Space INTELLIGENCE NOTES

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FROM THE WORLD PRESS

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ICE FROM SPACE. An 11-lbm (5-kg) chunk of ice that fell on nearby Domodedovo around September 1 might have come from space, the Soviet news agency Tass stated on September 7.

"There are grounds to believe that this ice is of space origin," Tass said. "Science, it is true, does not know any precedent. But theoretically a meteor body of ice can exist in space."

Astronomers, geochemists, glaciologists, and other specialists are trying to solve the mystery of the chunk of ice, which splintered on hitting the Earth.

They believe "it is absolutely impossible for the ice that fell in Domodedovo to be of atmospheric origin; clear sunny weather prevailed on that day in that area," Tass said. "The hypothesis that this ice fell off a plane flying at a great height is also rejected."

The ice will be subjected to a complicated analysis with the use of isotopes. (Source: Washington Post, September 8, 1963)

US TRACKING STATION PLANNED FOR AUSTRALIA. Canberra is to become the center of a US space tracking network as big as the one at Goldstone, Calif., Allen Fairhall, Minister of Supply, said on Aug. 1.

The United States plans to finance the 60-mi^2 (156-km^2) complex to track space vehicles, to be built by Australians and staffed by Australian scientists and technicians.

Mr. Fairhall stated that the network would be built around the Tidbinbilla tracking station now under construction 20 mi (32km) southwest of the center of Canberra. He announced the project after returning on August 1 from visits to the United States, Britain, India, and Pakistan.

Australia already has two major tracking stations at Island Lagoon, near the Woomera weapon range in southern Australia, and at Muchea, near Perth in western Australia.

All the stations will play an important part in American lunar probes and other space exploration projects. (Source: The New York Times, August 2, 1963)

INTELLIGENT BEINGS ON MARS. Soviet biologist Vasily Kuprevich supports the theory that thinking beings inhabit Mars and also feels that Martians once visited the Earth, perhaps several thousand years ago, the Moscow radio reported on August 28.

He believes that the "canals" on Mars cannot be explained by natural causes and that they resemble oases supplied with water artificially.

Kuprevich also feels that the greenish-blue vegetation of Mars is not lichen but cultivated plants, the radio said. (Source: The Washington Post, August 30, 1963)

FURTHER US-UK SATELLITE TESTS PLANNED. Several British space experiments are to be carried out aboard satellites launched by the National Aeronautics and Space Administration of the United States in the next 2 or 3 yr.

Announcing terms of an agreement for cooperation on space matters, the chairman of the British National Committee on Space Research said that the experiments would be built into various types of "orbiting observatories" scheduled to be launched from Cape Canaveral.

University College London is working on an instrument to measure the amount of radiation coming from ionized helium in the Sun. The experiment is expected to yield new light on the transmission of long-range radio waves when carried out in 1965 aboard an orbiting solar observatory.

Another instrument will be fitted to a later orbiting observatory to measure the strength of X rays emitted by the Sun. Others will check on X-ray emissions from stars of the galaxy by means of a high-power X-ray telescope.

In all, four experiments on this joint British-American basis have been agreed to so far. Originally, NASA invited British scientists to compete on equal terms with their American colleagues for inclusion of their experiments on US satellites.

Sir Harrie Massey said cooperation with the United States had so far been excellent. He hoped there would be no shortage of satellite space for valuable experiments.

Sir Harrie also announced details of the first all-British satellite, due for launching some time in 1966. The satellite, at present known by the code name of UK-3, is to be made by the British Aircraft Corp. in collaboration with a number of all electronic companies.

UK-3 will carry at least five experiments. Traveling in circular orbit at nearly 400 mi (640 km) above the Earth, it will measure the vertical distribution of oxygen in the upper atmosphere.

The University of Sheffield is to provide instruments for gauging the strength of long-wave radio signals from space. A third experiment will measure the amount of radio energy generated by thunderstorms, and others will carry on work begun aboard Ariel, or UK-1, a British-American satellite launched last year.

UK-3 is to be powered by 6000 solar cells. A large number of these will be carried by four booms extending from its cylinder-shaped body.

Sir Harrie foreshadowed a steady upswing in British spending on space research. Currently this is about £500,000 ($1,400,000) a year.

Within the next 3 or 4 yr, he said, this would increase about fourfold. Part of the money would go into experimentation aboard satellites.

There would, however, be increased spending on British rocket launchers such as Blue Streak and Black Knight. (Source: The Christian Science Monitor, August 3, 1963)

SUN ERUPTIONS MAY CAUSE ATOMIC GEYSERS ON THE MOON. Dr. V. K. Aappa Rav, a guest physicist from India at the University of Rochester, New York, fears that travelers to the Moon may possibly encounter deadly geysers of atomic particles during Sun flares.

For 4 mo Dr. Rav fired protons, helium nuclei, and other atomic particles at chrondrite and basalt rocks, which appear to constitute the Moon's surface. The resultant statistics on the number of neutrons emitted by the rocks were reported recently by Science, a journal of the American Association for the Advancement of Science.

