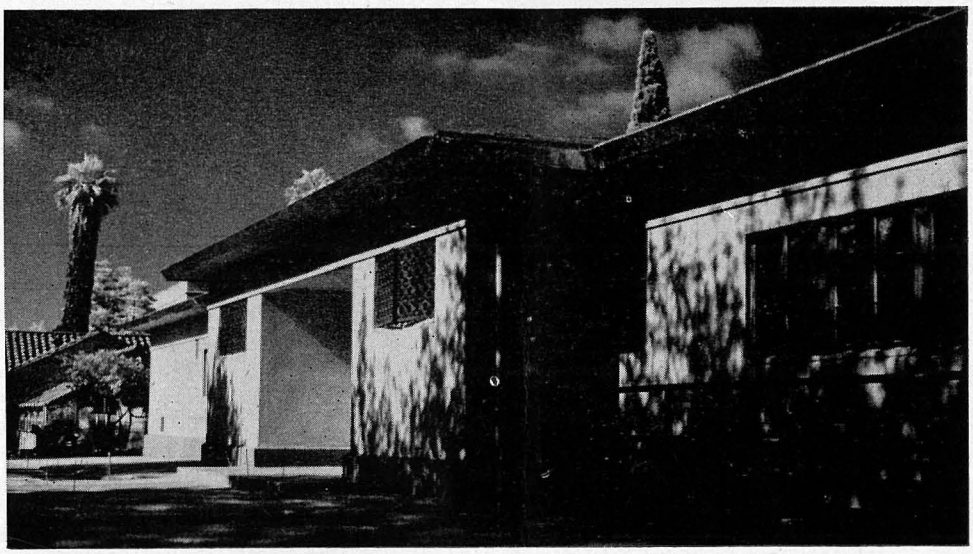
THE PHYTOTRON



Caltech dedicates its fabulous weather-factory

by Frits W. Went

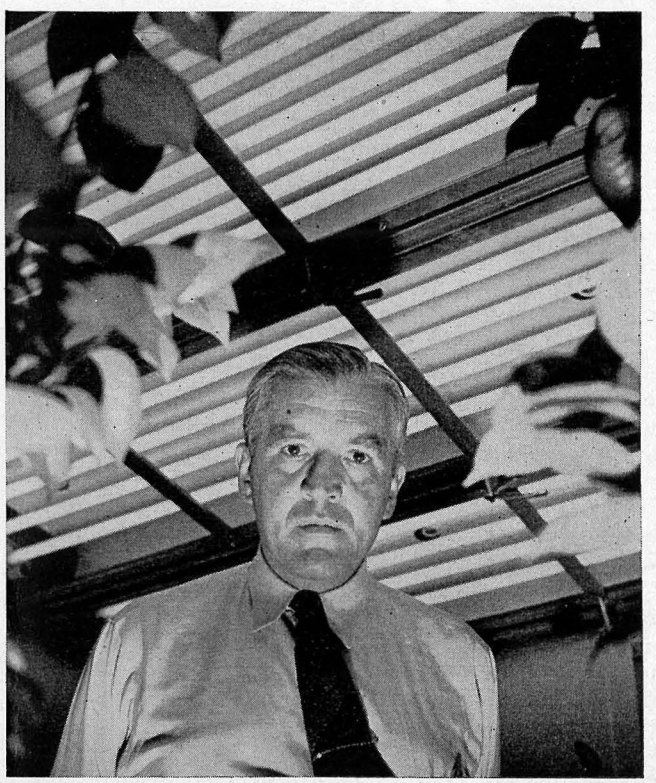
CALTECH'S Earhart Plant Research Laboratory, dedicated on June 7, is the first laboratory in the world in which plants can be grown under every possible climatic condition. Light, temperature, humidity, gas content of the air, wind, rain, and fog—all these factors can be simultaneously and independently controlled. The laboratory can create Sacramento Valley climate in one room and New England climate in another; it can even take the weather records of a single ranch and reproduce that ranch's particular climate.

