Research Notes

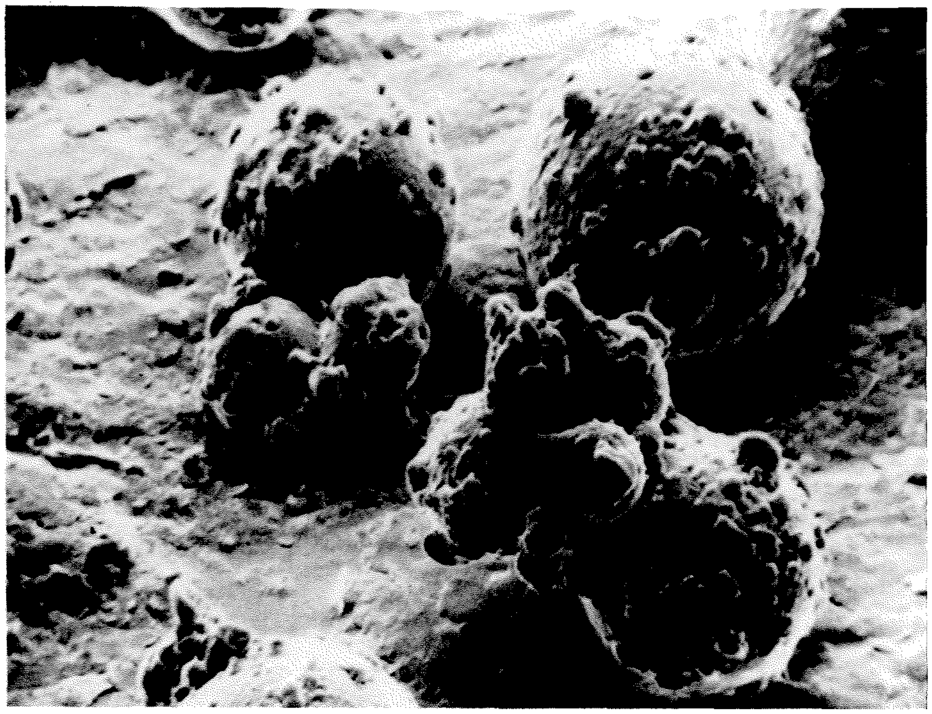
Capsulated Cops

Ever since the 1967 *Torrey Canyon* tanker disaster, when 700,000 barrels of oil poured onto English beaches, large-scale pollution from oil spills has increased sharply. With the newer and larger tankers now in use, it has been estimated that five to ten million tons of petroleum contaminate the oceans every year.

Beyond the difficulty and high costs of cleaning up the damage from such spills, there has been the additional problem of where to assign blame—often an almost impossible task. Many of the techniques proposed for identifying the sources of spills have been slow, expensive, and inaccurate. Now, Fredrick Shair, associate professor of chemical engineering, has developed a method that appears to have none of these drawbacks.

Working with graduate students Berill Mitchell and Peter Drivas, in collaboration with Peter Simonds, a former Jet Propulsion Laboratory scientist who has now returned to England, Shair has developed a quick, simple test that can be made at the site of a spill. The test reveals the identifying "license plate" with which a particular tanker's cargo of oil could be tagged at the time of loading. The system, for which a patent is being sought, has been successfully tested in the laboratory and in small-scale field tests. It is now ready for large-scale field tests.

The basic components of the tagging system are plastic microcapsules, similar to those used for timed-release medications. Measuring less than 1/800th of an inch in diameter, they are filled with combinations of 20 volatile liquids like, for example, Freon. About a million combinations of these liquids are possible, each a distinctive "license plate." Each vessel could be assigned its own particular combination. The cost of the system is less than 3/100ths of a cent for each barrel of oil, and as little as a pound of the microcapsules could tag the cargo of the world's largest tanker; tracer material from just



Each sphere in this oil-spill specimen is a plastic microcapsule about one-thousandth of an inch in diameter. When the capsules are heated to a temperature slightly above that of boiling water, they collapse and release a harmless gas that acts as a molecular fingerprint to reveal the source of the pollutant.

one microcapsule is enough to make a positive identification of its source.

The microcapsules, which have no adverse effect on the oil in the tanker or on the environment in case of a spill, can be added to oil in a tanker by methods commonly used for mixing additives with petroleum products. They are tough and will last in ocean water for about three months, roughly the duration of the evidence of an oil spill. When a spill occurs, a sample of it would be taken by means of a small syringe fitted with a filter to trap the microcapsules. The next step is to remove the filter and heat it to slightly above the temperature of boiling water. This causes the microcapsules to break down and release their contents in vapor form. These vaporous gases are then trapped in an electron-capture gas chromatograph, which can provide rapid and accurate analysis of the tracer. Sampling and analysis takes less than an hour.

