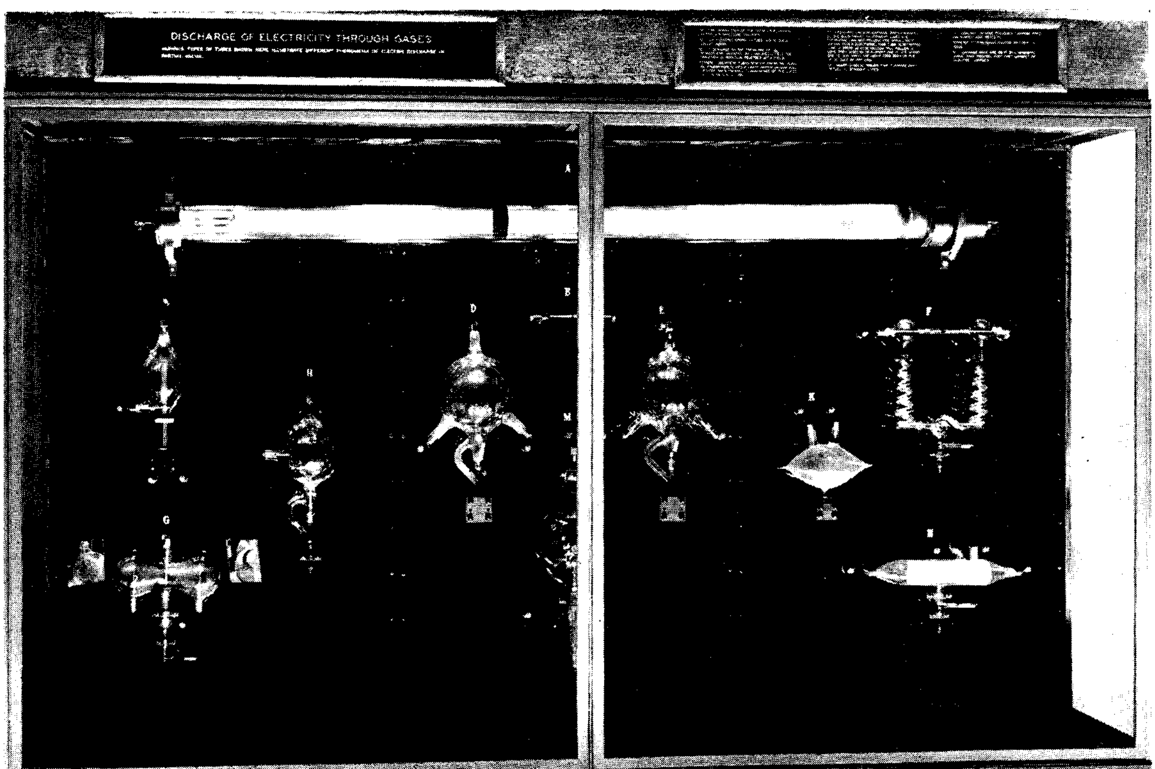
▲ Many kinds of electrical discharge tubes have come into every day life. They perform a myriad of services for man, most commonly in X-ray, in radio performance, advertising, and illumination, though there are other valuable applications.

▲ Some of the most interesting tubes are grouped in this exhibit and so arranged as to explain a little of the nature of the electrical discharge.

▲ Two of the tubes show that the electrical discharge is bent by magnetic fields. Another shows its heating effect on a small piece of platinum foil. Several tubes show the fluorescence on the glass, caused by the rays that produce X-rays. Others show that the discharge which produces X-rays travels ordinarily in straight lines and will cast shadows and will not pass through a coiled tube. One tube shows that if a vacuum is high enough the discharge may pass over a fairly long path rather than jump a short spark gap.

▲ The effect of electrical particles in causing minerals to give light of their own is shown dramatically by a tube which has a little pile of different kinds of minerals and by another tube in which flowers, made from sheet copper and painted with clear chemicals, glow under the electric bombardment, giving forth brilliant colors.

EXHIBIT OF DISCHARGE OF ELECTRICITY THROUGH GASES



THE EXHIBIT OF THE LOS ANGELES ASTRONOMICAL SOCIETY
Possible amateurs of the future study the production of the amateurs of today.

LOS ANGELES ASTRONOMICAL SOCIETY

▲ In the autumn of 1925 one of the eastern scientific magazines began a campaign of publicity relative to the then new hobby of telescope making. The interest aroused by this publicity swept the country like wild fire. Here in Los Angeles a young university student became interested to the extent of writing to that magazine, requesting a list of the names and addresses of persons in and around Los Angeles who had corresponded with them concerning telescope making. To his amazement he received a list of thirty names. He wrote to each of these persons, asking them to meet with him in the Science Seminar room of the Public Library. At this meeting the Amateur Telescope Makers Society of Los Angeles was born. This was the second society of telescope makers to be organized in the United States, the first being the Telescope Makers of Springfield, Vermont, the old home of Russell W. Porter, the dean of amateur telescope makers.

▲ In 1939 the name of the society was changed to Los Angeles Astronomical Society, with a section devoted to telescope making. Meetings are held monthly for the purpose of discussing astronomical and telescope-making problems. Many world-famous astronomers have lectured at these meetings. For seven years the Society has sponsored a series of lectures during the fall and winter months, at the Los Angeles Public Library. Some of our members have appeared before women's clubs, service clubs, lodges, church and scientific organizations, throughout Southern California, in the interests of popular astronomy.

▲ The keystone of our Society is, as always —Helpfulness. If you wish to become more familiar with the friendly stars, and desire to experience the thrill that comes from studying them by means of an instrument that you have made with your own hands, join us, and we will help.

▲ Today as of old, "The firmament showeth His handiwork."

EXHIBIT OF LOS ANGELES ASTRONOMICAL SOCIETY

▲ In this exhibit is shown the evolutionary development of a telescope mirror, from the rough blank of glass to the finished product. The abrasives and polishing agents necessary to produce this result are shown in the proper sequence.

▲ A spherometer, for measuring the depth of curve on a mirror surface, and a Foucault "knife-edge" testing apparatus, for determining the perfection of the final surface, are shown. While this testing device is home-made, it is, nevertheless, capable of detecting differences of less than a millionth of an inch in the curved surface of a mirror.

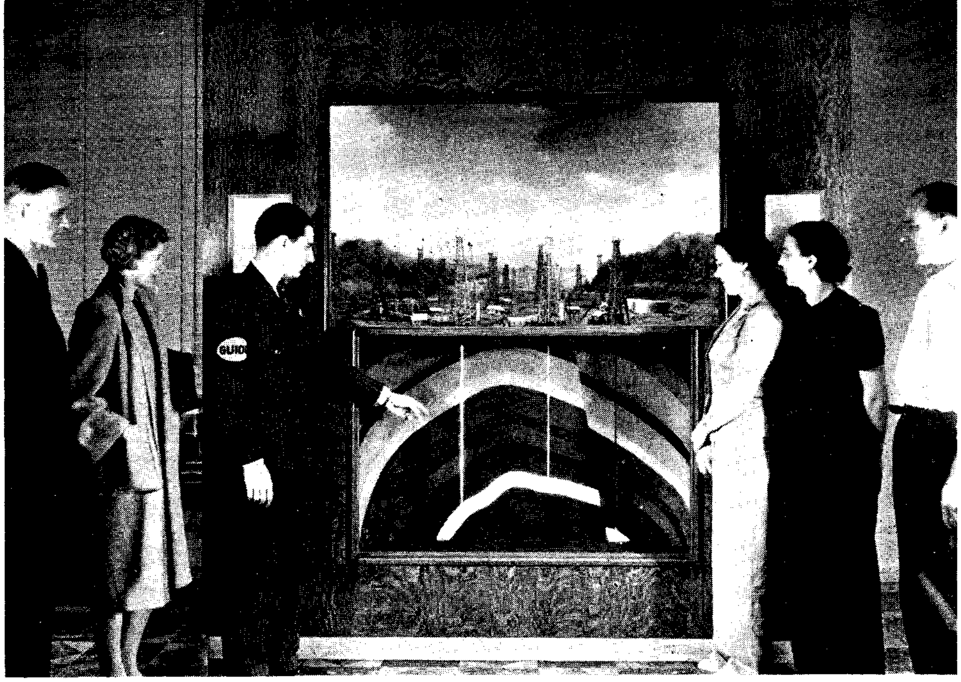
▲ Here are shown methods of supporting the prism or diagonal "flat" in the telescope tube. A mirror cell on its adjusting stage with the conventional push-and-pull adjustments, a "finder," an eyepiece, and focusing device are also shown.

▲ Every pile of junk contains rare possibilities in the eyes of the amateur telescope maker. The barrel of the finder was made from the exhaust pipe of a wrecked automobile, and the bracket for the focusing device was made from the hub and two spokes of the steering wheel from the same wreck.

▲ Cut-away models of a refracting and of a reflecting telescope show, by means of white threads, the paths of the light rays in the two types. A 60-degree prism for use in a spectroscope is displayed, as is also a 90-degree prism to be used as a telescope diagonal, and a 10-degree wedge for use in a solar eyepiece. These are accompanied by the crown and flint glass lenses of a refractor objective, and several eyepiece lenses of varying powers.

▲ Here also may be seen a diffraction grating. This consists of a plate of stainless steel, which has been ground and polished until it is optically "flat," and then its surface has been scored by means of a diamond point in a ruling machine, until there are, in this case, 14,435 lines to the inch. This finely corrugated surface separates the incident light into its different wave lengths. When viewed from the side the different wave lengths of light may be seen in all their beautiful colors. The diffraction grating is superior to a prism in its powers of dispersion of light and is, therefore, an important instrument in modern spectroscopy. This particular grating, and the ruling machine used in making it, are both the work of a member of the Los Angeles Astronomical Society. The ability to construct such apparatus reveals mechanical ability of a high order.

▲ A finished stellite (metal) mirror is part of this exhibit.



MODEL OF A TYPICAL OIL FIELD AND UNDERGROUND STRUCTURE
This shows why a "dry hole" may sometimes be found close to a highly productive well.

A TYPICAL OIL FIELD

▲ The upper part of this exhibit shows the surface features of a typical oil field in California. In the foreground are two steel derricks of the type in use at the present time, but most of the derricks are of the older type of wooden construction. The well in the center foreground is a flowing well, as is indicated by the complex valve system in the center of the derrick floor, which is used to control the high gas pressure often encountered. Other wells are being pumped, because the lifting force of the gas has been wasted or depleted. Formerly the gas was allowed to escape into the air, but now it is used to lift the oil up to the surface of the ground, and then it is piped for use as fuel.