The Earhart Laboratory will give us, for the first time, exact knowledge of how climate affects plants. It will provide plant material for basic research of a uniformity which has never before been possible on such a scale. It should tell us more about how to match plants to climate; how to predict ripening, flowering, and other phases of the growth cycle; how to control plant growth.

Since 1939 Caltech biologists have been able to study certain climatic requirements of plants in the air-conditioned greenhouses across from the campus on San Pasqual Street. These greenhouses—first of their kind—were built as an experiment, but they quickly became an absolute necessity in plant physiology work. By 1947 space limitations and the limited number of different conditions which could be reproduced in these greenhouses made expansion essential.

This expansion was made possible by the Earhart Foundation of Ann Arbor, Michigan, which made available all funds necessary for the development, construction, and equipment of the Plant Research Laboratory. The estimated cost of $200,000 has now swelled to $407,000.

To make certain that this awesome machine will not be mistaken for a mere greenhouse, Caltech's plant physiologists have unofficially christened the Earhart Plant Research Laboratory the *phytotron*—from the Greek *phyton*, meaning plant, and *tron*, which has come to mean device. Any similarity between the term phytotron and such terms as betatron, synchrotron, cyclotron, and bevatron is intentional. Caltech's plant physiologists happen to believe that the phytotron is as



Dr. Frits Went, in charge of the new Earhart Greenhouse.

The control room is the brains of the new laboratory. Here, every possible climatic condition can be created.

marvellously complicated as any of the highly-touted "atom-smashing" machines of the physicists.

The phytotron consists of six air-conditioned greenhouses in which natural daylight is used as a light source, and thirteen air-conditioned laboratories equipped with artificial light from fluorescent lamps. In addition there are eleven darkrooms and nine general laboratories kept at constant temperature and humidity.

The heart—or brains—of the building is the control room. All damper and valve control circuits are brought into this room on a 3.5 x 9 ft panel, with indicators and regulators. All circuits can be interchanged here, providing for unlimited flexibility.

Indicators for fans and pumps occupy a second panel. A third has time-clock circuits, with plugs to connect artificial light panels and other equipment to scheduling switches. Plugs for all electrical laboratory circuits are on another panel. Along the south wall of the control room a multiple CO_2 recorder will be placed, which can measure the CO_2 content of the air in twelve different rooms and greenhouses simultaneously.

In all greenhouses and light and dark rooms the air moves at a uniform rate of about 10 m./min. upward past the plants. Without radical changes it is impossible to increase this rate very much without unbalancing the air movement in the rest of the laboratory. Therefore, to conduct wind experiments, a wind tunnel has been built in one air-conditioned room. Plants placed in the tunnel can be subjected to air velocities up to 500 m./min.