Embryo Stars

W3, a cloud of gas and dust about 10,000 light years away in our Milky Way Galaxy, is so dense that astronomers have been able to tell only from indirect evidence that it contains several fairly young stars. Now, by using sensitive infrared detectors attached to the Hale Observatories' 100- and 200-inch telescopes, three Caltech astronomers have discovered what may be a group of even newer objects—embryo stars in the process of condensing out of the cloud of interstellar gas.

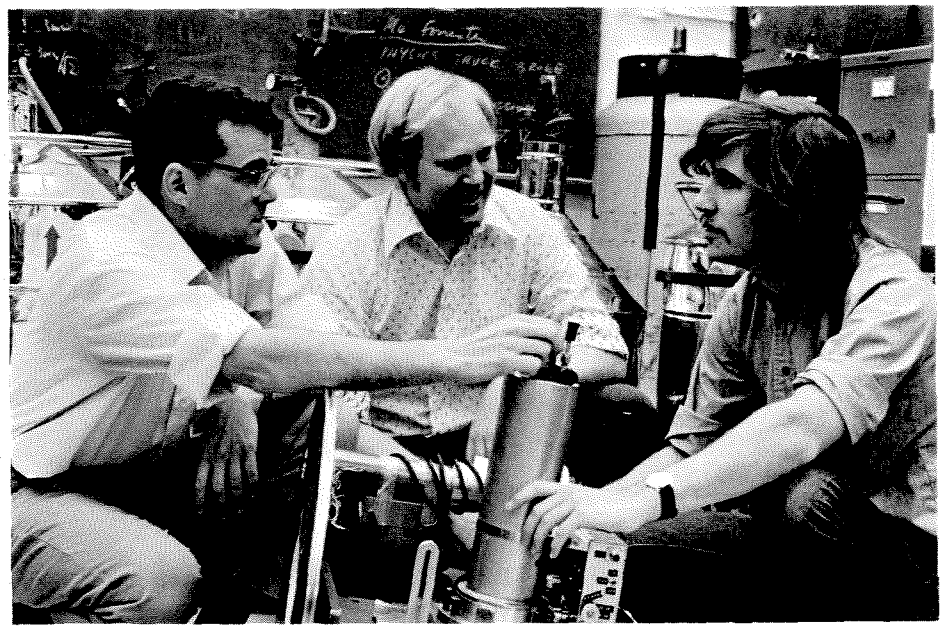
These new observations were made by Gareth Wynn-Williams, research fellow in astrophysics; Eric Becklin, senior research fellow in physics; and Gerry Neugebauer, professor of physics. Becklin and Neugebauer are also on the staff of the Hale Observatories.

Stars are believed to form from gas clouds that condense and shrink until their interiors get hot enough to cause nuclear reactions. Part of the energy of these reactions is then released as light. One of the newly discovered objects, called IRS-5 (for Infrared Source number 5), emits 30,000 times more energy than the sun and is larger than the whole solar system. Its temperature, however, is only 170 degrees Fahrenheit—which is extremely low when compared to the 5,000 degrees of a normal star.

IRS-5 is believed to be in the process of collapsing under its own gravitational pull to become—over the years—a much hotter and more compact star. This "protostar" is of great interest to radio astronomers because it is also an astrophysical "maser" that emits intense radiation at the precise wavelength of the H_2O molecule. Only one other such protostar—in the Orion Nebula—is known to astronomers, but IRS-5 is of even greater interest than that, because it is much more energetic and may eventually become an exceptionally bright star.

IRS-5 is only a few light years away from several very young, hot stars that were probably born within the last 10,000 years—a short time by astronomical standards. It is likely, then, that star formation is still taking place in cloud W3, especially since that region contains vast quantities of hydrogen gas—the raw material out of which stars are formed.

Unfortunately for astronomers, this hydrogen gas carries with it minute dust particles that make the inner part of W3 invisible to optical astronomers. Thus, in order to penetrate the cloud, it has been necessary to observe it at wavelengths in the infrared region, which are longer than those of visible light. The researchers speculate that eventually the radiation in the cloud will cause the dust to disperse and allow the new stars to be seen from the earth.

