PHYSICS

Cameras See in the Dark

Invisible infrared (heat) rays spy on missile sites, strip away camouflage, guide missiles up tail pipes of jets, watch people in the dark and observe stars in daylight.

By FREMONT DAVIS

➤ "THE CAMERA, I think, is actually going to be our best inspector," President John F. Kennedy has said.

The use of infrared is materially aiding the camera in doing its inspecting.

The satellites of today are using detectors. Mariner II, which made the Venus fly-by, had a detector aboard. Its infrared radiometer reported to earth the temperatures at the top of the clouds surrounding Venus.

Weather satellites such as Tiros have infrared equipment aboard. These satellites use infrared to map the clouds around the earth at night. They are oriented so they face the earth by infrared detectors that watch the horizon. The amount of heat received and that re-radiated is measured to give the earth's heat balance. This is done by infrared rays.

Carried on Military Spacecraft

Although the Defense Department does not talk about infrared equipment, there is little doubt that it is carried aboard some military spacecraft. The Midas program, the future of which is uncertain, was to develop satellites that would scan skies over Russia with infrared sensors to detect the heat of rocket engines. Advanced types of detectors are known to be available. Progress is being made toward more sensitive equipment and sharp, clear pictures under all conditions.

It is reported that $130 million for military infrared was spent in 1962 and higher expenditures are expected in 1963 and following years.

Military use of infrared in space includes: attitude control of "spy" satellites for surveillance of Inter-Continental Ballistic Missiles (ICBM) launch areas and reconnaissance; space traffic monitoring; space station defense surveillance; track-while-scan, and weapons homing systems.

For the future of infrared, solid-state infrared camera tubes, advanced mosaic imaging systems, and (not-too-far-off) infrared lasers promise a radical improvement of all infrared systems and should enable infrared to add its abilities to other devices and systems of electromagnetic communications for peaceful and military uses of space.

When the rays of the sun are spread out into a spectrum, blue, green, yellow, orange and red are visible. If a thermometer is placed below the red end of this visible spectrum, the temperature is found to rise. There is energy in this region. Here lie the unseen heat rays—infrared rays. They spread in a band of many wavelengths, none in the visible.

As do other electromagnetic waves, infrared rays will go through a vacuum. All objects that are warm emit infrared. The wavelength emitted depends on the temperature of the object.

Infrared can be used to detect heat differences and thus to photograph in a whole new way. For example, a parking lot that has recently been emptied of its cars will appear to be full. The cool shadows of the automobiles have caused a heat difference on the pavement and a picture shows this difference. The infrared pattern appears about like a photograph of an auto-filled lot.

Detect Tanks Under Trees

Infrared waves can be used to detect tanks and machines under trees, to tell hot smoke stacks from cool ones. The differences can be told either in daylight or at night. Because the heat differences remain after the objects that cause the differences have been removed the camera that records this pattern is often called a past-seeking camera. The photographs seem to be of what was there but is not there when the picture is taken.

Infrared homing devices have been improved so that they can go to just exactly the source they have been set to home on.

This can be done so well that one company finds it can save target drones used to test their rockets. If the missiles are set to home on flares at the wing tips of their target drones, the explosive missile flies to the wing tip and explodes. This causes the target drone to pop out a parachute and save itself for another time.

In actual combat a missile could fly up the hot tail pipe of the target and completely destroy it.

Infrared seeking apparatus must be capable of rather precise adjustment to be able to distinguish between flares and the heat of the engine, for instance.

Foresee Volcanic Activity

Infrared is finding nonmilitary uses. A survey of Kilauea Volcano in Hawaii made using the infrared sensors developed for military use is determining whether underground heat is detectable from the air and might be used to indicate incipient activity.

Photographic emulsions such as used in ordinary cameras are not very sensitive to infrared. Emulsion makers can make emulsions sensitive to it, however, so that special infrared plates and films have been developed for the ordinary camera. Some must be kept cool since heat gives off the infrared to which the film is sensitive.