While discussing these results with the Science staff, Dr. Rav stated that he had evaluated his measurements in conjunction with radiation biologists and was firmly convinced that a potential danger during solar flares did exist. He further stated that cosmic rays, which cause the atoms in the rocks to emit neutrons, increase from 15 per cent to 5000 per cent whenever solar matter from deep within the solar body surges to the surface and shoots out in giant streams. (Source: The New York Times, August 18, 1963)

FROM THE SEMITECHNICAL LITERATURE

SUN POWER. Conventional sources of energy can hardly keep pace with present day demands. Electric power, which plays a decisive role in the development of industry, agriculture, and household services, has only an average availability throughout the world of 0.1 kw per person. Coal and oil are being used more efficiently, the potential of more rivers is being put to work, and nuclear power holds promise for the future; but these power sources are usually owned and operated by industrial countries so that their utilization is possible only to a small percentage.

Man is turning to new and peculiar sources for energy. In New Zealand, California, and Mexico, boiling geysers are being tamed. The Russians have recently announced that they plan to hoist giant windmills by balloon to exploit the 100-mi-per-hr (160-cm-per-hr) set streams 10 mi (16 km) up. Along the Brittany coast, off the Korean Peninsula, and on the west coast of Mexico, the energy of the tides is being tapped. But the power supplied by these sources is not enough. The only form of energy abundantly available to all nations is the Sun.

The atmosphere and clouds absorb 70 per cent of the solar energy that reaches the Earth. Even so, of the remaining 30 per cent, only one-tenth could generate many thousand times more power than is now available. It has been estimated that every 45 hr the Earth is supplied with more energy from the Sun that the total remaining usable reserves of coal, gas, and oil.

The Sun could replace a substantial part of the fuel used in the heating of homes and offices. It could be used to provide refrigeration for preserving food, distillation plants for drinking water, and irrigation, as well as plants for drying and dehydrating fruits, fish, vegetables, and grain.

The equatorial regions of the world have more favorable climates for taking advantage of solar energy. Unfortunately, these underdeveloped countries have been financially unable to do research in solar devices. The industrialized countries have sought conventional sources. For example, Australia is spending a tremendous sum on oil and little on the control of solar radiation, although the country is abounding in Sun and has small oil supplies.

Early attempts at Sun exploitation utilized a series of mirrors and lenses that reflected Sun rays onto a blackened water container, in which the water boiled and the steam given off was harnessed. Solar furnaces use the same technique, the water tank being replaced by a metal-containing crucible. The largest solar furnace in the world, on Mont-Louis in the Pyrenees, has a 1000-ft^2 (93-m^2) mirror and produces a temperature of 4500° F (2400° C). It melts 130 lb (59 kg) of iron an hour free from the impurities normally found in conventional furnaces.

Glass and certain plastics allow solar radiation to penetrate but hinder the escape of lower temperature radiation from the heated surface.

Temperatures required inside a house, exclusive of cooking needs, can easily be produced by the penetration of sunlight through a glass or

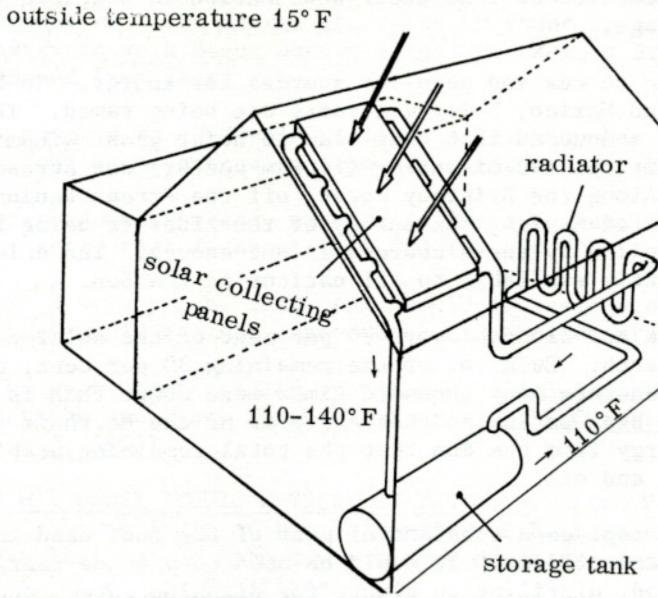
outside temperature 15° F
radiator
solar collecting
panels
110-140° F
110° F
storage tank

FIG. 1

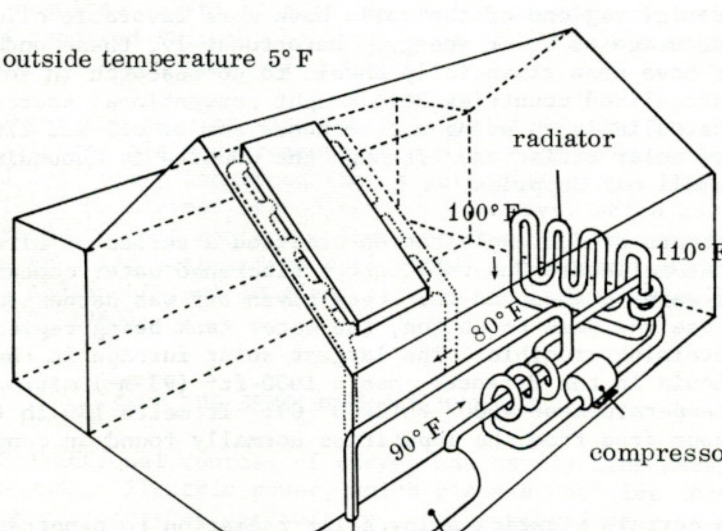
outside temperature 5° F
radiator
100° F
110° F
80° F
90° F
compressor
storage tank

FIG. 2

plastic cover to heat a blackened surface beneath. To maintain the heating at night or on cloudy days, a small booster heat source -- water tank or electric plug -- is necessary to store excess heat (Fig. 1 and 2).

