spectrum. As he moved the thermometer, he found that heat increases toward the red end but does not reach a maximum until the thermometer is moved beyond the limit of the visible spectrum.

Sir John Herschel, the elder Herschel's son, and others like Novili and Langley between 1830 and 1880 made other important contributions that resulted in infrared becoming a special field of study in the science of optics. Infrared proved to be an ideal tool for portraying the reality of many unseen and difficult-to-see processes and conditions. Thus by the 1930s chemists were using it to identify chemical groups such as molecules, and photographers were using it to illuminate the dark on photosensitive plates.

Rapid Advances

World War II applications such as the snooperscope, and defense research and application, afterward in such things as jet aircraft and missile tracking systems, stimulated rapid advances in the field. But it is the recent advances in medicine and industry that are exciting the most interest today.

In medicine, infrared is a supplement to X-ray diagnosis, providing doctors with a thermogram—a photograph that shows not what our eyes would see but what hundreds of thermometers would sense. Doctors know that malignant or malfunctioning parts of organs give off more heat than normal tissues, but the thermogram helps them pinpoint the disordered area by detecting such subtle temperature changes.

Thus, for example, one patient's breast cancer was very early discovered by infrared techniques because the malignant breast radiated more infrared than the normal breast and doctors were able to locate and remove the malignancy even before the tell-tale lump had developed. Another patient who complained of abdominal pains was given an infrared thermograph test and was found to have an inflamed appendix, which doctors removed.

Thermograms, however, can also indicate subnormal temperatures of body parts. A patient who experienced pain and cold for five to six weeks was examined with thermography and found to have an area with less than normal temperatures, brought on, the doctors discovered, by a closing of a blood vessel in the right thigh. A tube was inserted to bypass the infected area with blood, and postoperative thermography showed a return to normal temperatures in the general area with full restoration of blood circulation.

Outstanding industrial applications for infrared have come in the field of metallurgy. The infrared micrometer, for example, can measure to within 0.001 inch the thickness of hot metal as it travels at speeds of 90 miles an hour in a rolling mill or rod mills, allowing the engineer to make in-process changes that prevent waste or ruin of metals being formed.

In other metallurgical applications, infrared devices swiftly tell the engineer important facts about pouring or welding, both of which are extremely touchy processes. The engineer has to have precise swift information about temperature for accurate blending or purification of metals before they are poured, and in welding, heating must be to just the right degree to enable the material to be fused but not burned. Infrared provides such information just when it is needed.

Finding the defective part in a giant piece of electronic equipment that is malfunctioning—a laborious process in maintenance operations—is an easy task for infrared. By sending a current through the equipment and using an infrared sensor, the engineer can find the malfunctioning part in a short time because such parts either radiate more or less heat, and the sensor can locate the faulty part by detecting the subtle temperature differences, without in any way damaging the equipment.

Detection of wires and transformers in the electrical field that will soon fail but as yet show no external symptoms is another specialty of infrared. Wires with weak spots continue to carry the current but overheat, and transformers get hot when insulation breaks down and short circuits develop. The infrared thermograph spots such failures and thus can prevent entire towns from being thrown into darkness by power failures.

Costs May Be Cut

Another developing area of industrial application that will probably save American industry millions of dollars each year is the thermography—assisted maintenance of factory equipment. Early detection of worn-out bearings, unlubricated joints, and points of mechanical abrading allows scheduled maintenance rather than hurry-up repairs that shut down a production line.

The U.S. fishing industry will benefit from a Navy-developed infrared device that detects subtle temperature changes in ocean currents. Fish follow currents with certain temperatures but avoid waters with temperatures not to their liking, and the Navy infrared device operating from an aircraft portrays the subtle temperature changes, thus telling fishermen which way the fish are running.

California's devastating seasonal fires may be in for a new type of preventive medicine because of infrared. Forest rangers equipped with infrared radiometers can detect fires miles away before the smoke is visible, and such early detection enables them to get to the scene before the fire is out of control.

Fire fighters in the cities could also use the same technique because fires thought to be out often flare up again. Or, they can use the devices to locate hidden glowing embers or flames in smoke-filled buildings or behind walls. Infrared radiometry sees the hidden pockets of heat and allows firemen to douse them rapidly or more thoroughly.

The home-improvement industry could also benefit from infrared radiometry. Often it is necessary and difficult to trace intrawall wiring and plumbing during a room addition or similar add-on improvement, but the infrared device enables the repairman to find the wires and pipes without ever seeing them and without the bother and expense of tearing out part of the wall.

Other uses include the warming of houses from built-in invisible electric wall panels, cooking of food that prevents charring of outer surfaces as occurs in baking, drying paints, and medical heat therapy.

SPACE

Europe Begins Its Own Orbiting Observatory

➤ GREAT BRITAIN has won the quest for the heart of Europe's biggest space project, triumphing over German-Dutch and French-Belgian-Swiss alliances.

The prize is a $10 million contract to build a telescope for the European Space Research Organization's (ESRO) Large Astronomical Satellite (LAS).

Scheduled to be launched in 1971, LAS will be centered around a 10-foot-long, 32-inch-diameter reflecting telescope designed to make observations of infrared and ultraviolet wavelengths. the telescope's mirror and associated instrumentation are to be built by the Culham Laboratory of the British Atomic Energy Authority.

Ultraviolet and infrared observations are made difficult by the interference of the earth's atmosphere, but LAS, like the U.S. Orbiting Astronomical Observatories, will be above almost all of the air blanket.

"There is an unbelievable amount of work to be done when these ranges of cosmic energy are opened up," said Dr. Robert Wilson, head of the British design team. "The ESRO observatory alone could be kept busy for 100 years."

LAS will weigh approximately a ton, yet ESRO scientists are hopeful that it will be accurately aimable to within 0.1 second of arc. Including launch expenses, the project will cost about $42 million.