Research Notes

Piping Up the Shock Waves

When Bradford Sturtevant, professor of and executive officer for aeronautics, takes the lid off his "pipes," Guggenheim Laboratory becomes the noisiest place on campus.

Despite the cacophony, he is actually seeking ways to curb—and possibly eliminate—the racket from motorcycles, from jet engines, and even from sonic booms.

The objective of Sturtevant's research is to find ways to break up the shock waves produced by these "noisemakers" at their source rather than trying to muffle the resulting sound waves.

Shock waves are very abrupt increases in atmospheric pressure, density, and temperature and are major disturbances compared with sound waves, which are very weak pressure variations. The shock waves dissipate as they pass from the source into the atmosphere, degenerating into sound waves.

The key to Sturtevant's work is a simple open-ended acoustical pipe. He has discovered that, as far as the physics of sound is concerned, this is much like the exhaust pipe of a gasoline engine or the inlet compressor of a jet engine. While it might appear that an open-ended pipe allows the energy to dissipate too quickly into the atmosphere to produce the shock effect, Sturtevant finds that sounds produced by it are so strong that they could rupture the eardrums of a person standing close to the pipe while it is generating the waves.

The discovery that shocks are produced with one end of the pipe open, even when the driving action is as smooth as that of a reciprocating piston, makes it even clearer that shock waves may be much more prevalent in sources of intense noise than might have been otherwise suspected.

The ear-splitting noise of a motorcycle engine attached to an open-ended acoustical pipe demands distance or discretion. Brad Sturtevant and his co-workers wisely choose to wear heavy ear pads.

Sturtevant's shocks are produced by the piston of a motorcycle engine that uses a three-inch acoustical pipe as its cylinder. The length of the pipe can be varied from 2½ to 15 feet by adding or removing sections. Sturtevant places wire mesh and metal rings of various sizes and configurations in the pipe to test their effects on shock waves. The resulting noise level is of very high intensity—about 200 decibels, which is the same magnitude of disturbance as that generated by such sources as motorcycle engines. By comparison, the sounds of a hard rock discotheque reach about 110 decibels.

So far, Sturtevant has dared to turn the piston up to only 6,000 revolutions a minute—about 100 shocks a second. Shock waves up to 1½ times the speed of sound have been produced. He plans to take the piston up to 10,000 revolutions a minute, which will produce a more powerful shock wave and a greater potential for noise. Out of consideration for his colleagues who do not wear the heavy ear pads he does, Sturtevant confines the louder phases of his research to evenings and weekends. That is when he takes the lid off his pipe. The pipe is instrumented with pressure gauges to record the shocks. A sophisticated data acquisition system designed by Donald Coles, professor of aeronautics, puts the information on tape in digital form.

The problem of controlling noise from motorcycle and chain-saw engines is difficult because they are two-cycle, one or two cylinder engines. In engines like these, the loss of power due to muffling is much more critical than for automobiles. Also two-cycle engines are inherently noisier than four-cycle ones (such as autos have), because the exhaust and explosion occur at the same time; in four-cycle engines the exhaust takes place one stroke of the piston after the explosion. Some motorcycle engines actually use the shock waves in the exhaust pipe as a supercharger to get more gas into the cylinders. This is done by keeping the waves in phase with the engine at high speeds. The result is a series of shock waves that decay in the atmosphere into sound waves of many frequencies, producing loud, discordant noises.

Sturtevant's work may also shed some light on the nature of the shrill "buzz saw" scream emitted by airline jet engines, which is due to the inlet compressors. The noise has been somewhat suppressed by classical acoustical methods without taking into consideration that shock waves play a role in creating the disturbance. Acoustical liners have been used in jet engine inlets and have been reasonably successful, but no one understands the way in which they break up the shock waves, or how to design a better absorber.