Solar heat can be utilized for refrigeration. The University of Ceylon has produced an experimental solar refrigerator that has reached 10° F (37° C). A device of this kind could be used to air-condition homes and offices with water chilled to only 50° F (60° C).

A solar machine which has produced 15 w of power while running 300 hr and promises greater power output, has been devised at the Batelle Memorial Institute, Columbus, Ohio. It consists of two pistons motivated by solar radiation. One is a large working piston connected on a crankshaft; the second is smaller and is connected to the same shaft 180 deg out of phase. This smaller piston is the "regenerator" (Fig. 3). It is filled with steel wool, and the top face is blackened. Light enters a quartz dome that seals the top of the regenerator cylinder. The blackened piston head is heated, and warmth is transferred to the steel wool. Heat-expanded air forces the working piston downward, and the smaller piston is returned to its original position by means of the crank shaft. By this return stroke, the air in the cylinder becomes cooler, and some of the heat stored in the steel wool is exhausted. Thus the solar energy required to complete the cycle is relaxed -- a principal known as the regenerative effect.

In 1954, Bell Telephone Laboratories produced the first silicon cell to convert sunlight into electricity. This was ten times as effective as any previous photoelectric device.

The silicon cell consists of a sliver of silicon covered by a film of boron-impregnated silicon. Electrons migrate into the silicon filling as light penetrates the outer film, and a voltage difference is produced between the two. The size and consequent output are limited because the cell must be made from a slice of a single crystal. To compensate for this, a number of cells must be used in parallel.

The principal use of silicon solar cells is to replace small dry batteries, which are cheap but are easily exhausted. Silicon cells are already being utilized where the cost of replacing batteries exceeds original costs and where it is impossible to replace them, as in space vehicles.

Solar panels are of major importance for satellite and spacecraft flight. Tiros I, Explorer VI, and Vanguard I were all equipped with solar panels -- the latter being the first satellite equipped to convert sunlight into electricity. The silicon solar cell has made space probes

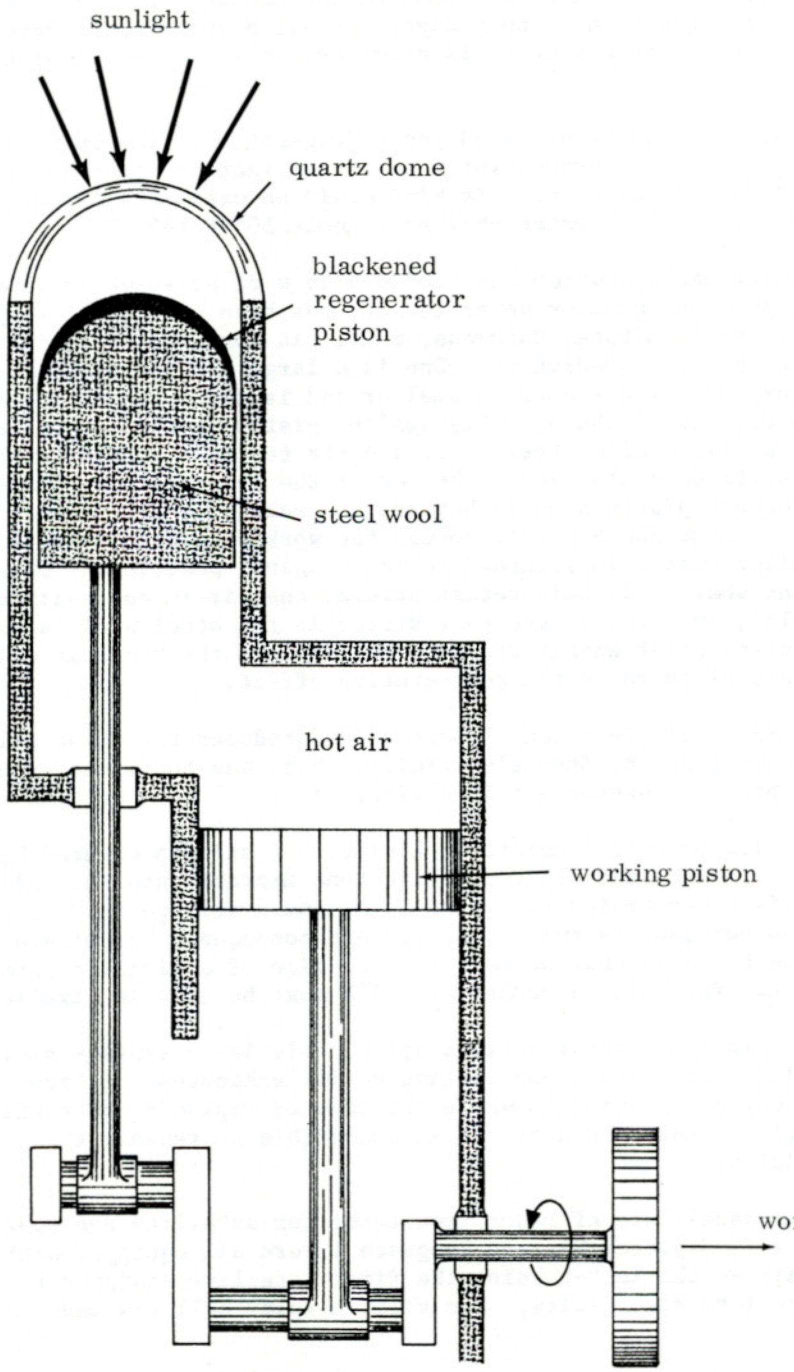
sunlight
quartz dome
blackened
regenerator
piston
steel wool
hot air
working piston
work