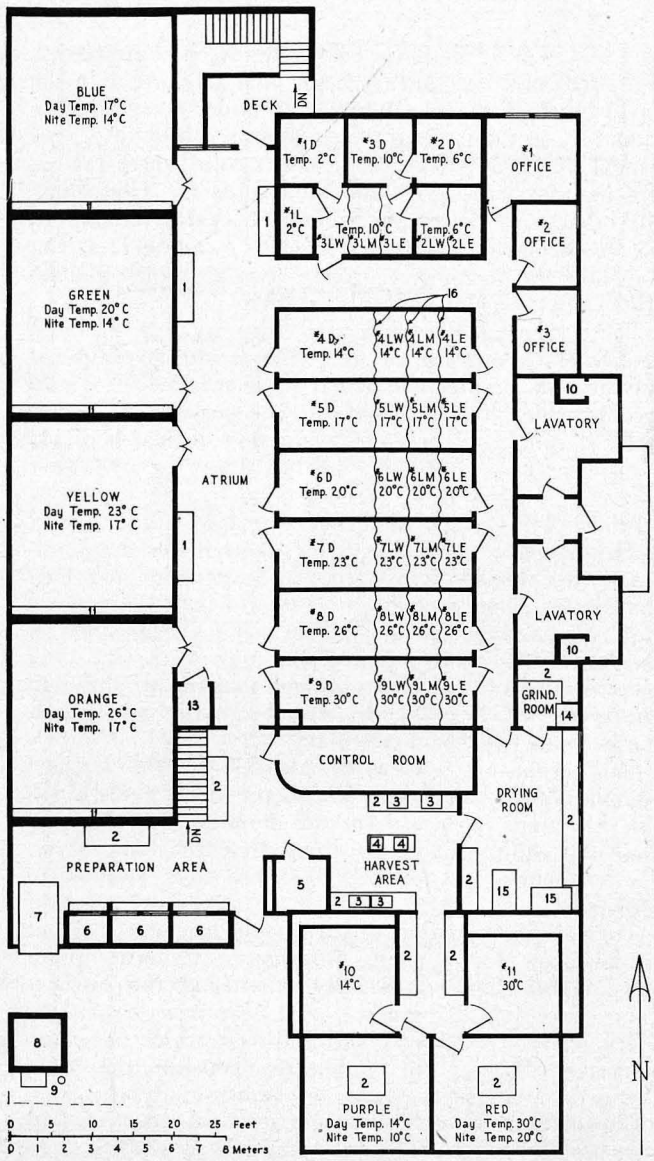
In another air-conditioned room, equipped with artificial light panels, a slotted steel floor and waterproof electrical outlets, rain and fog can be produced. A sump pump delivers water at atmospheric pressure to spray nozzles in the ceiling of the room. By changing the nozzle heads, rain of different intensity and drop size can be produced. The water disappears through the slotted floor and returns through a drain in the subfloor to the sump pump. In the same room a fog machine can produce fogs of different particle sizes.

Gas content of the air

Two rooms in the basement can be used for experiments on changed gas content of the air. They are made of concrete, with all openings towards the outside sealed. Each has a complete air conditioning unit, fluorescent ceiling lights, and a small ante-chamber, which acts as a gas trap. Still another gas trap has to be passed before anyone can enter the building or go outside. The fresh air intake to each room can be closed hermetically, and the exhaust ducts, which have a separate exhaust fan, can be closed in the same way.

These special gas rooms can not only be used for experiments on changed gas content of the air, or the effects of uncommon gases on plants (such as smog gases), but they can serve for quarantine, or for work with C_{14}.

The regular air conditioners for the several rooms cannot lower the relative humidity below 50 per cent, or at most 40 per cent. To study effects of very low humidity, one of the temperature-controlled rooms has been connected with a separate duct system to a



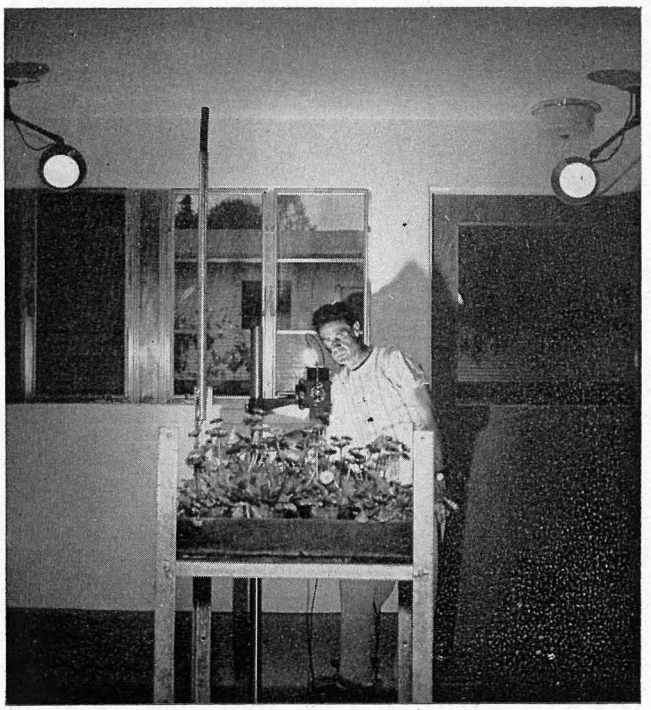
First-floor plan of the Earhart Plant Research Laboratory. Main entrance, right, center. is on Michigan Ave.