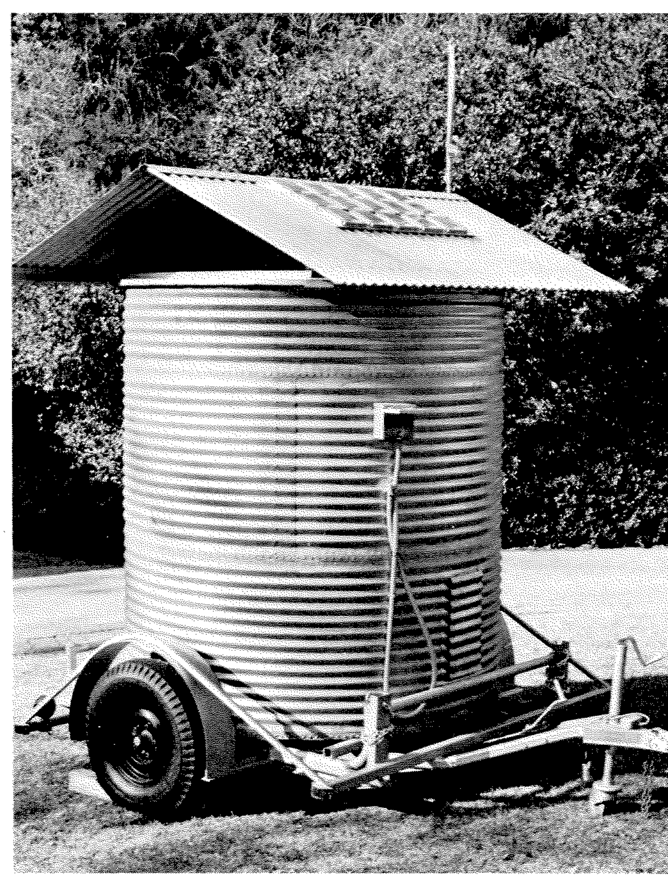
The sonic boom is a shock wave phenomenon very similar to the others, but dealing with it is much harder because, unlike the land-based sources of intense noise, it is extremely difficult to decrease the strength of the shock wave at its source.

Sturtevant's research is supported by the National Aeronautics and Space Administration.

Seismograph Stations Travel Economy Class

Economy in construction, simplicity in operation, and ease in moving from one spot to another are among the virtues of a new series of seismograph stations now being installed around the Gulf of California. Two of the stations are already in place, and four others should be in operation by this summer.

The sun shining on a total of 540 solar cells on the roofs of each of five of the stations will charge the 24-volt



By summer, six of these portable seismograph stations will be installed at 200-mile intervals around the Gulf of Mexico to monitor its earthquake-prone floor.

batteries inside—generating the power to run a recording lamp and drum, a quartz crystal clock, and a radio receiver tuned to a time signal. All this requires less power than is used to run an ordinary electric clock. The batteries should last for three years and will keep operating even if the sun shines only every fourth day. (The sixth station, already installed, uses available electric power.)

A roofed section of galvanized culvert six feet in diameter and seven feet high forms the structure that houses the instruments, and the whole package is mounted on a wheeled platform complete with a trailer hitch. When each station is in place, a seismographic instrument will be buried nearby and connected by electric cable to the recording instruments inside.

The goal of the project is to accumulate data on how the earth's crust is being deformed in the Gulf of California—and thus to understand and predict the behavior of the San Andreas fault system, of which the gulf fault system is really an extension. An international research team for the study consists of Clarence Allen, Caltech professor of geology and geophysics; James Brune, professor of geophysics at UC San Diego and visiting associate in geophysics at Caltech; Cinna Lomnitz, professor of geophysics at the University of Mexico and a Caltech alumnus (PhD '55); and Federico Mooser, chief geologist of the Mexican Federal Power Commission. The U.S. National Science Foundation has contributed $132,600 for the study, and the Mexican power commission, interested because it is developing a large geothermal power generating plant in the Colorado River Delta, has also given significant financial support.

EQL Issues a Warning

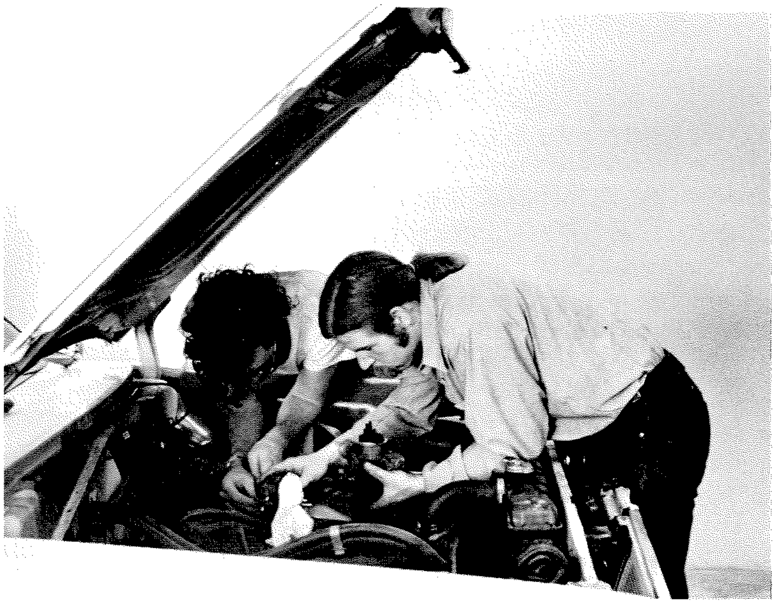
A report issued this month by Caltech's Environmental Quality Laboratory (EQL) warns that time is running out for reducing air pollution in the Los Angeles basin. In fact, the EQL strategy statement—"Smog: A Report to the People of the South Coast Air Basin"—lists drastic steps that will have to be brought to bear within this decade to save us from ourselves.