▲ The cross section beneath the oil field shows the geological structure which is responsible for the accumulation of the oil. Many millions of years ago rivers deposited particles of sand, silt, and mud on the floor of the sea. Gradually this material was changed into rock through heat, pressure, and chemical action. This rock is known to be marine in origin, because much of it contains fossil clams, oysters, and fishes. The layers of rock have a relatively constant thickness, and this fact tells us they they were originally horizontal or very nearly so. However, since the earth's crust has always been in a state of movement in one region or another, the stresses set up are relieved in various ways. Here we see that the layers of rock have been pushed upwards and folded into an arch. Near the right side of the cross section is a line along which the layers of rock are offset. This dislocation of the rocks, known as a fault, occurred because the pressure was so great that the rocks could no longer yield by bending. A snap and slipping, forming a fracture, adjusts the tension, and the sudden yielding to strain produces a quick shock which we call an earthquake.

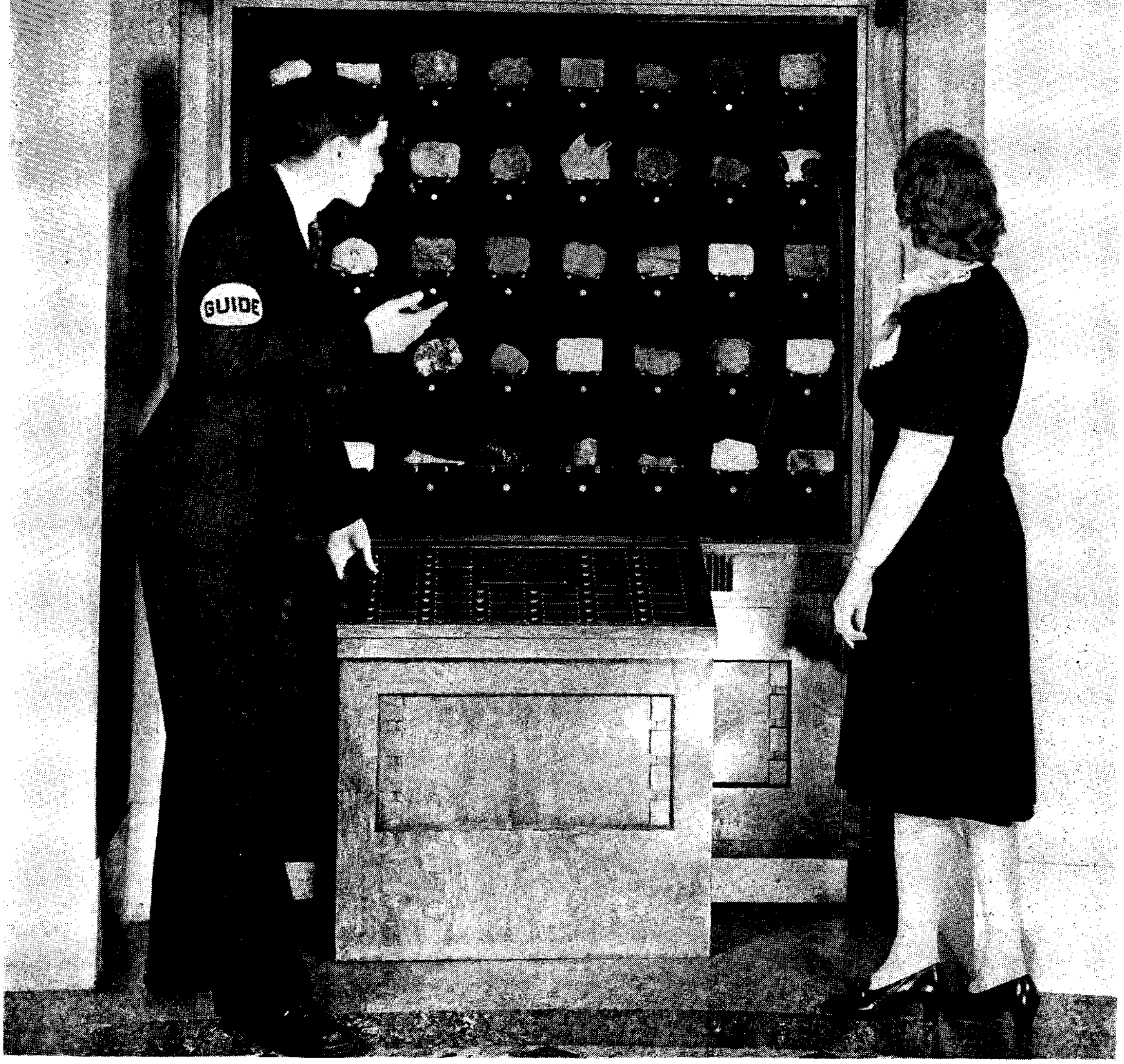
▲ One of the layers of rock in the cross section is illuminated. This represents the layer where oil and gas have accumulated. How these fluids were formed is not known, but it is generally believed that they have come from the remains of plant and animal life. The oil and gas collect in tiny spaces between the grains in the bed of sand at the crest of the arch. They have risen above the salt water, which is generally found in deeply buried sandstones, because they are lighter. However, they can not rise any higher, because the black shale above has no spaces in it through which they can pass.

▲ The fluids are represented by lights of different colors. The gas (yellow) is lightest and is above the oil (red), while the salt water (green), being heaviest, is lowest. The drilling is represented by a blue light which moves down from the surface to the oil-bearing sand. The well in the center is above the highest part of the arch, and it taps the reservoir where there is a rich concentration of natural gas. This flows up the well, as is indicated by the upward moving yellow light. The oil and salt water levels begin to move upward. As the oil level approaches the center well, a second well is drilled on the left flank of the arch, where it immediately begins to produce oil. The upper motion of the oil and water levels finally causes the two wells to fill with water when the oil supply is exhausted.

▲ In the meantime a third well on the right has found nothing but salt water, because any oil that may once have been stored in this part of the sand has escaped up the fault into the higher part of the layer. Thus, even though a well may be close to a highly productive well on the surface, underground structural conditions may cause it to be a "dry hole."

ONE OF THE MINERALOGICAL EXHIBITS

This exhibit of exquisitely colored minerals is the result of co-operation from the Mineralogical Society of Southern California, which has loaned these many valuable pieces from the private collections of its members.



Guessing the names of rocks and minerals intrigues many thousands of the public each year. Upon pressing a button beside the name on the panel, an electric light flares at the object.

MINERALOGICAL COLLECTION

▲ This collection is displayed in three cases and changed from time to time. The minerals in the first case are loaned by members of the Mineralogical Society of Southern California. There are specimens such as agates from Brazil and Mojave Desert, malachite from Belgian Congo, onyx from Death Valley, all beautifully polished; huge pyramidal calcite crystals; and crystals of galena, azurite, amethyst, and quartz, many formed by seepages in mines of Mexico. The second case contains numerous representative rock specimens.

▲ In the third case is a study in crystal shapes. The molecules of many substances as they slowly solidify from a liquid state arrange themselves into crystalline forms, often very large, with plane faces, each substance having its own characteristic arrangement. Crystals may be classified according to the number, shape, relative lengths of the faces, and their inclination to each other. Glass models of different crystals are shown accompanied by natural substances having crystals of the same form.

GEOLOGICAL MAP OF GRIFFITH PARK

The many installations for the benefit of the public contained within the 4254 acres of Griffith Park are shown in replica.

RELIEF MAP OF GRIFFITH PARK

▲ Griffith Park contains 4254 acres, more than six square miles. This relief map, 5 feet wide by 9 feet long, shows in detail by miniature lamps successively lighted, the location of the Griffith Observatory, Greek Theater, Los Angeles City Zoo, airport, 26 miles of scenic drives, 32 miles of bridle trails, 50 miles of hiking trails, athletic and recreation fields, picnic areas, and other features. From the summit of Mount Hollywood at an elevation of 1652 feet an excellent view of the surrounding country may be obtained.

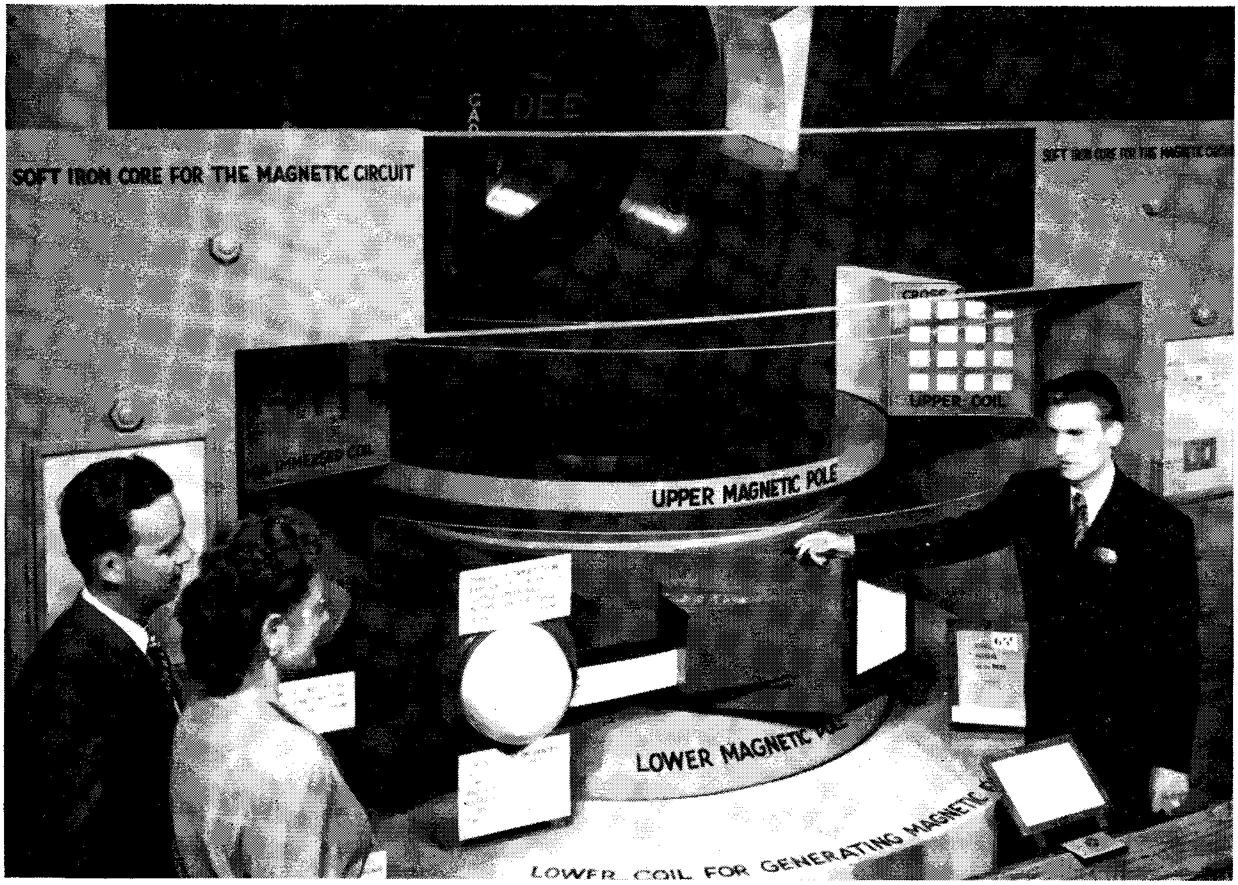
▲ At the sides and end of the model the subsurface geologic structure is shown by various colors for the many different rock formations. Layers of sand and silt produced by sedimentation were laid down at times in the distant past while Griffith Park was submerged beneath the ocean; igneous rocks were formed by crystallization from molten masses of rock as they were injected into the earth's crust; submarine lava and mud flows are evidence of violent volcanic activity long since extinct. At all angles old fault lines, cracks in the earth's crust, show where the rocks have slipped over each other and thus produced ancient earthquakes. A few of these faults are possibly still active, notably the Tunnel fault which is clearly exposed to view at the east end of the tunnel near the Observatory. The blocks of the earth's crust separated by the Tunnel fault have moved relative to one another very recently, and the scratches left by the rocks as they ground together are still plainly shown on the exposed fault surface.