FIG. 3

possible, for no other power source could function during such protracted periods. (Source: Discovery, August 1963)

THE CLOCK PARADOX. Dr. Y. Rumer and Soviet Academician A. Landau have written an interesting explanation to the clock paradox that exists in spaceship flying.

According to Einstein's theory of relativity, an increase in speed slows time. Therefore, a clock on a speceship would run more slowly than a clock on Earth. As this happens, all physical, chemical, and biological processes would slow down, too.

Today there is the possibility, arising from the relative theory, of building a time machine for travel into the future -- a spaceship flying at a speed close to that of light. Returned from a flight on such a ship, an astronaut would find his contemporaries advanced in years, while he is still young. Thus he will have made a trip into the future. There are experimental facilities capable of proving the feasibility of a time machine, although one is not likely to materialize soon.

The time intervals between two events, as measured by an Earth clock and by a clock on board a spaceship, are related by a simple equation: the ratio is directly proportional to the square of the rocket's speed relative to the Earth, and inversely proportional to the square of the speed of light, which is 300,000 km/sec.

The equation relating time intervals, T, between two events, as measured by an Earth and a rocket clock, to the speed of the rocket is:

$$\frac{T_{rocket}}{T_{rocket}} = \sqrt{1 - \frac{v^2}{c^2}}$$

where v is the speed of the spaceship relative to the Earth, and C is the velocity of light (300,000 km/sec).

The difference between the time intervals as measured on the spaceship and on the ground will be negligibly small, while the speed of the spaceship is small relative to that of light. But if a spaceship could be constructed capable of flying at essentially the same speed as light (240,000 km/sec), the picture would be different. For example, a trip to Sirius -- 6 light yr from Earth -- and back at 240,000 km/sec will take 15 yr by Earth calculations. By the ship's clock, Laevever, the astronaut will make the round trip in 9 yr. Back on Earth, the astronaut will be 6 yr younger than his contemporaries and will have completed a 6-yr "journey" into the future. If the speed of the spacecraft were increased, it would be possible to travel farther into the future.

The relativity theory makes possible only trips into the future. No advance of science will ever enable us to travel into the past.

On close examination, the technical prospects of building a time machine are very slight. In order to fly a spaceship to the modest weight of 1 ton at 240,000 km/sec, the energy must be about 215 billion kWh. This is equivalent to the amount all power stations on Earth generate in several months.

The ship will have to be accelerated on take-off and slowed down for safe reentry. With existing propulsion techniques, tremendous energies would be required for such tasks. Even if it were possible to build a rocket engine expelling its exhaust gases with the speed of light, the highest attainable speed -- twenty times the energy given above -- would have to be produced for a flight into the future. This requires as much energy as all the stations on the globe generate for decades. Therefore it seems improbable that such a machine will be within man's reach for a long time, even disregarding the fact that every tiny speck of dust is a lethal missile to a ship flying at such speeds.

The theory that an increase in speed slows time has been proven experimentally by means of the elementary particles that make up cosmic rays. Many cosmic rays have been proven to travel at essentially the speed of light.

The cosmic rays impinging upon the Earth from outer space are streams of protons and the nuclei of other light elements. Rushing into the atmosphere, they give rise to a variety of secondary particles. At low altitudes, a large proportion of cosmic rays is made up of μ-mesons. Their mass is about 206 times that of an electron. The speed of μ-mesons may vary from very low velocities to near the speed of light.

μ-mesons are unstable and easily decay into other particles. Their life-rate has been measured by means of the "clock" equation, relating speed and time, since the speed of fast μ-mesons is very close to that of light. The equation is solved for the ratio of the life-rate of the μ-meson to the life-rate of the observer.

The first term in the ratio is the life-rate of a stationary μ-meson, a vital characteristic of the particle. It is 1·53 microsec. The other term of the ratio is the life-rate of a moving μ-meson, which has been found to increase with speed. Thus a meson in flight lives longer than a meson at rest.

