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ORGANIZATIONAL PROFILE

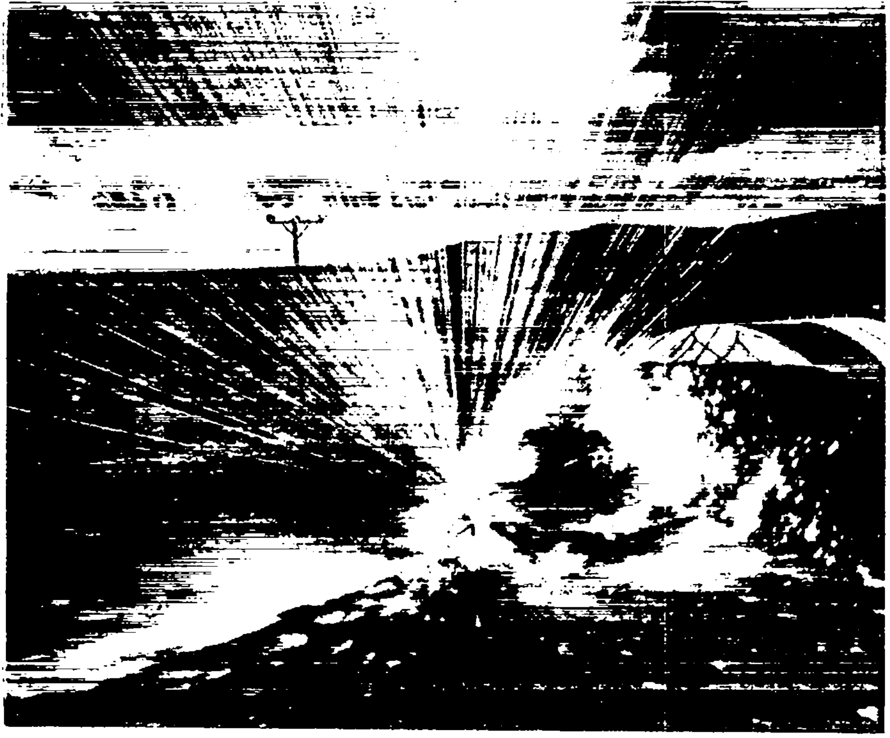
Dynamic Testing Division

Through fundamental and applied research in explosives and testing technology, the Dynamic Testing Division (M) contributes to Los Alamos National Laboratory's national security programs and makes its expertise available to the nation's defense community. All aspects of explosives research and development, including the development of test diagnostic procedures and equipment, are the responsibility of M Division. These activities include the detailed measurement, analysis, and understanding of hydrodynamic systems.

Among M Division personnel are chemists, engineers, and physicists, supported by a variety of technicians and others. The Division is organized into five groups that occupy about 22 square miles, nearly half of the Laboratory's area. This area contains laboratories, offices, and all of the Laboratory's explosives firing sites, which M Division operates.

Current Division research includes synthesizing molecules of new organic explosives and studying the behavior of explosives at the molecular level; formulating and characterizing new insensitive explosive compounds; and studying explosive reaction rates and incorporating them into complex computational models. Division research also includes studying the physics of shock-wave interactions and the behavior of materials at extremely high pressures and temperatures, developing new dynamic testing equipment and procedures, and using explosives to produce electrical energy and a variety of advanced conventional munitions. Division scientists carry out their work through theoretical studies supported by computational models combined with detailed experiments that employ the most sophisticated diagnostic equipment available.

Radiographs of explosives tests at the Laboratory's PHERMEX facility allow weapon designers to determine whether the performance of a weapon will match calculations.



EXPLOSIVES RESEARCH

Los Alamos scientists have undertaken a new project to discover in detail what an explosive is and how it works at the molecular level. This fundamental research enlists the most sophisticated techniques to study interactions of nitrogen and oxygen in a relatively simple explosive molecule, nitric oxide. Scientists hope to learn what holds the explosive molecules

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together, what makes them come apart during an explosive reaction, how the released energy interacts with other molecules, and how that released energy causes other molecules to break up and release even more energy. Such studies should improve the ability to predict how a new explosive will behave; they may also indicate how materials can be made to produce explosives with specific desired characteristics.