THE TELEVISION RECEIVER
Television is the novelty of today, but it will be the commonplace of tomorrow.

THE TELEVISION RECEIVER

▲ Today television is a novelty. It occupies about the same place in American life as radio did when the first tube sets with their accompanying storage batteries received the experimental programs of the early twenties. Tomorrow television probably will develop as rapidly as has the radio. It is important that people have an opportunity to know by their own observation the present development of this great invention. For this reason the Griffith Observatory has installed the latest television receiving equipment and has mounted it in a cabinet with glass sides, so that all parts may be inspected carefully. On the 12-inch face of the large cathode tube at the top of the instrument the crowds watch the actors, athletes, and lecturers as they perform.

▲ The television receiver demonstrates the interrelationship between apparently widely separated fields of scientific development. More than 50 years ago in England Sir William Crookes developed an interesting vacuum tube which glowed greenishly because of a special radiation within it. Less than 10 years later Roentgen learned through accident that rays from this tube pass freely through many substances which are opaque to ordinary light. With this discovery began the great development of the Roentgen or X-Ray that has meant so much, both in commercial and in the biological field. Television now has taken this same tube, has modified it very slightly, and has caused it to impress upon its inner surface the miniature replica of scenes that are taking place at the same instant miles away.



MODEL OF CYCLOTRON

CYCLOTRON MODEL

▲ The heart of this instrument was presented to the Observatory by the University of California in 1940. The University had constructed it for the World's Fair at San Francisco. The model attempts to give the observer a simple, vivid picture of the real cyclotron. In the actual instrument, a proton, which is one of the minute building blocks of atomic nuclei, is introduced into the center of a very powerful magnetic field which alone would cause it to move continually in a circle. Accelerations produced by the alternating electrical field of the "dees" cause it to spiral outward and to gain tremendous speed.

▲ The proton and its motion within the magnetic and electrical fields are simulated by a small lamp which spirals rapidly outward from the center of the magnetic field. In the darkness below this lamp, there is a rapidly revolving arm which carries it. As the arm revolves, a screw moves the lamp outward by a small fraction of an inch for each revolution. The "dees" are represented by opal glass through which the lamp is seen less plainly than when in the "electric field" gap between them. By the time the lamp has reached the boundary of the "magnetic field," it is moving about ten feet per second.

▲ In the actual instrument the proton, leaving the magnetic field tangentially at extremely high speed, strikes a "target". The target is the atom of some element which it is desired to break down into lighter ones. The model imitates one of the actual cases. In it the simulated "proton" appears to enter the nucleus of an atom of lithium. This atom shows as a projection on a translucent screen. The screen shows the "proton" joining the three protons and four neutrons which make up the nucleus of lithium. With this addition, the observer watches these particles start apart into two groups of two protons and two neutrons each. Each of these groups is a nucleus of an atom of helium. As a final act, each new nucleus appears on separate screens. The atom of lithium plus the proton has resolved into two atoms of helium. In the real cyclotron many millions of protons are spiralling outward at the same time.

▲ The visitors operate the model themselves. By pushing a button it starts through its cycle and the voice of Professor J. Reginald Richardson, well known atomic physicist from the Los Angeles Campus of the University of California, is heard giving a six-minute simple explanation of the action.

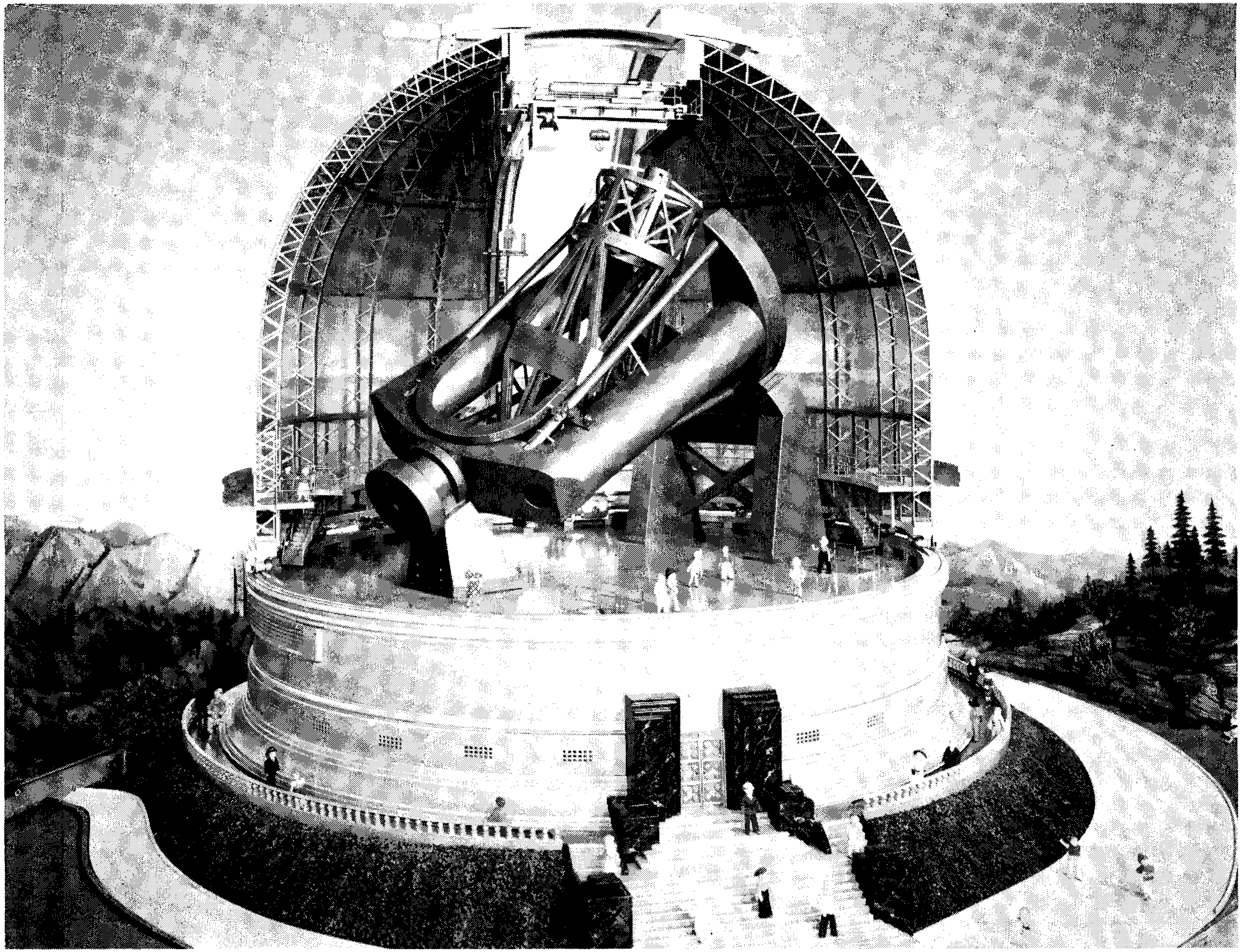
MODEL OF 200-INCH TELESCOPE

▲ With the 200-inch telescope at Mount Palomar finally being completed in 1947, it is very timely that a model of that observatory is being put on exhibition in the Hall of Science of the Griffith Observatory. This model was built by Samuel Orkin at a cost of nearly $25,000. The original drawings supplied by the California Institute of Technology were followed, except for a few minor differences.