The mean life-rate of a μ -meson is related to its speed:

$$T_{Earth} = \sqrt{\frac{1.53 \text{ microsec}}{1 - \frac{v^2}{c^2}}}$$

Physicists have learned to produce beams of μ -mesons of essentially the same speed. Thier life-rate has been measured as a function of their speed, and the "clock" equation, a fundamental proposition of relativity, has been proved. (Source: Spaceflight, July 1962).

FROM THE TECHNICAL LITERATURE

ASTROGEOLOGY

ON VISUAL ESTIMATES OF THE DEPTHS OF SMALL LUNAR CRATERS. A group of British scientists, belonging to the British Astronomical Association, are presently engaged in the accurate measurement of lunar craters, utilizing the Mercury computer at Manchester. As of March 1963, the group had measured the depths of more than 200 lunar craters and was in the process of studying the obtained data from numerous others.

In order to minimize the errors arising from individual judgment and differences in optical equipment in estimating the lunar crater shadow, one can make a single check by placing a lunar photograph at a suitable distance and then viewing it through a small telescope. f values (measurements of the ratio of a lens diameter to its focal distance) can thus be obtained by the same method as used in actual Moon observations. If the f estimates differ from the measured results, the proper corrections can then be made.

The aperture effect also can be evaluated in a semi-quantitative method through the simultaneous observation of the same crater with telescopes of differing apertures. The author used the 18-in. (45.7-cm) and 8-in. (20.3-cm) refractors at the University of London Observatory for this purpose and found that his estimates were systematically about 0.04 per cent smaller when using the 18-in. (45.7-cm) telescope to measure a number (30-50) of small lunar craters, chosen so that f lay between 0.4 and 0.6. This aperture effect is logical because the smaller telescope tends to blur the edge of the internal shadow.

To proceed further, the author did not have an obvious trend of a discrepancy δf with f, except for a possible and understandable minimum near $f = 0.5$. In his case the value of δf was in the range 0.05 - 0.07. It was significant that a systematic difference in f was noted between the author's results and that of another observer, which properly should be applied in the estimates.

Although the author's group of lunar observers did not make any allowances for systematic errors δf in crater depth estimates, it can still be accomplished when an error δf produces an error δd in depth; thus $\delta d = \delta f \cdot \Delta \cdot \sin A$, where Δ is the crater diameter in kilometers and A is the altitude of the Sun at the crater at the time of the observation.

Previously, G. Fielder, in the "Report of the Lunar Section," The Journal of Astronomical Association, 72, 216 (1962), had reduced f to obtain the depth d of a crater at the tip of the observed internal shadow, so that presently only an analysis of the depths is needed. Only for $f = 0.5$ has the actual central depth been accomplished. However, few observations will be precisely at this point. If twenty or more observations, which range between $f = 0.3$ and $f = 0.0$ together with a few for larger and smaller f, are used, and all are utilized to get central depth d_o, then the straight mean of all the d's will give too small a depth. However, it is possible to use a small correction to deduce d_o from the mean of the d's if the crater profile is considered hemi-elliptic. Since the majority of the small craters appears to be bowl-shaped without a central elevation, the profile should be a fair approximation at least near the center of the floor.

Thus

$$\frac{d^2}{d_o^2} + \frac{4x^2}{\Delta^2} = d \qquad (1)$$

where x is the distance from the center to the point where the depth is being measured. Depth d can be found at the point where the interior crater shadow ends on the floor. It can be deduced from (1) that

$$\frac{d}{d_o} = 2\sqrt{(f - f^2)}$$

Values of d/d_o for f at either side of 0.50 are of interest and are listed in Table 1. When $f = 0.50$, the values of d/d_o are symmetric.

Table 1

f	d/d_o
0.20	0.80
0.25	0.87
0.30	0.92
0.35	0.96
0.40	0.98
0.45	1.00
0.50	1.00

From Table 1 it appears that d differs from d_o by only 4 per cent if restricted to $0.35 \leq \underline{f} \leq 0.65$. Thus a mean of d's obtained from this range of $\underline{f}$ differs only slightly from d_o. True, the real crater profile may not be exactly hemi-elliptic, but the difference in profiles near the center of the floor would be only slight.

Since a straight mean $\bar{d}$ of the d's within specified limits requires only a small correction to convert it into d_o, for $\underline{f}$ lying in the range $0.50 - \underline{a} \leq \underline{f} \leq 0.50 + \underline{a}$, there is:

$$\bar{d} = \frac{1}{2a\Delta} \int_{-a\Delta}^{ta\Delta} d \cdot dx \qquad (2)$$

Using (1)

$$\bar{d} = \frac{1}{2a\Delta} \int_{-a\Delta}^{ta\Delta} \sqrt{\left(\frac{1 - 4x^2}{\Delta^2}\right)} dx$$

which reduces to $d_o = \underline{k} \cdot \bar{d}$, where k is a function of $\underline{a}$. Table 2 gives k for various values of $\underline{a}$, determined by evaluating 3.

Table 2

a	k
0.1	1.00
0.2	1.03
0.3	1.06
0.4	1.14

Thus in $0.30 \leq \underline{f} \leq 0.70$ (i.e. a = 0.20) there is an error of 3 per cent in $\underline{d_o}$ when using $\underline{d}$ for d_o. Alternately, $\underline{d}$ increased by 3 per cent will help to obtain d_o.