As a last resort, EQL proposes gasoline rationing in order to reduce driving and, therefore, air pollution. But to prevent such a step EQL offers a $1 billion strategy for reducing air pollution in the basin by about 80 percent by 1975. The strategy includes:

1. Mandatory conversion of about 500,000 fleet and commercial vehicles in the Los Angeles basin to natural gas or propane. This would cut back gasoline consumption by one-third.
2. Mandatory use of evaporative and exhaust emission devices on 1960-1970 used cars.
3. Periodic inspection of all vehicles for emissions.
4. Socioeconomic pressures that would cut back driving 20 percent through a variety of penalties and incentives.
5. More stringent controls that would cut current industrial and power plant emissions in half.
6. A new kind of smog alert during which many vehicles would be banned from the freeways and many industrial and commercial sources of emission would be shut down.

The first series of emissions reductions proposed by EQL would reduce the number of days on which the state's standard for oxidants is violated from 241 in 1970 to 50 in 1975. A second phase would add stringent smog alerts to stimulate the effect of the other measures and cut the violations of the oxidant standard by yet another half: from 50 days in 1975 to 25 days in 1977. The violations of the state standard for nitrogen dioxide would decline from 130 days in 1970 to 10 days in 1975.

The report suggests that the air quality standards set up in 1970 under the amended federal Clean Air Act probably could not be reached by the 1975 deadline. However, the EQL study shows than an 80 percent reduction on smoggy days is possible. The EQL team recommends setting up an interim "management" standard that could be a first step toward eventually reaching the stringent federal air quality standards.



Gary Rubenstein and James Henry are converting Caltech's security car to the use of propane instead of gasoline. Because this car must idle or be driven at very low speeds a great deal of the time, use of propane should improve its efficiency as well as reduce emissions.

The mandatory control devices suggested in the report for used cars are the capacitor discharge ignition optimization system for 1960-65 cars; the vacuum spark advance disconnect for 1966-70 cars; and the device for controlling evaporation from the tanks of 1966-69 vehicles. All were found technically and economically feasible for immediate controls on used car emissions.

Social and economic incentives to reduce the total number of cars on the road include:

1. Emissions taxes, which would be made possible by an emissions inspection system. Motorists would pay the tax in proportion to the total contaminants their cars put into the air.
2. Reserved "fast lanes" for buses and car pools on the freeways during rush hours.
3. Controlled access to freeways during peak hours, giving priority to buses and car pools.
4. Expanded bus, jitney cab, and minibus service.
5. Free parking to car-poolers.

If no combination of these measures can reduce driving, gasoline rationing is proposed as a last resort. The report suggests that demonstration projects are necessary to determine which of the socioeconomic measures are feasible.

The tough smog alerts would begin in 1973 and would be called when oxidant concentrations are 0.2 parts in a million at any station in the basin, compared to the present first-stage alert level of 0.5 parts in a million.

During alerts only low emission cars—such as those burning natural gas—and those vehicles with two or more passengers would be permitted on the freeways.

The Biology of Cancer

When normal cells turn malignant, it is the body's immune system that determines whether the cancer will take hold and spread (*E&S*, January 1972). But what makes normal cells turn malignant in the first place?

One cause of cancer is infection with a tumor virus. There are about 200 different tumor viruses now known to cause cancer in a wide variety of animal species—chimpanzees, monkeys, cats, rats, mice, hamsters, and chickens.

Though human cancer has not yet been shown to be caused by a tumor virus, evidence is accumulating that viruses can cause cancer in man—*and* that the malignant process may be reversible. The infection of cells by tumor virus was discovered by Walter Eckhart of the Salk Institute for Biological Sciences. His talk at Caltech on January 4 was the second of a series of seminars on The Biology of Cancer.

In "Polyoma Gene Functions for Cell Transformation" Eckhart described what goes on inside normal cells—after infection by a tumor virus—that causes them to turn into malignant cancer cells. Much of his research (largely in collaboration with Renato Dulbeco, also of the Salk Institute and formerly of the biology faculty at Caltech) has been with the polyoma tumor virus—an excellent model system because of its genetic simplicity.