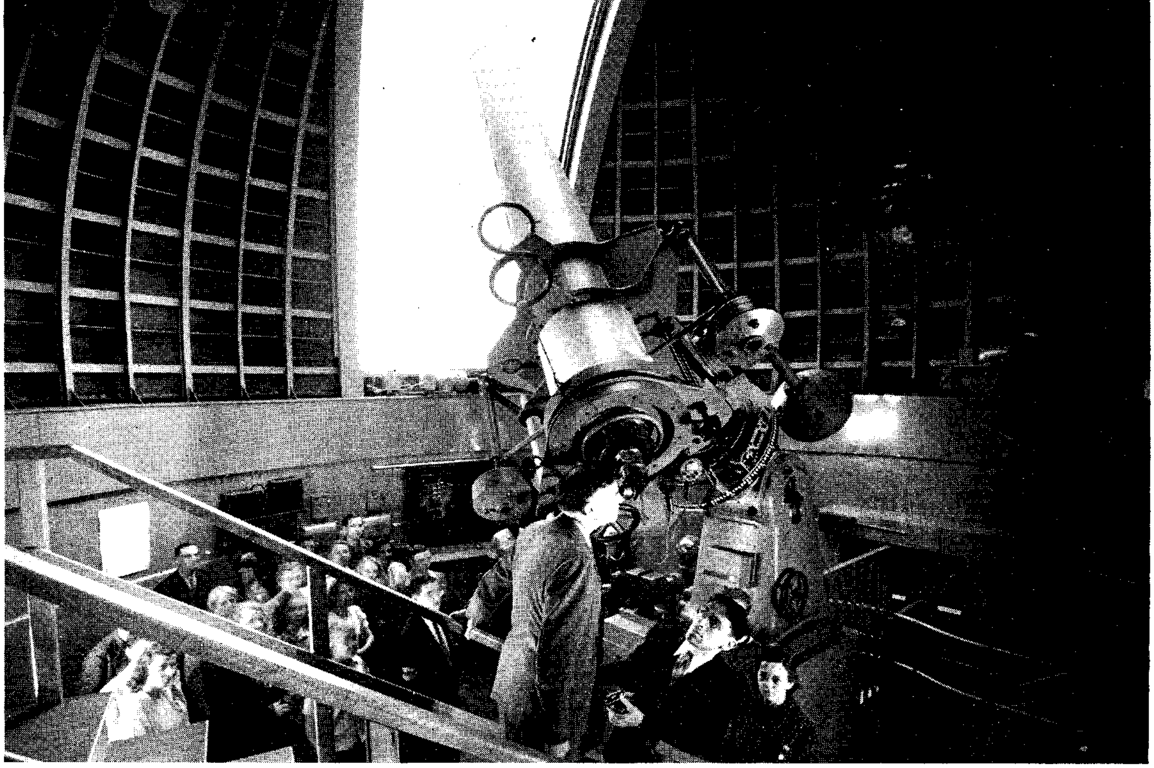
▲ This replica is 1/24 the size of the original. The dome is six feet in diameter and is made of spun aluminum. Only one-half of it has been included, in order that a full view of the telescope may be obtained. The dome can be turned by a motor and the shutters in it can be opened and closed by a motor. The telescope is operated by two motors. One moves the tube in a north-south direction and the other moves the whole instrument about its polar axis in an east-west direction, exactly as is done for the real instrument.

▲ Small dolls represent people walking around the building, while miniature automobiles drive along the road to the observatory. In the background are trees, shrubs, mountains, and the sky. Twilight is brought on by changing and fading colored lights, which are shown in proper sequence by an automatic control. At night the stars appear in the sky which forms the background of the diorama.

▲ The oak paneled case is sixteen feet by twelve and is eleven feet high. The window through which the exhibit is viewed is one piece of plate glass twelve feet long.



MODEL OF 200-INCH TELESCOPE



THE 12-INCH ZEISS REFRACTING TELESCOPE
This telescope has given hundreds of thousands of people their first glimpse of the mysteries of the heavens.

Invented by the genius of Galileo and developed through the years into the giant instruments of today, the telescope has steadily extended man's knowledge of the universe and has profoundly influenced his thought and imagination.—Walter S. Adams.

THE TWELVE-INCH ZEISS REFRACTING TELESCOPE

▲ Who has not gazed into the star-sprinkled skies and wondered what flashing pictures the astronomer sees through his powerful telescope? And who has not thrilled to the marvels revealed by even small instruments, such as binoculars and the telescope of the man on the street who offers "a peep at the Moon for a dime?" The ambition of the layman to see what the astronomer sees may be gratified by the telescope in the east dome of the Griffith Observatory. This is available for free public use on certain special occasions in daytime and on every clear night that the observatory is open, from dark to 10 p.m.

▲ The telescope entertains and instructs the visitor with glimpses of heavenly bodies far in the depths of space. By day the sun's glowing disk can be focused on a screen or examined with a special eyepiece, and Venus shows her phases like a tiny moon. Although the brighter objects can generally be viewed in the daytime, this is usually not worth while since they are seen so much better when the sun's overpowering glare is not present. Venus is an exception to this rule.

▲ By night a whole panorama challenges observation. In our solar system is the naked Moon with its vast mountains, craters, and plains whose origin is not certainly known; elusive Mercury, closest to the Sun and seldom seen by most people; brilliant Venus, the brightest body except the Sun and Moon; ruddy Mars, whose seasonal color changes strongly suggest the presence of plant life; giant Jupiter with his cloud bands and four moons easily seen; ringed Saturn, unique among the planets; distant Uranus and Neptune with their greenish disks; asteroids and occasional comet wanderers. Within our stellar system, or galaxy, estimated to contain at least 100,000,000,000 stars, are stars greatly differing in size, brilliance, and color, such as Antares, one of the largest known, glowing fiery red, or Sirius and Vega, majestic scintillating searchlights of beautiful blue; stars that vary in brightness, as Algol, the Demon, in Perseus; double stars, like Castor, or a quadruple system like Epsilon Lyrae; open star clusters like the seven sister Pleiades and the beehive Praesepe; globular clusters, such as the great Cluster in Hercules composed of at least 50,000 stars; diffuse gaseous nebulae, like the Great Nebula in the sword of Orion or the Trifid Nebula in Sagittarius; and planetary nebulae, like the Ring Nebula in Lyra.

▲ Outside our galaxy are many others, such as the Great Spiral Galaxy of Andromeda, the nearest comparable to our own, revealing its apparent oval form. Stretching in all directions to the farthest horizon within reach of the 100-inch telescope at Mt. Wilson are 100,000,000 such galaxies. The imagination is staggered in attempting to contemplate that the galaxies undoubtedly extend beyond, perhaps without limit throughout an infinite universe.

Description of Dome and Telescope

▲ Most telescopes rest upon a pier set in bedrock, but here the walls and ceiling of the east gallery have been structurally designed and reinforced on such solid foundation that they rigidly support the dome walls and telescope pier. The dome, nearly 30 feet in diameter, is mounted on a circular track and easily turned by two electric motors in order to direct the shutter slit to any part of the sky. The shutters are mounted on straight tracks and opened and closed by two motors.

▲ The telescope tube in any position is braced inside by a system of eight lengthwise rods. Individual weights attached to the eye-end of the rods automatically pull on the rods that happen to be uppermost and release on the lower ones. Thus even the usual slight bending of the tube by the pull of gravity is counteracted. Four equally spaced blackened diaphrams inside the tube prevent internal reflections by cutting off the unneeded edges of the converging rays of light which are bent to a focus by the 12-inch lens.

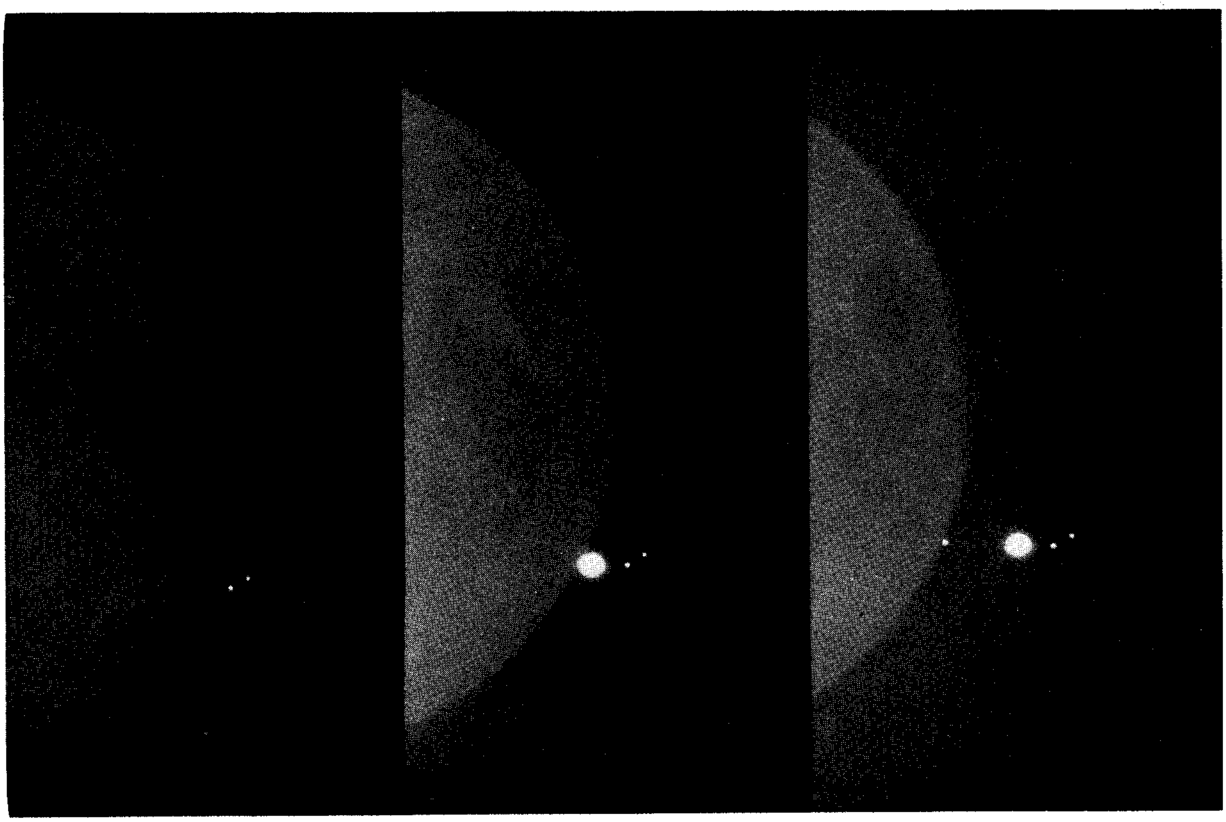
▲ The telescope swings on two axes. The "polar" axis is parallel to the earth's axis and therefore points toward the north pole of the heavens. The telescope is so delicately balanced that even though the moving parts weigh about three tons a tiny electric motor, regulated by the precise astronomical "sidereal" clock located on the wall near the telescope, keeps the instrument turning westward around the polar axis accurately at the same speed that the earth rotates eastward. Thus with the earth's motion counteracted, the object under observation remains stationary in the field view. The telescope is turned by hand in a north-south direction on the "declination" axis, which is perpendicular to the polar axis. Because of this mounting the instrument easily may be pointed to any direction in the sky. The method of balancing the telescope tube brings the eye-end close to the axes so that it moves only very slowly; hence the position of the steps and platform, which the visitor mounts, may remain unchanged for many minutes.

▲ Astronomers make catalogues of the positions of stars and record their positions in coordinates which are almost exactly similar to the longitude and latitude used to denote positions on the earth. This telescope has large circles and indicators which, in conjunction with a clock, enable the operator to point the telescope even at objects which are invisible to the naked eye, if their catalogue positions are known.