The author chose the two lunar craters (Bessel and Dawes) and plotted depth $\underline{d}$ against fraction of diameter $\underline{f}$ without making any allowances for systematic errors (Fig. 1).

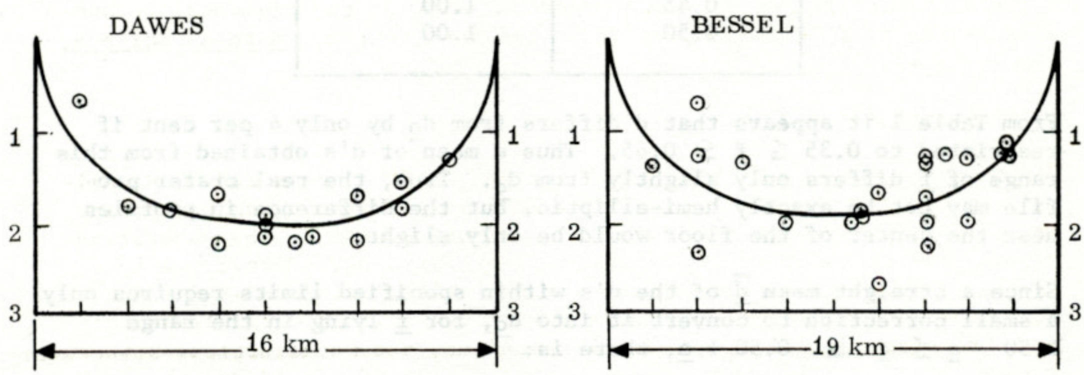

FIG. 4

The total scatter of raw data is of the order of ½ km in depth. This curve can be improved through rejection of poor data and a suitable allowance for errors. The full curves through the points in Fig. 4 emanate from the profile given by equation (2).

Thus the central depths of Bessel and Dawes, using an average of estimates for $0.30 \leq \underline{f} \leq 0.70$ and correcting the resulting mean with the help of Table 2, are:

	$\underline{d_o}$	$\triangle$
Bessel	2.00 km	16 km
Dawes	2.60	19 km

(Source: The Journal of the British Astronomical Association, Vol. 73, 1962-1963).

LIFE SUPPORT

DEADLY CONCENTRATIONS OF OZONE INEFFECTUAL AGAINST ONE CLASS OF MUSHROOM. The mushroom (Armillaria Mellea), which is normally found in pine forests, exhibits a great tolerance for concentrations of ozone (in excess of 30 parts per million -- at a rate of 99 per cent per min) that are sufficient to kill plant and animal life. This high toxicity of ozone has made it invaluable for the sterilization of microorganisms found in water and dairy products.

Study of the mushrooms' remarkable resistance to this powerful oxidizing agent has shown that the mushroom increases its phosphorescent effect when the ozone concentration reaches 200 parts per million. Simultaneously, a brownish pigmentation can be observed on its surface. It is assumed that this pigmentation contains anti-bodies that protect the mushroom since the newly formed mushrooms without the pigmentation succumb easily as do mushrooms of other classes (Source: Natural Science, August 1963).

MATERIALS ENGINEERING

THE BEHAVIOR OF LIQUID METAL UNDER THE ARC. R. L. Apps and D. R. Milner, of the Department of Industrial Metallurgy, Birmingham University, reported recently that rapid advances are being made in the understanding of many of the complex phenomena of arc welding. However, very little is known about the behavior of the molten metal under the arc. The conditions in the molten metal are important in several respects: heat transfer, dilution, gas-metal reactions, and metallurgical structure. Because of its rapid movement during the making of a weld and the high temperatures in the arc, it is not an easy subject for investigation; a stationary molten pool is much more amenable.

During previous research on heat flow, the temperature distribution was determined in some steady-state arc-melted pools of metal; and a technique of interpretation of the data was tried to gain information about the behavior of the liquid metal. Due to experimental difficulties, only limited results were obtained; however, these have stimulated interest and are presented here.

A steady-state molten pool was formed under an arc in a piece of metal that was adequately cooled, and the temperature of the pool was surveyed with a fine thermocouple. With suitable symmetry in the experimental conditions, analysis of the data obtained could be interpreted in terms of the "effective conductivity," which is a measure of the motion within the molten metal.