The Laboratory's emphasis on safety in its nuclear weapons development work has led to the development of insensitive high explosives. During the 1970s, Los Alamos pioneered the use of insensitive high explosives, which dramatically increase safety during handling and transportation and reduce the likelihood of nuclear material dispersal from a weapon accident. Most modern weapons are designed to incorporate these insensitive explosives. Insensitive explosives—such as triaminotrinitrobenzene, or TATB—can be dropped from great heights and will only shatter. These materials resist explosion caused by extreme pressures, high temperatures, and shock. In addition, they can be handled safely when normal precautions are observed and remain stable when stored for long periods in military stockpiles. To ensure the reliability of nuclear weapons in the nation's stockpile, Laboratory researchers continue to study the compatibility of materials in long-term storage and continue to develop new materials for weapons components.

In another project, M Division developed a gauge to simplify analysis of reaction rates during the initial stage of an explosion, before the actual detonation. (Initiation is an early transitory stage that culminates in detonation.) The new gauge allows simultaneous measurement of pressure and velocity. In the past, only pressure or velocity could be measured, and data were compiled only after a lengthy series of separate tests. The gauge measures the rate of progress of a shock wave and its effect on an explosive material just before detonation. Such data will help determine how the microstructure of an explosive affects the rate of the reaction; if the minute imperfections that alter reaction rates in an explosive are understood and controlled, scientists can gain additional control over the way chemical energy is released.

Through testing, M Division confirmed theories that a reaction strongly accelerated by change in temperature or pressure is characteristic of an insensitive explosive. These experiments should lead to more precise computer models of initiation and detonation, helping researchers understand how reaction rates affect sensitivity, initiation, and detonation.

Technician Robert Medina displays one of the small projectiles fired by the massive two-stage gas gun behind him and used by M Division to shock-compress materials in billionths of a second to pressures and temperatures equivalent to the interior of a star—or a nuclear weapon.

DYNAMIC RADIOGRAPHY

Dynamic radiography is one of the major tools used in M Division to obtain data on the performance of mock-up nuclear weapon components. In dynamic radiography, large machines are used to produce extremely short-duration bursts of x rays. After passing through the rapidly moving test object, the x rays are recorded on film as an image of the test object. The short bursts of x rays effectively "freeze" the motion of explosive-driven weapon mock-ups. The resulting radiographs are then examined in detail to determine whether the theoretical calculations

Dennis Herrera and James King prepare a prototype rail gun for a second test shot at the Los Alamos Explosive Flux Compression Facility. Previous rail guns could be used only once because they were extensively damaged by firing.

used to design the mock-up weapon assembly agree with the experimental results. This process saves both time and money because it reduces the number of field tests of weapon designs required for comparing calculations with experiments.

For the past two decades, all new weapon designs and all major changes to existing weapons have been examined at —PHERMEX (Pulsed, High-Energy Radiographic Machine Emitting X rays) as a routine part of their development. PHERMEX is a large, radio-frequency, linear accelerator. It directs pulses of high-energy electrons to a tungsten target where the energy of the electrons is converted into x rays.

M Division recently upgraded PHERMEX. The upgrade involved the design, fabrication, and installation of new high-power amplifiers for the accelerator. Division personnel designed and installed the amplifiers, and much of the fabrication work was done by the Mechanical Fabrication Division. The new computer-monitored amplifiers provide stable operation and will nearly double the peak energy output. State-of-the-art control circuitry was added and a new electron injector will be installed.

MATERIALS UNDER PRESSURE

To help understand the high-pressure properties of materials—such as plastics and metals—used in nuclear weapons, Division researchers use a variety of high-pressure-producing systems including explosives assemblies, gas guns, and diamond anvil cells to subject the materials to pressures more than 200,000 times normal atmospheric pressure. These unconventional testing techniques are necessary to simulate the extreme conditions that occur in an explosive-driven system. Under these conditions, materials may undergo molecular rearrangements that can alter their behavior. In dynamic experiments, metals may melt or separate into layers. In static experiments, the result can be as dramatic as the solidification of a gas such as oxygen. Compu-

A SAFER LOW-VOLTAGE DETONATOR

Safety is paramount at Los Alamos. In the field of explosives, the Laboratory is a leader in developing safer materials and procedures for nuclear weapons development. Recently, M Division researchers created a prototype electrical detonator that uses low-voltage power and, because of its less sensitive explosives, is safer to manufacture, store, and use than existing low-voltage detonators. It uses secondary explosives, which are less sensitive to heat, spark, and impact than the primary explosives used in ordinary, low-voltage detonators.