▲ Accurately aligned with the telescope tube is an ordinary small telescope, with a large field of view and used as a "finder." In practice, for very faint objects, settings with the circles are made accurately, but for brighter objects only closely enough so that the object is in the finder and not in general in the relatively small field of the large telescope. To adjust an object in the field of view, fast and slow electric "slow motions" modify the speed of the driving clock and a hand slow motion adjusts the telescope in declination. When brought to the center of the field of the finder, the object is in the field of the large telescope.

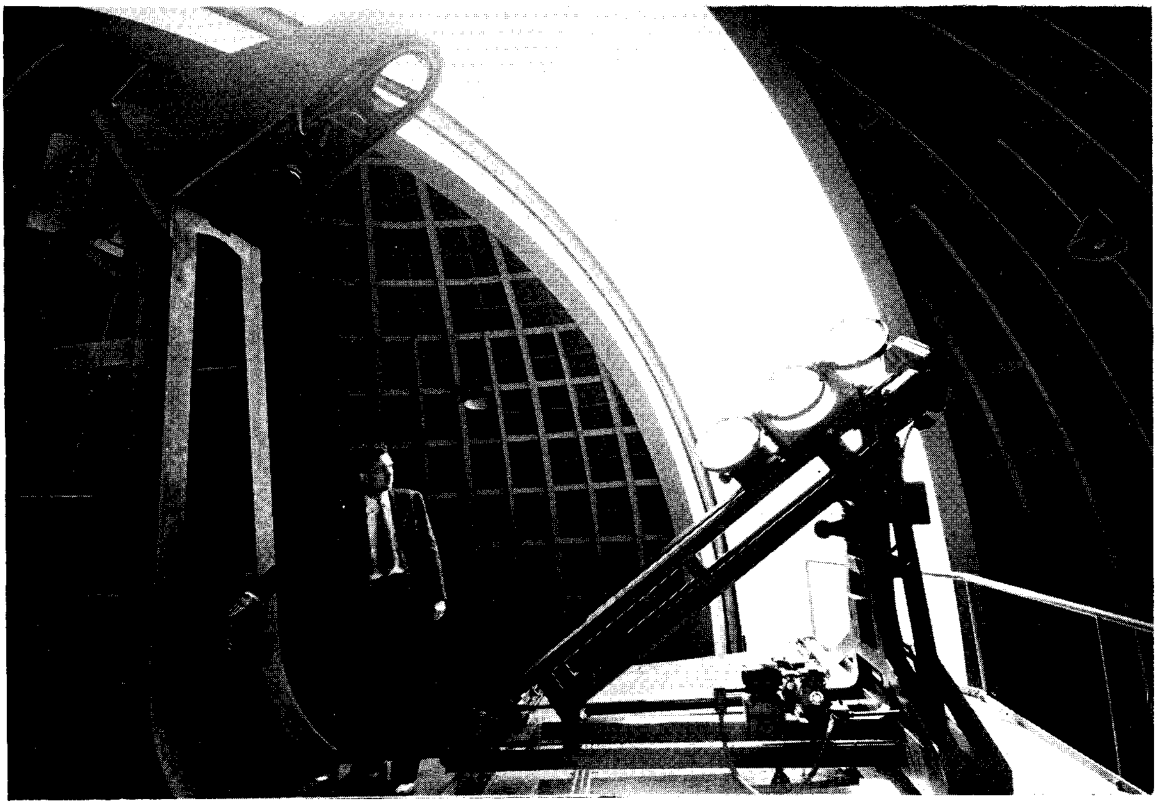
▲ The instrument is of the refractor type with a focal length of 16½ feet. The large "objective" lens is 12 inches in diameter and has the fine quality required for professional research. The 12-inch objective collects 3600 times as much light as the eye and hence stars can be seen which are nearly 3600 times fainter than the faintest star visible to the unaided eye.

▲ The image formed by the large lens may be allowed to fall upon a photographic plate; many fine photographs of the Moon and planets have been made. However, the instrument is primarily for visual observation; various "eyepieces" may be fitted quickly to magnify the image from 40 to 800 diameters, 125 to 300 being commonly used. When the transparency and steadiness of the earth's atmosphere are excellent, the Moon is brought visually within 300 miles by the highest power eyepiece; a man on the summit of Catalina Island 50 miles away would appear to be 1¼ miles away in the lowest power and only 350 feet away in the highest power. The field of view of a visual telescope decreases with increasing magnification. The 40-power eyepiece has a field 1¼° in diameter, more than twice that of the Moon, but the 800-power has a field of only 3½′ of arc, about one-tenth the apparent diameter of the moon.



OCCULTATION OF JUPITER

These three photographs were made at the Griffith Observatory by Paul Roques on January 16, 1947. They show Jupiter and its four bright satellites emerging from behind the moon. The portion of the moon shown was being illuminated by earthshine. The nearly circular, dark area is Mare Crisium.



THE TRIPLE COELOSTAT

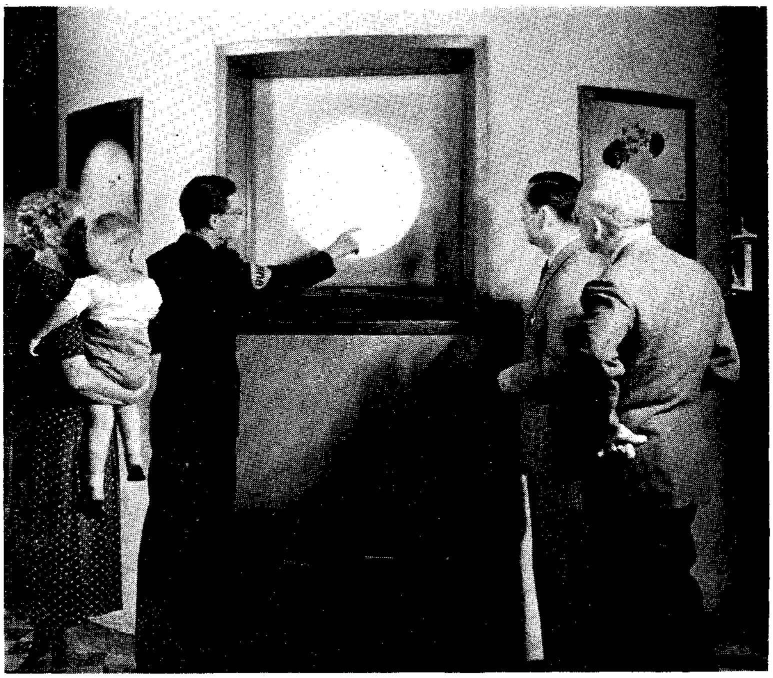
In this dome above the Hall of Science these mirrors, throughout each clear day, bring the sunlight to the three solar telescopes. Far below this dome visitors in the Hall of Science make their observations.

THE SOLAR TELESCOPES

▲ The first observatory fully equipped for popular observation of the sun is installed in the Hall of Science. As the visitor walks down the west gallery he sees a large image of the sun projected on a translucent screen. Sunspot groups, faculae or bright streaks and patches, mottling over the whole surface, and darkening at the edge of the disk, may be observed in detail. Any shimmering, or "boiling" effect, is caused by unsteadiness in the earth's atmosphere, as the sun's rays pass through layers of air that vary in position and density from instant to instant. This image is produced by the first of three solar telescopes.

▲ A second telescope places its image in a spectroscope. The spectroscope is the device which furnishes the key that unlocks the secrets of the chemical and physical constitution of the sun and stars. In the spectroscope of the Griffith Observatory the sun's image is focused on a narrow slit. Light passes through the slit into a pit 20 feet below the floor and falls on a mirror surface ruled with 14,000 lines per inch, called a diffraction grating. The light reflected from the grating is spread out, just below the microscope through which the visitor looks, into a continuous band of all the colors from violet to red, crossed by thousands of dark lines of various intensities, called the spectrum. Any part of the spectrum may be seen by tilting the grating. Each chemical element has its own peculiar pattern of lines. By comparing with the lines of known elements, their presence or absence in the sun's "atmosphere" has been determined. In this manner the gas helium was found on the sun before its discovery on the earth.

▲ The third telescope supplies light to the spectrohelioscope. The spectrohelioscope is a spectroscope specially modified by George Ellery Hale in order to show a small section of the sun in the light of only one wave length and of one element, commonly that of the strong red line of hydrogen. Clouds of hydrogen, helium, calcium, and other gases, projecting beyond the sun's disk are called prominences. Until an application of the spectroscope was made shortly after the middle of the last century, they could be seen only during a total solar eclipse when the glaring light from the sun's disk was cut off by the Moon. The spectrohelioscope shows them much better than did the original form of the instrument. At times, much as volcanoes on the earth erupt clouds of smoke, the sun ejects hydrogen prominences to stupendous heights at terrific velocities. They rise above the sun's surface at various speeds up to 450 miles per second and up to heights as great as 900,000 miles, which is more than the sun's diameter. These flaming red hydrogen prominences of all shapes, often rapidly changing in appearance, are one of the most spectacular sights in astronomy.



THE SOLAR DISK
The eye-end of this one of the three solar telescopes form this large image of the sun on a screen in the Hall of Science. Nearby photographs of the sun tell their part in the story.

▲ Each exhibit requires its own optical system, most of which the visitor does not see. Sunlight falls on an aluminized mirror which is mounted on an axis in the west dome and turned by a synchronous motor at such a speed that the earth's rotation is counteracted and the light after reflection continuously strikes another mirror. This mirror is fixed and reflects the light through a stationary telescope with an 8-inch objective which forms an image of the sun in the Hall of Science below. Such an arrangement is called a coelostat. Of course, in this case there are actually three complete coelostats, one for each exhibit, the moving mirrors being mounted on a common axis.