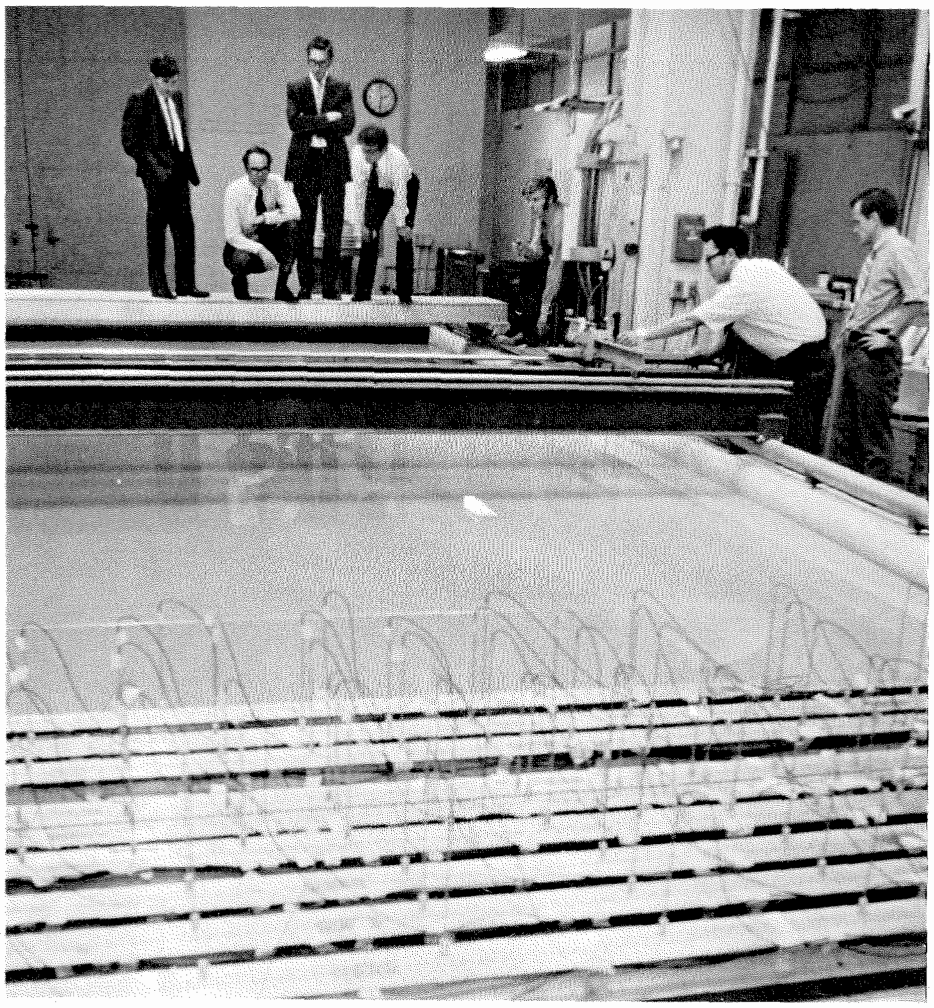


Gerry Neugebauer, Eric Becklin, and Gareth Wynn-Williams use an infrared detector to search for embryo stars. Attached to the 100-inch or the 200-inch telescope, the device uses a material cooled to within two degrees of absolute zero to detect small amounts of heat energy. This is often the only clue to the location of embryo stars.

Cooling It

How can water that is removing the heat from power plants be safely returned to the ocean without adversely affecting the marine environment? To answer this question, Norman Brooks, professor of environmental science and civil engineering, and John List, associate professor of environmental engineering science, have built a large water basin in Keck Hydraulics Laboratory. It is 36 feet long, 20 feet wide, and 16 inches deep, and it simulates 15 square miles of ocean off the California coast at San Onofre where the Southern California Edison Company and San Diego Gas and Electric jointly own a nuclear generating plant.

In this indoor ocean Brooks and List are exploring various techniques for diluting the warm water discharged by power plants so it can meet the new state standards that specify that this water must not increase the temperature of the ocean water more than 4 degrees once it has passed beyond the 1,000-foot mixing zone.



John List (under the clock), Norman Brooks (under the light), and Robert Koh and Eric Wolanski (far right) demonstrate the operation of their indoor ocean to officials of Southern California Edison. The tank is used to develop techniques for diluting warm water discharged into the ocean by coastal power plants.

When ocean water is used for cooling in steam-electric power plants, its temperature is increased by about 20 degrees Fahrenheit. When it is pumped back into the ocean through large outfall pipes, it must be diluted immediately to reduce the temperature increase in the ocean to the allowable limits. To get the information they need, Brooks and List have reproduced, to scale, the ocean floor, the coastal currents, and the outfall systems. Time is also scaled down; a day's tidal currents in the ocean take only 22 minutes in the laboratory basin.

The engineers monitor water temperatures at more than 100 locations in the basin to make sure there are no areas where the temperatures exceed the 4-degree legal limit. The temperature measurements are made by tiny thermistors that feed electrical impulses into a data-acquisition system. A computer uses data from this system to make maps showing contour lines that represent the surface water temperature. Brooks and his co-workers are also using colored water and overhead photography to observe and record the flow patterns of the returning water as it mixes in the basin.

List and Brooks are assisted by Robert Koh, research associate in environmental engineering science, who is in charge of the laboratory work; Eric Wolanski, research fellow in environmental engineering science; two engineers from the Jet Propulsion Laboratory, Wayne Marko and Don Kurtz; three graduate students, Nikos Kotsovinos, Philip Roberts, and Max Irvine; and undergraduate Bruce Bennett.

The work is being done under contract with Southern California Edison, and eventually the researchers will be able to make recommendations that will assist the company in preparing a detailed design of its cooling system outfalls. The study may also yield more general information on how water disperses in the ocean, which should be useful in doing similar studies on other coastal power plants.