The new, safer detonator contains four working elements. The first is the bridgewire, a small wire attached to the power supply. Electrical current passing through the bridgewire heats it quickly because of its high resistance and small size. The next element, the donor charge, is a small amount of secondary explosive powder pressed into the cavity against the bridgewire. When the bridgewire reaches a certain temperature, the powder ignites. If conditions are right, it burns completely in a few thousandths of a second, producing a pressure of several thousand pounds per square inch in the cavity.

The third element, the confinement plate covering the donor charge, then ruptures. and a disk-shaped portion is torn out of its center. The disk is rapidly driven into the final element, the transition charge—a long, narrow column of low-density secondary explosive. The disk rapidly compresses this powder and causes it to detonate.

The key to the detonator's effectiveness is the tightly confined donor charge, which must perform perfectly to contribute to a complete detonation. If the assembly has any gaps, or voids, the pressure in the burning region will be reduced and ignition may be incomplete. For successful ignition, pressure must be maintained in the ignition region to create a boot-strapping process. That is, increased pressure yields a faster burning rate, which in turn develops greater pressure. The new detonator will probably be slightly more expensive to produce than current ones, but Division researchers believe that is a small price to pay for increased safety.

Robert Dinegar, who helped develop a new class of detonators, works on one of his inventions. Because the detonator does not use primary explosives, it is insensitive to sparks—yet it can be fired with only a few volts.

tational models rely heavily on detailed data acquired from experiments; without such data, errors in the models cannot be eliminated. But accurate models based on experimental data permit theoretical designers to explore variations without requiring an actual explosive test at each step.

Plastics are used in many weapon components. These complex polymeric materials consist of large molecules held together by a complicated network of chemical bonds. Current research in M Division focuses on understanding how these materials respond to shocks and how their properties are altered as a result of the shock process.

ELECTRICAL ENERGY FROM EXPLOSIVES

Conventional explosives have long been regarded as essential components in nuclear and nonnuclear weapons. However, a new use for these explosives, one with future application, produces high-power bursts of electrical energy. Division scientists are experimenting with explosive-driven generators that convert part of the energy released by an explosive reaction into huge amounts of electrical energy. Potentially, these generators may be used as power sources for defensive weapons that could destroy or disrupt sensitive components in enemy weapons or equipment.

In 1980, a team of researchers from Los Alamos and Lawrence Livermore National Laboratory successfully fired electric rail guns powered by explosive-driven generators. These rail guns can fire projectiles at velocities many times greater than the velocities of gunpowder-driven bullets because rail guns are not limited by how fast gunpowder products can expand. The tests, conducted at the explosives magnetic-flux compression facility at Los Alamos, demonstrated that explosive generators are ideal power sources for electric guns. In the experiments, plastic cubes about the size and weight of sugar cubes were accelerated up to 22,000 miles per hour—more than ten times the velocity of a rifle bullet—in a six-foot rail gun.

Rail guns have both research and weapons applications. In research, they can produce high pressures and temperatures in materials colliding at high speeds. Los Alamos plans to use rail guns for high-pressure equation-of-state measurements, which define the physical state of a material by relating its pressure, density, and temperature under all conditions. After further development, the guns may be useful for testing the vulnerability of warheads. Eventually, they may be able to launch projectiles at a velocity high enough to produce nuclear fusion reactions on impact.

Potential military applications of rail guns include both armor penetration and defense against high-speed, rapidly maneuvering missiles and planes. Another possible application may be launching payloads from the moon to earth or to other planets. Despite the potential for extremely high velocities, progress on rail guns has been slow because of the stringent requirements for materials used in both the projectiles and the gun barrels. To achieve high velocities in guns of reasonable length requires enormous accelerations and results in extremely high material stresses.

As a technology-based organization, M Division conducts many activities not necessarily slated for immediate application. Division scientists and technicians create a reservoir of information that can be used for research by other Laboratory divisions, the military, and private industry and universities. As the Laboratory continues to explore the limits of technology applied to national security, the Dynamic Testing Division will continue to provide fundamental data on reactive and inert materials and innovative technological solutions related to nuclear and nonnuclear weapon systems.

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GROUPS IN THE DYNAMIC TESTING DIVISION

M-1	Explosives Technology
M-3	Detonation Physics
M-4	Hydrodynamics
M-6	Shock Wave Physics
M-7	Detonation Systems

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