THE ZEISS OPTICAL PLANETARIUM

THE PLANETARIUM

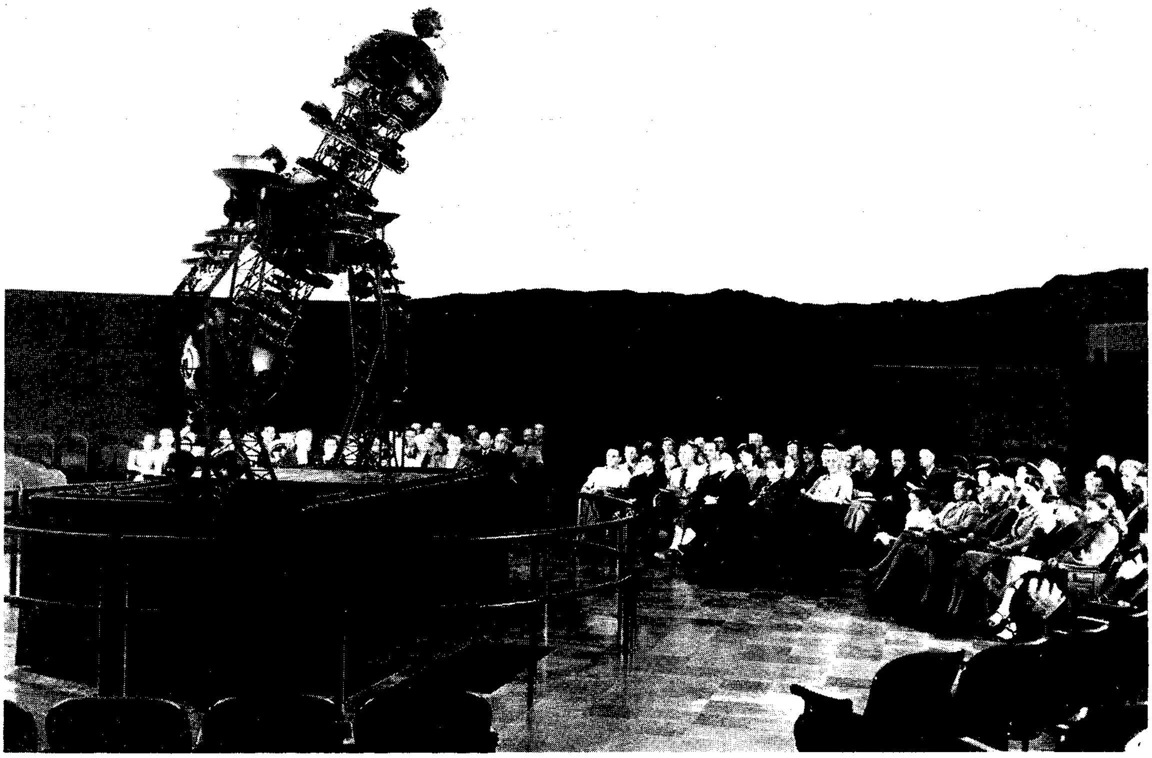
▲ No description can reproduce the overwhelming impression made by a demonstration of the Zeiss planetarium projector. All that can be done here is to describe briefly how this instrument works and what it can do. It is a composite slide projector throwing images on the interior surface of a great hemispherical dome. All the stars visible to the naked eye are reproduced so realistically that the observer feels as if he were outdoors looking at the heavens under the clearest of conditions. It is possible to show the sun, the moon, the five planets, and the naked-eye stars, all in their proper places for any instant of any year for thousands of years in the past and in the future, and as viewed from any place on the earth. Of course, the motions of the stars through space produce, after many thousands of years, small changes in positions which are not shown in the planetarium sky.

THE CONSOLE OF THE PLANETARIUM

The demonstrator plays the planetarium by the keys of the console and at the same time describes to the audience what they see in the artificial sky.

▲ The planetarium instrument resembles a giant dumb-bell about twelve feet long. Its center is in the plane of the horizon and is about ten feet above the floor. The weight of the movable parts approaches one ton. The large globes at the ends contain projectors which produce the stars. Inside each globe is a 1000-watt lamp which furnishes the illumination for the star images. Each of the 32 star projectors contains a system of lenses and a thin copper plate perforated with holes of 65 different sizes to represent stars from the brightest to the faintest that can be seen with the unaided eye. Invisible pencils of light, corresponding to each star, are projected on the dome. The images of the fainter stars range from one-eighth of an inch to two inches in diameter, so that the brightest stars show decided disks. However, the observer readily adapts himself to the appearance of stars as disks instead of points. The positions of the tiny holes in each copper plate have been computed from maps of the sky, so that the stars are shown in their correct relative positions. The individual star fields produced by the 32 projectors are in accurate mutual adjustment, so that the whole sphere of the sky is covered and without any overlapping.

▲ Only about one-half of the celestial sphere can be seen at one time. The light which reproduces those stars which happen to be below the horizon at any instant must be cut off so that it will not shine on the audience or on the floor. This is done by means of



THE PLANETARIUM THEATER
The planetarium projector makes the audience forget that they are in a theater and think that they are under the actual sky under the clearest of conditions.

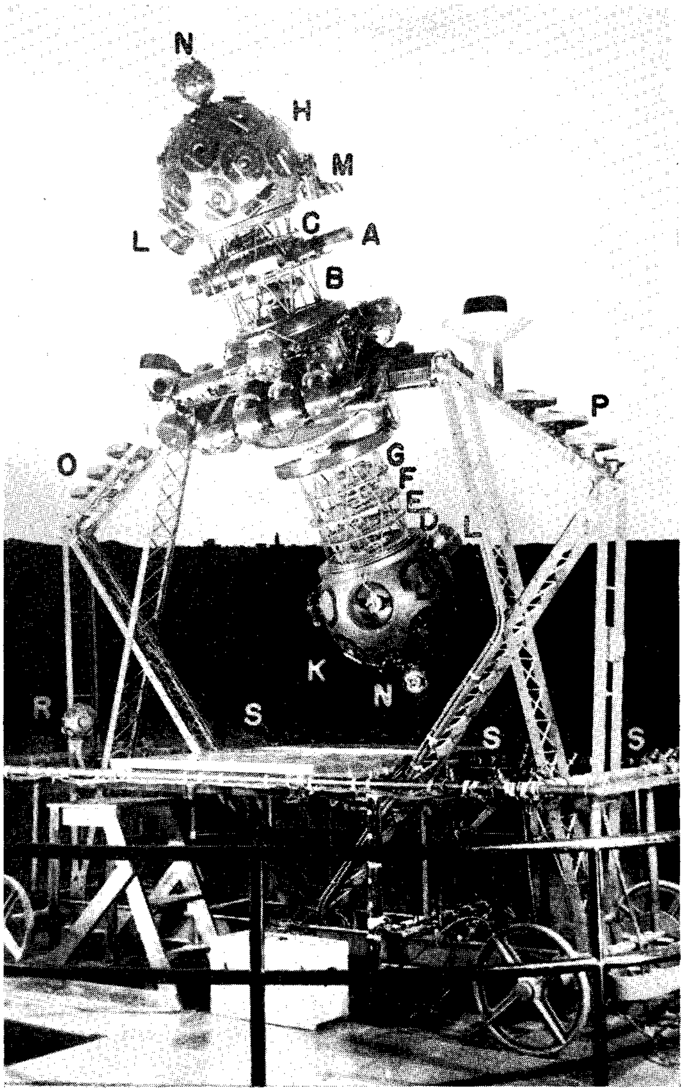
mechanical eyelids, which are like the devices used to open and close the eyes of dolls. These eyelids are inverted, covering up the lower parts of the projectors first. The upper edge of each eyelid is kept parallel to the horizon by a weight, consisting of a small cylinder partially filled with mercury, which provides a delicate sense of level.

▲ As the earth turns on its axis each day, it causes the stars to rise and set. The turning of nature's sky is so slow that we find it difficult to visualize the daily circles which the stars appear to describe. The planetarium projector speeds up time for us so that we see a whole day passing in a few minutes. This is accomplished by a motor which turns the instrument about an axis parallel to what would be the earth's axis at the observer's latitude. The projector may also be turned about an axis pointing toward the east and the west points of the horizon. This causes the stars to move toward the north or the south and enables the observer to see how the sky appears from any place on the earth.

▲ The stars are so distant that their real motions through space are not evident to the unaided eye even after centuries. The sphere of the stars appears about the same now as it did thousands of years ago. Therefore, no changes need to be made in the star projectors to show the sky in the distant past or future. However, the earth wobbles like a top once in about 26,000 years. The direction in which its axis points is slowly changing. Now it points close to what we call the Pole Star or the North Star, but in 14,000 A.D. it will point near the bright star Vega. At that time the Southern Cross will be visible in the United States. The planetarium projector can be moved in such a way as to show these changes, carrying the observer through thousands of years in a few minutes.

▲ The very earliest watchers of the sky must have noticed that the sun, the moon, and the planets change their positions with respect to the stars. The moon moves from one new moon to the next in about a month, and the sun appears to describe a circuit of the heavens in one year. The planets move at different speeds, and occasionally go backwards for a while.

▲ The accurate reproduction of these movements by the planetarium projector has required a high order of optical technique, mechanical skill, and astronomical knowledge. The images of the sun, the moon, and the five naked-eye planets are produced by individual projectors located in the cage-like framework between the globes and the mid-section. There are two projectors for each object, to avoid the loss of an object if a lamp burns out and to minimize the effects of obstruction of the struts of the cages. The observer easily distinguishes the planets in the planetarium sky, because they are shown as they appear through a small telescope. The belts of Jupiter and the rings of Saturn are shown. Mercury and Venus are distinguishable by size, and Mars by its red color.



ZEISS OPTICAL PLANETARIUM

A-Solar Projectors; B-Lunar Projectors; C-Saturn; D-Jupiter; E-Mars; F-Venus; G-Mercury; H-Stars of Northern Hemisphere; K-Stars of Southern Hemisphere; L-Milky Way Projectors; M-Comet Projector; N-Name Projectors; O-Dawn Projectors; P-Twilight Projectors; R-Meridian Projectors; S-Constellation Outline Projectors.

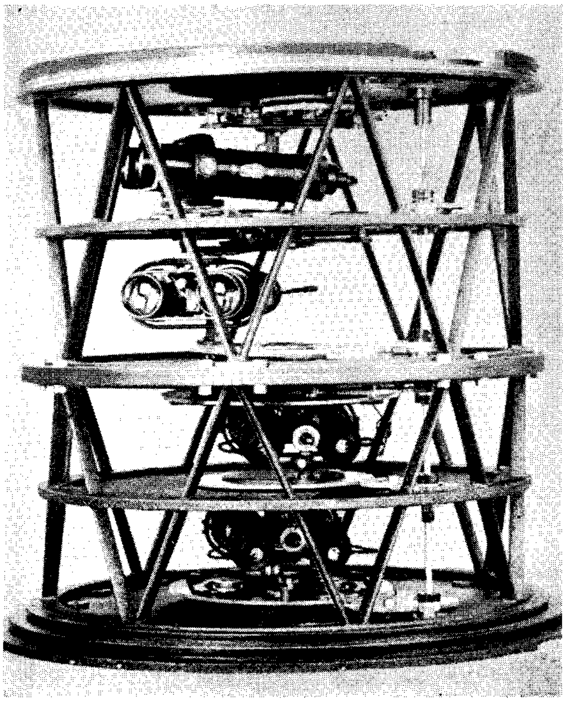
▲ The sun appears dim in the planetarium sky, so that the stars are visible during the day as well as at night. As the sky turns each day, the observer sees that the sun's position among the stars slowly changes. The earth's revolution around the sun causes the sun to appear to move eastward with respect to the stars about one degree per day. The moon also moves eastward, but about twelve times as fast, and it goes through its phases. In order to make the motions of the planets evident, the planetarium projector may be speeded up so that a year, instead of a day, passes in a few minutes or even less. When we travel at this high speed through time, we do not see the daily turning of the sky. We imagine that the earth has stopped rotating on its axis, and we see the results of its yearly revolution around the sun. We see the inner planets, Mercury and Venus, swinging from one side of the sun to the other. The other planets move eastward among the stars most of the time, but appear to go backwards whenever the faster moving earth overtakes them. Watching the planetarium sky for ten minutes can give one a better conception of the motions of the planets than could be acquired in a lifetime of outdoor observing.