Photographs taken with these materials produce pictures in which the blue of the sky, which does not give off much infra-

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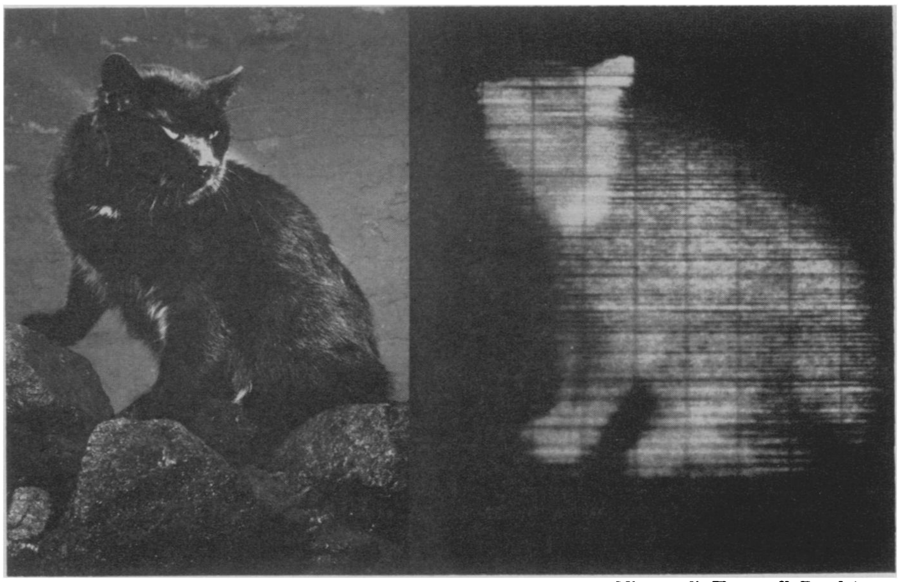

Minneapolis-Honeywell Regulator

SEEN IN THE DARK—A new infrared "eye" developed by Minneapolis-Honeywell is so sensitive it can "see" the proverbial "black cat in a coal bin at midnight." The photograph at the left was taken by a standard camera, while to the right is the infrared picture of the cat. Areas around the face, ears and feet show up lighter because of the greater heat given off where the cat's hair is short.

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red, is black and leaves of trees, which reflect infrared for their own protection against heat, are recorded as white.

This kind of film is used to detect the difference in many camouflage installations. Cut leaves or many materials will not look like the surrounding area although otherwise the camouflage might fool the unaided eye.

Earlier infrared films were not sensitive enough to do what is possible today. Now an eye that is very sensitive to these infrared rays has been developed. It gives a black to white picture difference when the temperature difference of the object being photographed is only a fraction of a degree.

Infrared Sandwich

A key component of one of the newly developed systems is a unique infrared-sensitive detector, or retina. The retina is a three-layer sandwich only a few millionths of an inch thick.

The center layer of the sandwich is a support film of aluminum oxide about one millionth of an inch thick. This film is made by chemically dissolving away all of the aluminum metal in a piece of suitably treated household aluminum foil, leaving only the thin layer of aluminum "rust" that coats the foil's surface.

The front surface of the oxide support film is coated with an even thinner layer of nickel, deposited in such thickness that it strongly absorbs infrared radiation. The back surface of the film is coated with a thin layer of a photoemitting material called cesium bismuth, which is capable of releasing electrons when light shines upon it. Of importance is the fact that the photoemitter's ability to release electrons under the stimulus of light varies with its temperature, changing two percent or three percent for every degree of temperature change.

To increase the overall sensitivity and performance of the detector, it is cooled to about 180 degrees below zero Fahrenheit.

In use, the infrared radiation from an object is focused on the heat-absorbing layer of the retina, forming a temperature pattern of the scene. This temperature pattern transfers through the thin support layer to the photoemitting surface, where it can be perceived merely by scanning a spot of light across the surface.

As the light spot scans the photoemitting surface, many or few electrons flow from the surface in exact conformity to the heat pattern on it. These electrical signals are then amplified and fed to a standard television picture tube, on which a visible picture appears. Thus, a point by point description of the temperature scene is created on a television screen.

Although much interest and money are being spent on infrared for military detection systems that we must have, the future for peaceful use is bright.

Outer space medicine, navigation and world communications will profit from the unseen light, the infrared.

• Science News Letter, 83:135 March 2, 1963

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First Thorium Fuel Power Reactor at Full Operation

See Front Cover

➤ FULL POWER operation has been achieved at Con Edison's Indian Point atomic electric generating station in Buchanan, N. Y., seen on this week's front cover, 35 miles from the center of New York.

At full power Indian Point generates 275,000 kilowatts for Con Edison's six-million-kilowatt system serving New York area residents. The steam that drives the turbine at Indian Point gets approximately two-thirds of its heat from the atomic reactor and one-third from oil fired superheaters.

The reactor, according to its designer and builder, the Babcock and Wilcox Company, has operated smoothly since it achieved criticality.

The core of the reactor, the first power reactor to use thorium as fuel, will last approximately two years without refueling, the company reported.

• Science News Letter, 83:141 March 2, 1963