METALLURGY

Explosions Join Metals

The tremendous power generated by explosives is now being harnessed to cut, weld, shape and harden the complex metals and materials required for life in the Space Age.

By ELIZABETH HALL

➤ AN EXPLOSION of dynamite rips the air, shooting out invisible waves of high energy. But nothing around has been destroyed.

Instead, something useful has been created. Two metals have been fused in a novel and secure bond.

The power released in the explosion may cause a metal to take the shape of a huge rocket dome or a tiny complex part of a satellite. It may add extra strength and hardness to manganese steel railroad equipment.

Using explosives to replace giant forming presses is a new concept that has emerged with the Space Age. The field of metal working that began more than 5,000 years ago has advanced through discoveries of more complex combinations of metals and methods of joining and shaping metals that can fulfill the needs of space exploration and industry in the most economical way.

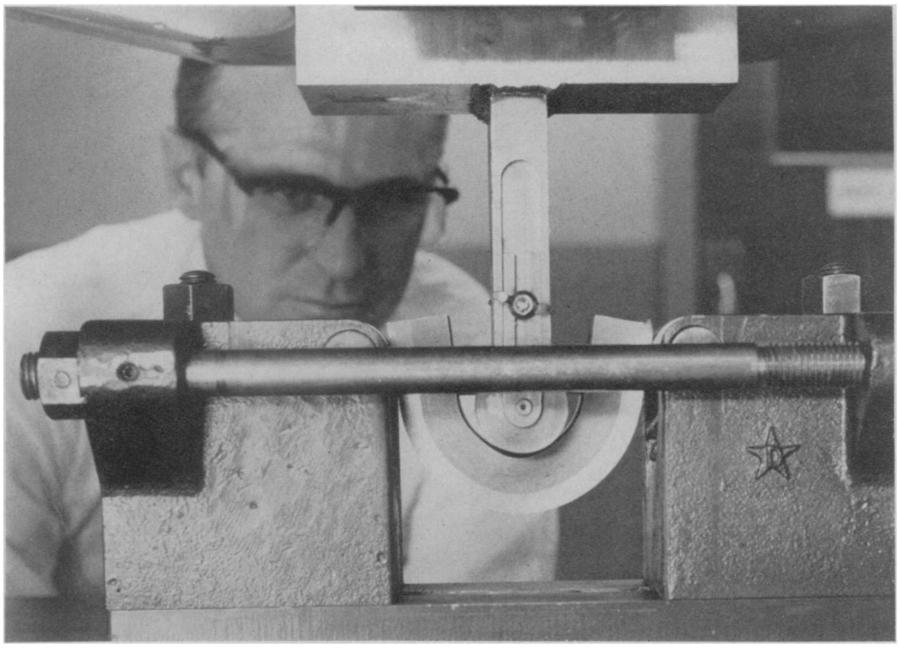
Nuclear Threat

The threat of nuclear warfare has driven scientists to find ways of harnessing man's deadliest weapon for peaceful uses—such as generating electricity at much lower costs than present. Conventional explosives such as dynamite and ammonium nitrate also have been adapted to shape, join, cut, clad and harden metals.

One of the newest applications of explosives in the metal working field is the use of shock waves set off by detonating explosives to cause two metals to collide and join in a metallurgical bond as strong as the metal itself. The metals "jet" together, momentarily creating a thin zone of melted metal between the adjoining surfaces.

Using explosives to join metals is one of the newest developments in the field of welding, an art dating back to ancient times. Forge welding, using the fire's heat and a hammer, was the earliest means of fastening heads to spears and joining wheel rims. More recent welding methods include the oxygen-acetylene torch welder and electric arc welder in which flames and electric currents provide the necessary heat energy.

Another welding tool of modern times is the electron beam welder in which the beam can be focused to thousandths of an inch in diameter. Still more or less in the experimental stage is the laser, a narrow concentrated beam of light than can fuse two pieces of metal in a microsecond.



Du Pont Company

IT JUST WON'T BREAK—Exploded into one plate, the two metals shown above remain joined together in an unbreakable bond. John J. Douglass, a Du Pont Company engineer and one of the three inventors of the explosive bonding process, conducts a bending test to see how strong the bond really is.

The explosive welding process is especially useful for cladding, which is the coating of one metal with a thin layer of another to add corrosion resistance or some other useful property.

Clad plate provides an economical way of combining special qualities in structural materials with the strength of steel. For example, an eighth-inch of acid-resistant titanium used to clad two inches of steel plate for a pressure tank will combine corrosion resistance with high strength. The cost will be lower than if pure titanium alone were used for the tank.

Industrial Clad Plate

Industrial clad plate is used primarily for chemical reactors and storage and bulk-transport tanks. Some of the principal cladding processes now used commercially include weld deposition, brazing and hot rolling, in which heat and/or pressure is applied to join one metal to the other.

The theory behind explosive cladding is that any two metals or alloys in wrought form that have sufficient ductility and impact strength can be metallurgically bonded without the use of heat or intermediate materials.