▲ In addition to the stars, sun, moon, and planets, other celestial objects and phenomena may be shown. Three projectors produce a comet, which starts as a small, hazy patch of light. As it moves slowly among the stars during several months, it grows in brightness and develops a tail pointed away from the sun. The direction of the tail reverses as the comet passes the sun, and the object fades away as it leaves the sun. The northern lights, a rainbow, and a shower of meteors are produced by devices which are not a part of the planetarium projector. The classical figures of the constellations can be shown in faint outlines among the stars by means of projectors fastened to the railing around the instrument.

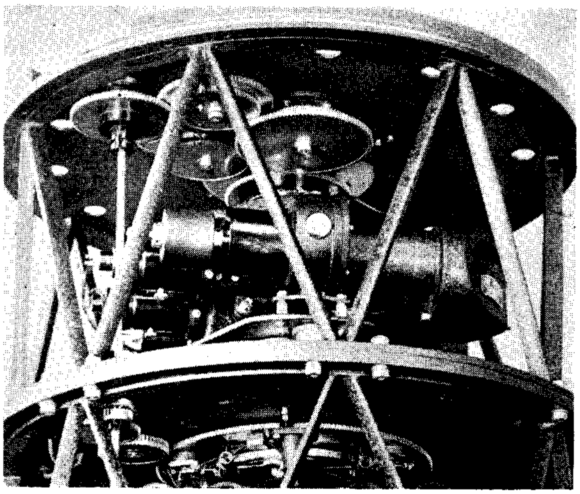
▲ Other projectors produce the meridian, the celestial equator, the ecliptic, an eclipse of the sun, the Milky Way, three variable stars, the zodiacal light, the twilight, and the dawn. Altogether about 150 projectors are used. The instrument is moved by seven motors and is controlled at a console by the demonstrator, who operates the keys while he talks and points out objects in the sky. In one hand he holds an optical pointer like an electric flash light, which projects aloft a luminous arrow.

▲ A planetarium show usually lasts about an hour. Except for introductory material, the shows are different each month of the year, and many of them are changed from one year to the next. They are given on most evenings of the week and on several afternoons. In addition to this, a program for school children is carried on. Courses in astronomy for youth leaders and special lectures on navigation for members of the Armed Forces are also given.

PROJECTORS FOR FOUR OF THE PLANETS
These are for Jupiter, Mars, Venus, Mercury



PROJECTORS FOR THE MOON



ASTRONOMERS MONUMENT

▲ The Astronomers Monument in front of the Griffith Observatory contains the figures of six of the greatest astronomers of all time. The base is in the shape of a six-pointed star about twenty feet across, the astronomers' figures are about ten feet tall, and at the top of the monument 35 feet high is an armillary sphere. This is an ancient astronomical instrument, composed of an assemblage of rings, designed to represent the positions of important circles in the sky.

▲ In the following very brief sketches of the work done by these six astronomers, it is interesting to note that five nationalities are presented. We have Hipparchus, a Greek; Copernicus, a Pole; Galileo, an Italian; Kepler, a German; Newton, an Englishman; and Herschel, a German, who became a naturalized citizen of England. Their names are outstanding examples of the comparatively few which belong to the whole world.

ASTRONOMERS MONUMENT

This beautiful monument presents the heroic-sized figures of six great astronomers of the past. Those visible in this picture are from left to right: Hipparchus, Herschel, Newton, and Kepler.

Hipparchus (160-125 B. C.)

▲ The greatest astronomer of antiquity was Hipparchus, a Greek who made observations on the Island of Rhodes between 146 and 126 B.C. His improved astronomical instruments enabled him to determine the places of objects in the sky with a greater accuracy than had been attained before. He determined the length of the tropical year, the size and distance of the moon, the eccentricity of the sun's orbit, and other important data of astronomy. His greatest discovery was that of the precession of the equinoxes, a slow movement among the stars of these intersection points of the sun's path with the celestial equator. This discovery was the result of the comparison of his own observations with those made a century and a half earlier. He made a catalog of 1080 stars, which he divided according to their brightness into six magnitudes His development of the subject of spherical trigonometry places him high among great mathematicians.

Copernicus (1473-1543)

▲ Nicolaus Copernicus was born at Thorn in Poland, but spent most of his life at Frauenburg near the mouth of the Vistula River. His life work is contained in his book, "De Revolutionibus Orbium Coelestium," which was printed just before he died. He placed the sun in its true place at the center of the solar system. His great merit is that he dared to doubt the Ptolemaic system, which placed the earth at the center of the solar system and which had been universally believed for centuries. He brought about a great revolution in thought by suggesting that the earth was not the central and all-important body in the universe. It was only on the score of simplicity that this scheme could be urged at that time. Copernicus showed that the daily rotation of the earth on its axis would account for the apparent daily revolution of the stars. He also showed that the planetary motions were much more simply explained by supposing that the planets, including the earth, revolved in circular orbits, with the sun slightly out of center.

Galileo (1564-1642)

▲ Galileo Galilei was born in Pisa, but also lived in other Italian cities, including Florence, Venice, and Padua. He made discoveries and brought forth arguments which secured the triumph of the Copernican system. Hearing of the invention of the telescope, he made one himself and pointed it at the sky, and was the first to understand what he saw there. He discovered four satellites revolving around Jupiter and found that Venus presents phases similar to those of the moon. He observed that the Milky Way is made up of many faint stars, and he made rough measurements of the heights of the mountains on the moon. He showed that the spots on the sun are not planets revolving near the sun, but are on the sun's surface. Of still greater consequence was his formulation and experimental proof of the laws of motion, and the laying of the foundations of mechanics. Since the Copernican doctrine of the motion of the earth was regarded as heresy by the Church, Galileo's work brought him into the hands of the Inquisition. He was imprisoned and forced to recant his belief in the Copernican theory. When released, he was forbidden to teach or publish anything. He retired in broken down health, and became blind five years before he died at the age of 78.

Kepler (1571-1630)

▲ John Kepler was born at Weil, in Wurtemburg, Germany. His genius was recognized by Tycho Brahe, who invited him to Prague as his assistant. He inherited his master's records of observers, which showed more precisely than ever before how the planets seemed to move among the stars. After many years of incredible labor, Kepler formulated his Three Laws, which describe how the planets are really moving. His First Law states that each planet moves in an oval-shaped path called an ellipse around the sun which is located at a point known as a focus, displaced from the center of the ellipse. His Second Law states that the line joining any planet with the sun sweeps over equal areas in equal times. His Third Law relates the periods of the various planets to their distances from the sun, in that the squares of the periods are proportional to the cubes of the mean distances. Kepler overcame ill health, poverty, and misfortune to discover these laws, which vindicated Copernicus and prepared the way for Newton.

Newton (1642-1727)

▲ Isaac Newton was born at Woolsthorpe, England, in the year in which Galileo died, and he spent most of his life at Cambridge. He clarified and expanded the work of Galileo on the laws of motion, and, aided by Kepler's Three Laws, he went on to his ultimate triumph, the law of gravitation. This states that every particle of matter in the universe attracts every other particle with a force that varies inversely as the square of their distance apart, and directly as the product of the masses of the two particles. Newton showed that the familiar phenomena of falling bodies at the surface of the earth are merely manifestations of a force that pervades the universe. In doing this, he developed an important branch of mathematics known as the calculus. He also discovered the compound nature of white light, and built the first reflecting telescope.

Herschel (1738-1822)

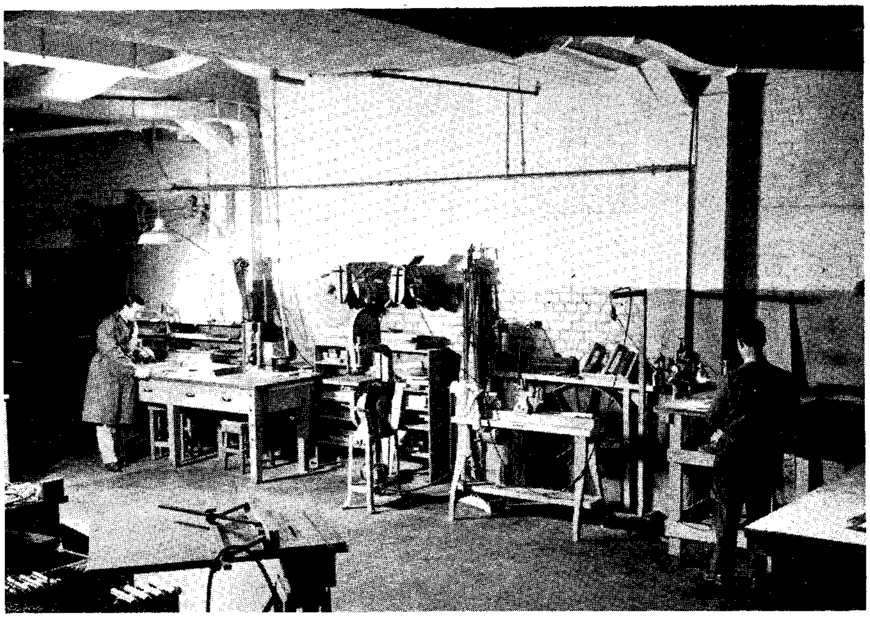
▲ William Herschel was born in Hanover, Germany, but at an early age he moved to England, where he spent the rest of his life. He was trained as a musician, but he became the greatest observing astronomer. He developed the reflecting telescope, making with his own hands several hundred mirrors and a great number of complete instruments. His largest telescope was four feet in diameter and forty feet long. With a smaller instrument, he discovered the planet Uranus, which brought him fame. However, his greatest work was the opening up of the subject of stellar astronomy. With him, every star was a sun. He investigated the distribution of the stars and the form of the galaxy. He found that many pairs of stars consisted of two suns revolving about each other, and that our sun is moving through space. He discovered and studied many nebulae. Herschel brought to the attention of the world the stupendous size and complexity of the universe of stars, in contrast to the smallness and simplicity of the solar system.