Two methods were tried. In the first case, a molten pool was obtained in a piece of metal about 2 in. (0.3 cm) across and 0.375 in. (.00953 cm) thick, by water cooling an annular area around the bottom of the specimen (Fig. 5). The temperature was then surveyed by traversing a platinum-platinum/rhodium thermocouple across the pool at various depths, through an opening in the side of the specimen. The type of result obtained with copper and aluminum is illustrated in Fig. 6 and 7, which

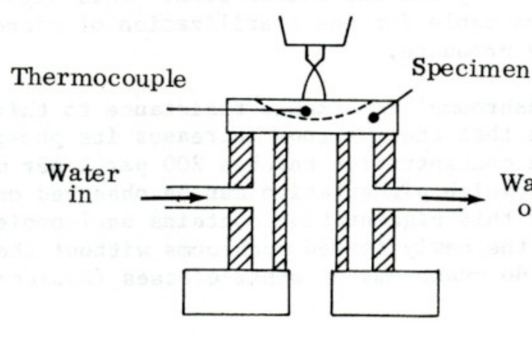

FIG. 5

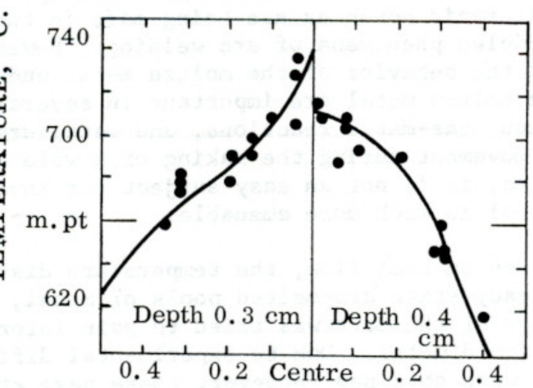

FIG. 6

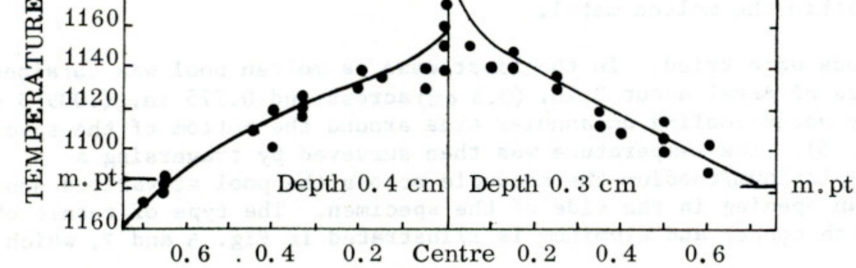

FIG. 7

show temperatures in excess of the melting point.

This system was experimentally convenient because the steady-state molten pools were obtained easily with all the metals tried -- aluminum, copper, iron, and lead. However, the results were difficult to analyze because of the comparative complexity of the heat-flow pattern.

A second approach, utilizing spherical symmetry, was investigated. Hemispheres of lead were cast with a supporting flange and mounted in a water jacket (Fig. 8). Uniform cooling and a steady-state molten pool were achieved by making the total area of holes in the hemispherical shell around the lead hemisphere smaller than the area of the remainder of the water-flow system. The temperature distribution within the pool was ascertained from traverses at various depths with a thermocouple inserted from above -- shown in Fig. 9 for two conditions of current and arc length. The pool was not truly hemispherical; however, by determination of the temperature gradient along a series of radii emanating from the center of impingement of the arc, and the assumption that the flow of heat is a joint source at the center of the surface of the hemisphere ($q = -2 \pi r^2 K \frac{dT}{dr}$ where q is the heat input from the arc, and $\frac{dT}{dr}$ is the temperature gradient at a distance r from the center point), the "effective thermal conductivity" k was determined, Fig. 9. The value of q had been determined previously. A liquid boundary layer existed adjacent to the solid surface and around the extremity of the pool, wherein which the 'effective conductivity' was close to the thermal conductivity stationary liquid lead - 0.04 cal/cm/sec/amp. Over most of the pool, the rate of heat transfer was 2 to 3 times as large; this shows that forced convection was playing an important part. This effect was even more pronounced directly under the arc, the rate heat transfer being 7 to 8 times as large as in a stationary liquid.