"Kathabar" unit, which can decrease the humidity much further. To this end, air from the room is circulated through an absorption tower, in which a concentrated LiCl solution is sprayed over cooling coils. This removes the water vapor from the circulating air. In another part of the Kathabar unit the LiCl is continuously regenerated by spraying it over heating coils and passing a stream of air over them, which is then exhausted towards the outside.

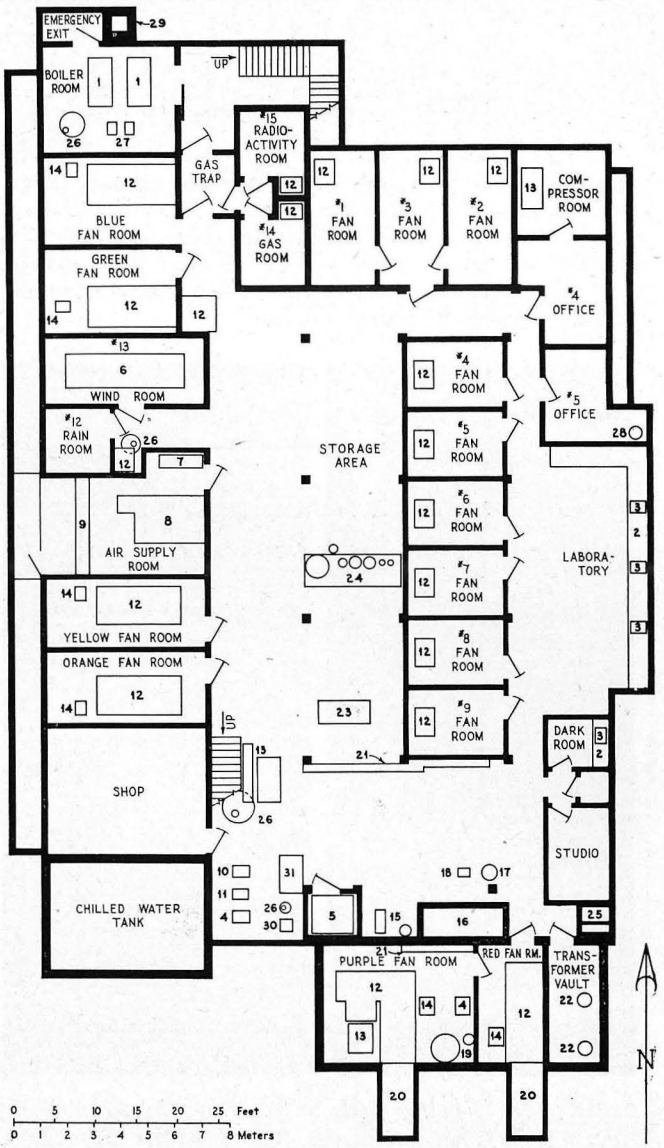
Photographic equipment

All plants growing in the greenhouses will be photographed at regular intervals. This is done with a "photorecord" camera fixed at one end of the atrium. The camera is prefocused, and set at a standard diaphragm and exposure time. One truck at a time is wheeled in front of the camera, the wheels are brought over marks on the floor, and with a foot pedal the floodlights are turned on, illuminating the truck. The same foot movement automatically takes the picture and moves the film one frame further, so that the stage is set for a picture of the next truck.

In a basement studio, pictures of plants will be made for reproduction purposes. Since no plants can be taken into the greenhouse without fumigation, it would be impossible to use outside studios for such photographic work.



Photographic setup includes a prefocused camera, used to take pictures of all plants at regular intervals.



Basement floor plan indicates some of the complex equipment which is needed to maintain the Earhart Laboratory.