THE SHOPS OF THE GRIFFITH OBSERVATORY

▲ The visitor to the Observatory enjoys a co-ordinated program of exhibits comprising Hall of Science, Planetarium, and telescopic observation. Behind the scenes is another program, much of which is carried out during the long hours that the building is closed to the public.

▲ If the Observatory were content to have a static program of exhibits, like the old-time museum, the maintenance work would be comparatively small. One or two technicians could keep the planetarium and the telescopes in excellent order and could replace lamps as they burned out. Exhibits which have moving parts continually need repair. No manufacturer has been able to create complicated working displays that do not require a great deal of attention.

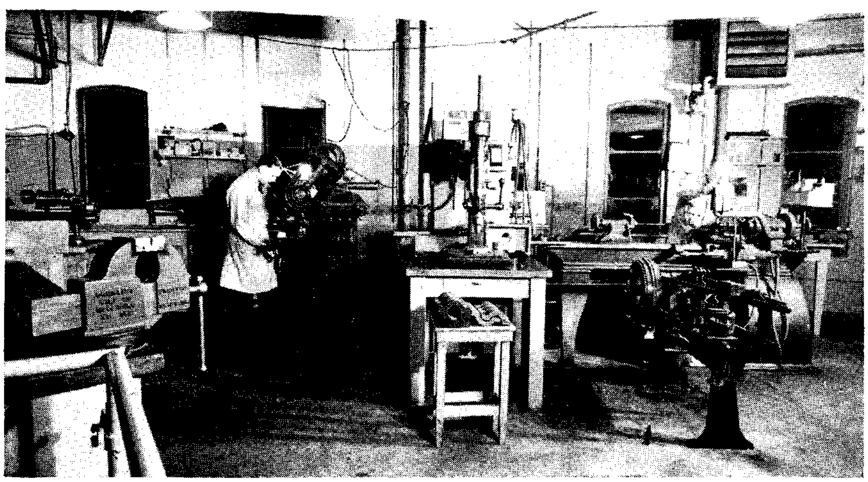
▲ In addition to the time involved in work caused by the chosen type of exhibits, the creation of new ones requires almost as much more time. No matter how excellent the displays may be, it is important that visitors frequently find new ones installed. Some exhibits are of a character that they carry a passing interest due to an astronomical event that is conspicuous in our skies. To purchase exhibits would demand a budget beyond anything that could be met. The only alternative is construction in the shops of the Observatory itself. Such construction has an additional importance, for experience has shown that most manufacturers do not appreciate the difficult conditions to be met in continually operating public exhibits. The purchased exhibits, secured before the opening of the Observatory, have shown a greater average maintenance cost than have those constructed in our shops. The Works Progress Administration has made possible much of our construction.

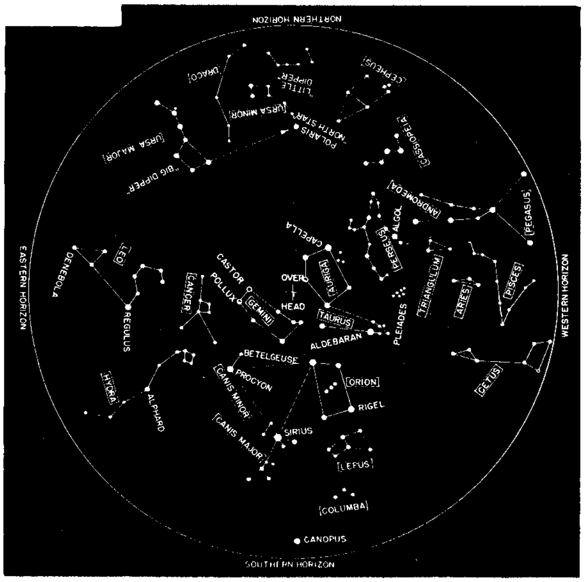


THE WOOD WORKING SHOP OF THE GRIFFITH OBSERVATORY

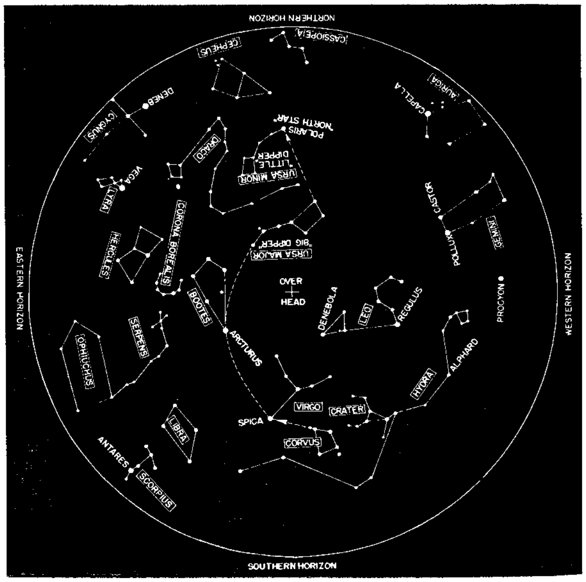
▲ The shops of the Observatory are well equipped to build almost any exhibit that is desired. Among the machines are a precision lathe and a 6-inch lathe, a large and a small miller, two electric drill presses, wood turning machinery, sheet metal working equipment, and a host of smaller tools. Indeed, most of the vacuum tubes of the electrical discharge exhibit are serviced in these shops. They may be depended upon to continue production that will intrigue and instruct all those who visit the Hall of Science.

THE MACHINE SHOP OF THE GRIFFITH OBSERVATORY

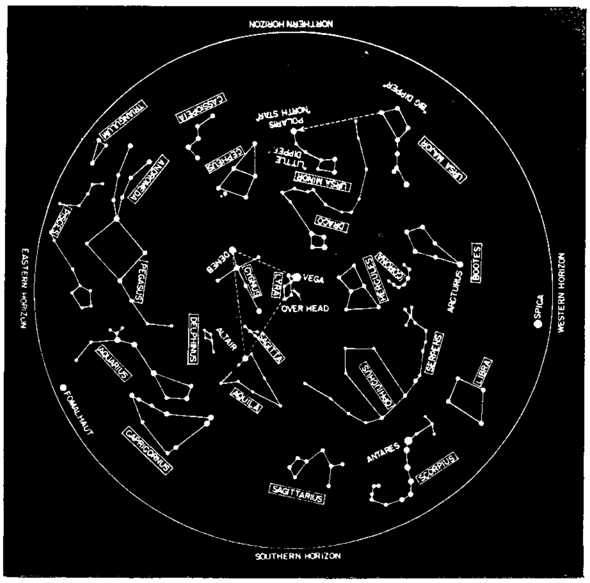




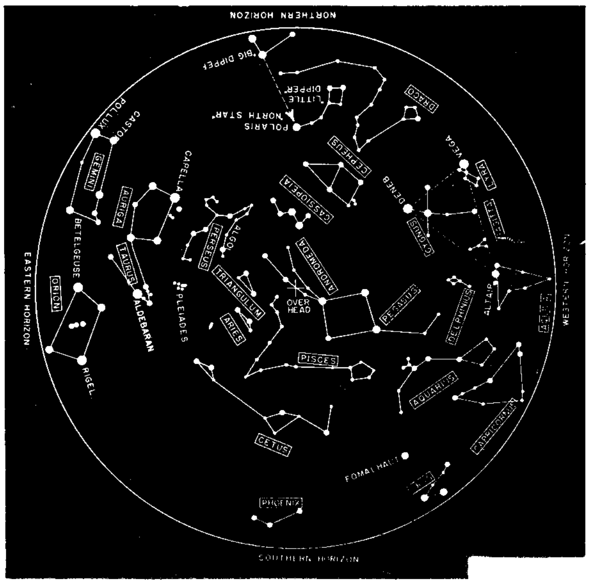
The Stars at 11 P.M., Jan. 15; at 9 P.M., Feb. 15; at 7 P.M., March 15.



The Stars at 11 P.M., April 15; at 9 P.M., May 15; at 7 P.M., June 15.



The Stars at 11 P.M., July 15; at 9 P.M., Aug. 15; at 7 P.M., Sept. 15



The Stars at 11 P.M., Oct. 15; at 9 P.M., Nov. 15; at 7 P.M., Dec. 15.

THE NIGHT SKY THROUGHOUT THE YEAR

A similar map appears each month on the back cover of The Griffith Observer, the magazine published by the Griffith Observatory.

THE GRIFFITH OBSERVER

▲ The Griffith Observer is a monthly magazine for the public, containing articles on astronomy, physics, and related subjects written in the simplest language that accuracy permits. All articles are written by astronomers, other scientists, or trained technicians. Each issue of the magazine is well illustrated. There usually are 12 pages, although sometimes as many as 16 are included. Subscription rates: $1.50 per year, $2.50 for two years. Single copies, 15 cents.

ASTRORAMA

▲ A circular map of that part of the sky which is visible from the latitude of Los Angeles. The Astrorama shows the sky as it is seen for each hour of the year. The user merely turns the movable disk to match the hour of the day with the day of the year and thus presents the sky in the open oval window. It is quite satisfactory for use in any place in the United States and for corresponding latitudes in other parts of the world. 50 cents, or by mail, 65 cents.

For either of the above or for free circular of information, address Griffith Observatory, P. O. Box 9787, Los Angeles 27.

PLANETARIUM SHOWS

of the Griffith Observatory

▲ The planetarium show is held in an air-conditioned theater having a seating capacity of 500. In the center is the planetarium projector, which reproduces upon the dome all the stars visible to the naked eye so realistically that the spectators feel as if they were outdoors looking at the heavens under the clearest of conditions. It is possible to compress days and even years into minutes and to show the sun, the moon, and the naked-eye planets and stars, all in their proper places for any instant of any year for centuries in the past and in the future, and as viewed from any place on the earth.

The planetarium show lasts about one hour and is accompanied by an explanation of the most interesting aspects of astronomy. The topics are different each month of the year, and some of them are changed from year to year.

Schedule effective as of November 1, 1947:

Wednesday and Thursday at 8:30 P.M. Friday, Saturday, and Sunday at 3:00 and 8:30 P.M. Extra show on Sunday at 4:15 P.M.

ADMISSION PRICES (including tax) to Planetarium Shows:

Adults, 50 cents;

Children under 18, and service men and women in uniform, 25 cents;

Children from 5 to 12 on Friday and Saturday afternoons, 9 cents;

Children under 5 not admitted.