There are several advantages to working with polyoma virus:

1. The DNA of the polyoma virus is made up of only five genes as compared to the millions that make up the DNA of an animal cell—thus increasing the chances of determining the functions of each of the viral genes and learning about its role in the cancerous change.
2. There is no need to work with whole animals. Polyoma virus can infect normal animal cells that grow in culture—in laboratory dishes.
3. After infection with polyoma virus, both the nature and behavior of infected cells growing in dishes change markedly; the cells become similar to abnormal, malignant, polyoma-caused cancer cells growing within an animal.

After a cell has been infected with a polyoma virus, it undergoes a *transformation* into an abnormal, malignant cell capable of passing on to its descendants the same cancerous characteristics. And it takes only two of the polyoma's five genes to bring about cell transformation. The function of one of these two genes, called *ts-a*, is needed only temporarily to start the transformation. The function of the other gene, called *ts-3*, is needed continuously to maintain the transformation. If this ts-3 gene function is stopped, then the transformation is reversed; the cell goes back to a normal, non-malignant growth pattern. Thus, only two of the polyoma genes appear to be involved in the cancerous transformation of the tissue culture cells.

Research like Eckhart's is changing an old view that the cancer process is irreversible. If we knew what the ts-3 gene function does within the transformed cell, then we might be able to turn it off and cause cancerous growths (at least those caused by polyoma infection in an animal) to revert to normal tissue. And such a discovery could lead to some clues to the treatment of human cancers that would cause them to revert to normal growth.

Experiments for a New Accelerator

Experiments proposed by Caltech physicists Felix Boehm and Petr Vogel are among the first to be selected for the $56 million proton accelerator now being built at the Los Alamos Scientific Laboratory in New Mexico. The experiments, which are delicate investigations of the structure of the atomic nucleus, are made possible for the first time because the new instrument will develop a sufficiently intense beam.

The studies will have two objectives:

1. To determine whether the particles that give the atomic nucleus its magnetic properties are far inside the nucleus or near its surface.

2. To find out more precisely whether muons (mu mesons) are particles just like electrons by finding how accurately they obey the laws known to be valid for atomic electrons.

Muons are unstable particles present in cosmic rays or artificially produced by large accelerators. Their seemingly complete similarity to electrons—with the one exception that they are 200 times larger in mass—is puzzling to physicists. In fact, it is difficult to find any reason for their existence.

The new linear accelerator at Los Alamos, which should be completed next year, is operated by the University of California for the U.S. Atomic Energy Commission. It will have a more intense meson beam than any existing accelerator.

In the proposed Caltech experiment, the beam will consist of muons, which carry a negative electrical charge just as electrons do. A muon will impact upon a "target" atom and move in an electron-like orbit around its nucleus in a smaller orbit than does the electron. Some of the muons actually orbit partly inside the nucleus. As they do, they are affected by the electrical and magnetic forces in the nuclear interior. These effects will be recorded, and it is hoped that they will yield information about the nuclear particles that are the sources of such forces.

The gamma rays of the nucleus will be measured to detect changes in the nucleus caused by the presence of the muon. The X rays resulting from the muon changing its atomic orbit will be measured as well, to detect the so-called screening effect of the atomic electrons and effects caused by possible dissimilarity between muons and electrons.

Because muons can penetrate deeper into the larger nuclei of heavy atoms than into those of light atoms, the relatively heavy rare-earth atoms will be used as targets for the muon beam. An additional advantage of these atoms is that they have "deformed" nuclei—nuclei that have an ellipsoidal shape instead of a spherical one. The muons have a tendency to readily change the velocity of rotation of such ellipsoidal nuclei. The energy corresponding to these changes is released in the form of nuclear gamma rays.

The instrument that will detect and measure the gamma rays and the X rays caused by the reaction of the muon "bullets" and the rare-earth "targets" is a curved crystal diffraction spectrometer developed and used at Caltech. It is the most accurate tool for the determination of the energies of these X rays and gamma rays. The spectrometer's quartz crystal sorts and focuses these radiations according to their energies (wavelengths). Under favorable conditions, accuracies to within one part in 10 million can be attained.

There is a long tradition of work with curved crystal diffraction spectrometers in the nuclear spectroscopy group at Caltech, dating back to the pioneering work of Jesse W. M. DuMond, professor emeritus of physics, in the 1930's. Among recent achievements with such an instrument is the observation and measurement of the isotope shift in atomic X rays, in which the relative sizes of the nuclei of two or more isotopes of the same element can be deduced from tiny differences in X-ray energy.