Among the wide variety of metals and alloys that have been successfully bonded at the experimental level are these: stainless steels to steel; aluminum to aluminum or steel; copper and copper alloys to nickel or steel and stainless steel; titanium, tantalum, zirconium, nickel, and nickel alloys to steel; gold, silver and platinum to nickel, and titanium to columbium.

Research and development work on the process has been done at the Du Pont explosives department's Eastern Laboratory, Gibbstown, N. J., by John J. Douglass, a mechanical engineer, Dr. George R. Cowan, a physicist, and Dr. Arnold H. Holtzman, a metallurgist.

Specialized Needs

Explosives are manufactured for specialized commercial needs today, including underground coal mining, coal stripping, quarrying, seismic prospecting, pipelining and highway construction.

In the metal working field explosives are an important part of the concept of high energy rate forming (herf). Electric sparks are used also to produce high energy shock waves that will shape metals.

High energy rate forming processes may never be valuable in the mass production of metallic parts such as the shaping of a metal car fender. So many millions of cars are manufactured each year that conventional assembly line methods are more economical. High energy rate forming processes become desirable when the need is for only a few elaborate and complex pieces of machinery, such as part of a satellite or rocket. These complex pieces require different structural qualities and

Du Pont Company

BLASTED INTO SHAPE—The three-inch steel disc being examined above by a Du Pont Company engineer was made by blasting two types of steel into a single plate. The end result—stainless steel on top of carbon steel. The two were joined by powerful shock waves generated in a precisely controlled explosion.

can be more economically produced one at a time by high energy forming methods.

Explosives are used in the metal working field primarily in the areas of forming, hardening, cutting, cladding, wire-rope "swaging," and in a slightly different sense, riveting.

Explosive metal forming, just as electric spark metal forming, usually takes place underwater. A sheet of the metallic material is placed on top of a die with a vacuum between the underside of the metal and the die. Then, an explosive charge, suspended in the water above the metal, is detonated.

The tremendous shock waves generated by the explosion are transmitted through the water, pressing the metal into the shape of the die. If electricity is used in forming the metal, a spark is generated between two underwater electrodes to produce similar waves.

Sheet explosive, a high energy explosive that comes in a linoleum-like form is increasing the wear life of railroad manganese steel frogs and other trackwork castings. Pieces of sheet explosive are attached to the frog or other metallic equipment and detonated.

The explosion subjects the metal to high shocks that cause the molecular structure of the steel to readjust. This readjustment within the steel increases its hardness, sometimes by as much as 300%.

Sheet explosive is used to cut metallic materials into different shapes. Wire rope swaging involves the use of explosives to compress fittings onto wire rope.

Using the force of explosives to blow things together rather than into bits marks another milestone in the progress of man. Inventive genius has found another peaceful and creative use for destructive force.

• Science News Letter, 85:378 June 13, 1964

CHEMISTRY

Hydrogen Is Headache For Saturn Engineers

➤ LIQUID HYDROGEN has created many problems, and solved a few, for engineers working on Saturn rockets, one of which will boost the first Americans to the moon.

Liquid hydrogen, or LH_2, gives much greater thrust than conventional rocket fuels. In 1960, the National Aeronautics and Space Administration assigned the Rocketdyne Division of North American Aviation to develop a liquid hydrogen engine with 200,000 pounds of thrust. It was to be used singly or in clusters in the upper stages of Saturn boosters.

Problems began right away.

First, such an engine cannot contain oil or other conventional lubricants. LH_2 has a temperature of minus 423 degrees Fahrenheit, so any sort of oil would freeze.

LH_2 also leaks, said Paul Castenholz, chief of the project at Rocketdyne's installation, Canoga Park, Calif. Ordinary insulated joints will not hold it, so joints must be welded. Non-weldable joints were made with metal-to-metal flanges.

In addition, fuel tanks had to be insulated to keep the liquid in liquid form. Liquid oxygen, or LOX, forms a sort of "frost" from the moisture in the air around it. This front is a good insulator.

LH_2, however, liquefies the surrounding air, which runs off the fuel tank like water, leaving no insulating coating. Special techniques were needed to keep the LH_2 cold. The solution was a sort of "thermos bottle," with an inner and outer tank, with a vacuum in between.

Unfortunately, the engine also had to be restartable in space with no outside power source.

For restarting in space, LH_2 is converted to hydrogen gas and compressed in a "bottle." When the bottle is full, a stream of gas is released, turning the engine motors and starting the fuel flow. A brief electrical impulse ignites the fuel.

Completed engines have now run almost 700 static tests of which over 500 were beyond the 500-second time required in flight.

Liquid hydrogen, however, sometimes solved its own problems. It proved to be its own best lubricant, for example. LH_2 is injected into bearings, providing perfect, almost frictionless motion. Furthermore, it saves considerable weight over oil.

• Science News Letter, 85:379 June 13, 1964

Do You Know?

About five percent of the U.S. population is allergic to *penicillin.*

The *fatty acids* in dairy products, eggs and all but the leanest of meats increase blood fat levels.

The "snooperscope" uses infrared light to illuminate young *salmon* while they are still submerged in gravel beds.

Giant *balloons* are expected to aid loggers in removing timber from now inaccessible forest areas.

• Science News Letter, 85:379 June 13, 1964