There are no fixed greenhouse benches in the building. All plants are placed on small wheeled tables, called trucks. These are made of steel, and galvanized, and they can be attached to each other with steel hooks, so that they can be pulled in trains by an electric tractor.

To show at a glance whether a group of trucks is in the proper greenhouse or light room at the proper time, a steel pipe is welded to one corner of each frame. A wooden dowel is inserted in this pipe and protrudes four inches. Around the dowel are placed metal rings of one inch in height, colored according to the greenhouse in which they have to be placed. The upper ring indicates the greenhouse from 0-17 centidays (8 a.m. - 12 noon), the next from 17-33 centidays, the third from 33-67, the lowest from 67-0 centidays. When the truck has to be in the yellow greenhouse from 8 a.m. - 4 p.m., and in the blue house from 4 p.m. - 8 a.m., the upper two rings will be yellow, the lower two blue.

Thus it is simple to see whether all trucks are in the proper greenhouses at any particular time. The warmest greenhouse is red, and in succession the coolor ones are orange, yellow, green, blue and purple. The darkrooms are indicated by a black ring with white number according to whether darkroom 1, 2, etc. to 9 is meant, and the light rooms are indicated by white rings with black numbers, with further indication of W, M, or E according to which compartment of the light rooms (West, Middle or East) is meant.

The plants are watered either from hoses suspended from the ceilings of the greenhouses, from tanks on wheels, or from five gallon bottles placed on shelves in the atrium. Each greenhouse or light and dark room has taps for de-ionized water and one for a nutrient

solution. The wheeled tanks, made of monel metal, contain special solutions used in large quantities; the five gallon bottles (30 of them) contain nutrient solutions with various deficiencies. In nutrition experiments the trucks with the plants to be fed with a special solution can be wheeled under the respective bottles and fed from a tube.

Sterility

Complete control over diseases and pests is of great importance in the phytotron. Immediately after completion of the construction and preliminary testing the entire building is to be fumigated, top to bottom, so as to kill all living organisms—at least all animals. To maintain this relative sterility, all air, water, sand, plant material, and personnel have to be made germ-free as far as it is practicable.

Air entering the building is sterilized by being passed through a Raytheon Electric precipitator, located in the filter room in the basement. Before passing through the precipitator air moves past an ionizing unit—a gridwork of thin metal wires charged to 13,000 volts, which impart a charge on all particles moving past them. The precipitator consists of 16 groups of 95 metal plates, placed parallel to each other and parallel to the air stream, of which alternating plates are charged with 6500 volts. This charge will cause all charged particles to be attracted to the plates and a thin oil film, sprayed onto the plates prior to the beginning of operation, will keep the particles attached to the plates until washed off by a periodic water washing.

A large squirrel-cage fan (10 HP. motor) with about 30,000 c.f.m. capacity blows this filtered air into the main fresh air supply duct of the building, from which all air conditioning systems draw their fresh air. The static pressure in this duct system is kept constant with a controller, which bleeds air out of the duct system back into the filter room.

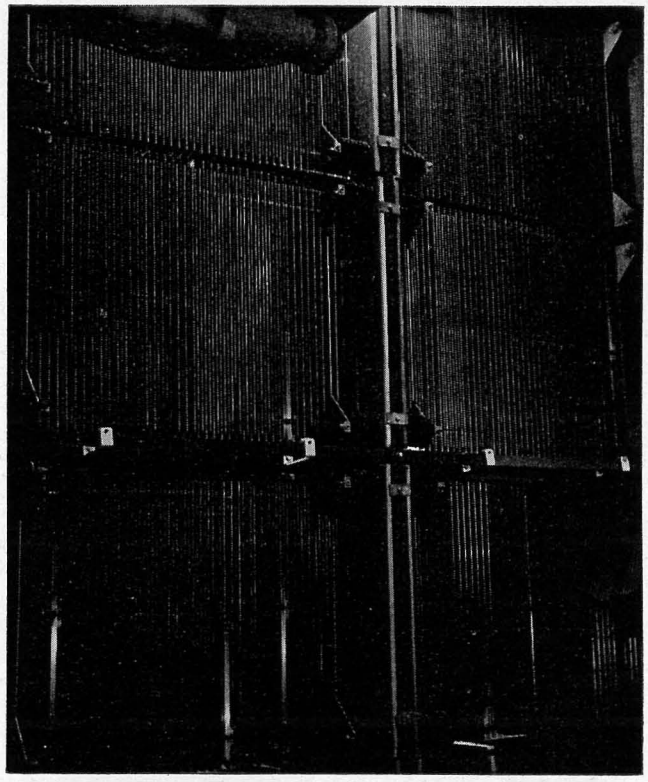
Sterilization and decontamination of soil, sand, pots, and plant material are accomplished in a preparation room. Three large bins, holding about 3, 3, and 2 cubic meters of material each, have two lids each sealed with neoprene, opening towards the outside and into the potting room. Trucks can dump sand or gravel in these bins. Before opening the bin on the inside the sand or gravel is sterilized *in situ* by steam, which issues from a slotted pipe in the bottom of each of the bins. This arrangement makes any intermediate moving of the material superfluous.

Visitors under cover

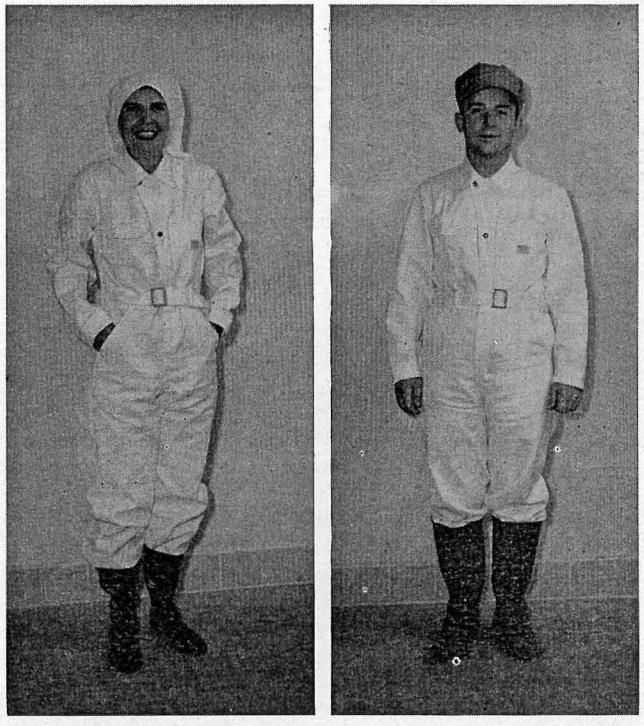
The entrance to the building is exclusively through two washrooms, which serve as decontamination units for personnel and visitors. All persons working regularly in the building have a change of clothes in lockers in the washrooms. Before they enter, their outer clothes and shoes are changed, a cap is put on, and hands are washed. Visitors have to don a coverall, boots, and a cap.

Unfortunately the number of visitors to the Earhart Plant Research Laboratory will have to be reduced to the minimum, because each entrant may be the unwitting carrier of a plant disease or pest. Even without considering the loss in research time, this would mean that a single infection might cost as much as $10,000 in operating expense.

The phytotron will go into operation sometime next month. Undoubtedly it will have a great influence on the future development of botany and of the applied plant sciences—horticulture and agriculture. And it will also certainly develop much-needed fundamental knowledge in the border fields between physics, chemistry, and botany. It is not unlikely, in fact, that methods developed in the phytotron for analyzing the complex interrelations between organisms and their environment, will be helpful in an analysis and better understanding of our social and economic system.



All air enters the greenhouses through this electric precipitator. Streaks of light, lower left, are sparks between plates, caused by insects being electrocuted.



Every effort is being made to keep the phytotron germ-free. Visitors have to cover up in outfits like these.