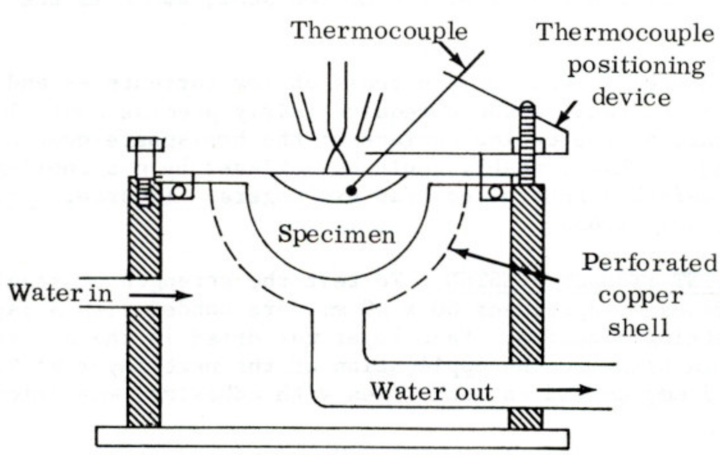

FIG. 8

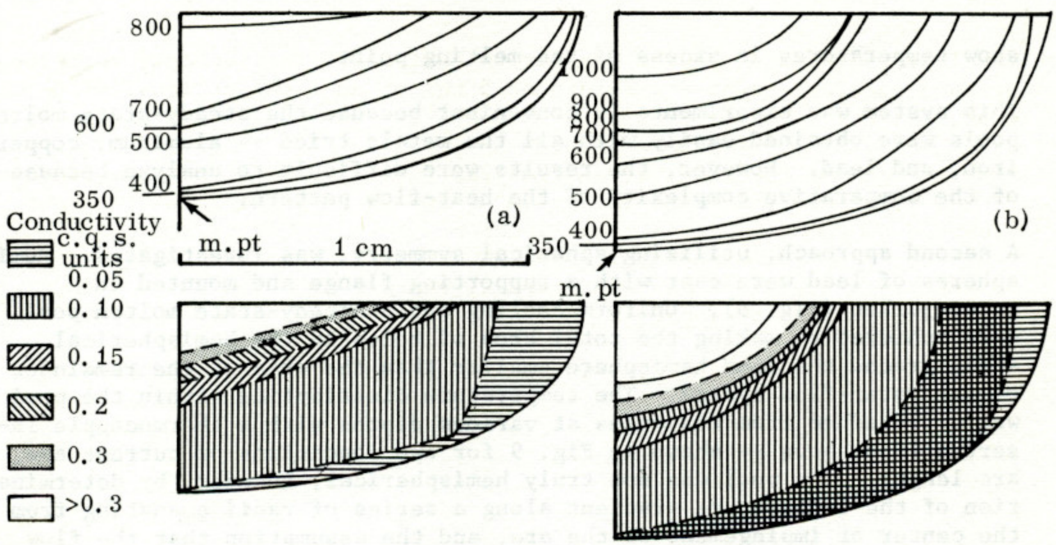

FIG. 9

The second technique yields results that are more amenable to analysis than the first technique, but it has the disadvantage that high currents are required to sustain a molten pool in a water-cooled hemisphere. These can be figured approximately from the formula for spherical heat flow:

$$q = 2 \pi K \frac{\triangle T}{\frac{1}{S} - \frac{1}{R}}$$

Where $\triangle$ T is the temperature of melting above that of the water-cooled surface, S is the radius of the molten pool; and R is the radius of the hemisphere.

To obtain steady-state molten pools at low currents -- and at will at any chosen current -- would require fairly precise control of the temperature at the cooled surface of the hemisphere over a wide temperature range. This probably could be achieved by gas cooling operating through suitably controlled heat exchangers. (Source: British Welding Journal, July 1963)

STEEL JOINT STRENGTH TESTED. To test the strength of steel joints, faying surfaces of specimens 60 x 30 mm were bonded with 3 layers of $\partial \Phi$-2 thermosetting adhesive. Each layer was dried in the air for 1 hr and for 15 min prior to the application of the next layer at 90° C. Glass cloth 0.3 mm, coated on both sides with adhesive, was dried in the air for 1 hr and placed between the faying surfaces. The surfaces were then pressed together under a pressure of 5 kg/cm^2 and kept at 160-170° C for 4 hr.

The strength of the bond varied from 230 to 410 kg/cm^2; the most frequent (~ 80 per cent) value was 300 kg/cm^2. The shear strength of the bond depended on the time of load application. As the load application time (rupture life) increased from 1 to 1000 min, the average strength dropped 40 per cent. Under 50 per cent stress, rupture life can reach 6-8 yr. (Source: Library of Congress, A.I.D. Press, No. 20, July 29, 1963).

DEVELOPMENT OF HIGH-STRENGTH ALLOYS. J. Hinde of the Development and Research Department, International Nickel Co., has written an article dealing with materials having special properties to meet the conditions of high pressures and low or high temperatures. The increase in pressure can be met simply by increasing the thickness of the vessel. However, there are limits to the increase in weight or effects on heating or cooling rates that can then be tolerated, and a high-strength material is needed. When temperature is increased with pressure, the effects of creep must be considered. Under sub-zero temperatures, ordinary steels are subject to brittle fracture; special compositions are necessary, the choice depending upon the precise operating temperature.

Higher strength in relation to room temperature tensile properties can be effected in many non-ferrous materials by precipitation-hardening treatment. This method of heat treatment was first used as a means for improving aluminum alloys. In the simplest concept, alloys that are amenable to age-hardening usually have constituents that show a reduction in solubility of the solute with decreasing temperature. The heat temperature necessary to develop the properties is in two stages: solution heat treatment at a relatively high temperature followed by rapid cooling to dissolve the hardening constituent; and precipitation-hardening, in which the hardening constituent comes out of solution in a finely dispersed form. If this process occurs at room temperature, it is called age-hardening; but more often the process is accelerated at slightly elevated temperatures. This dispersed constituent largely accounts for the properties of the alloy.

In addition to aluminum alloys, copper-base and nickel-base alloys may be age-hardened in this manner. The corrosion resistance of precipitation-hardened alloys, in the sense of weight loss, is not greatly different from that of the basic material; but susceptibility to intergranular or stress corrosion is possible in certain environments.

The development of nickel-chrome base alloys for high temperature service is an important aspect of precipitation-hardened non-ferrous alloys. Precipitation-hardening compositions based on this 80/20 nickel-chromium alloy were developed to meet the needs for alloys of high creep resistance for use in gas turbine engines. Compositions of the alloy, developed from a matrix of nickel-chromium by precipitation-hardening with titanium and aluminum, have resulted in increasing resistance to creep and rupture at elevated temperatures. There is a corresponding improvement found in short-time tensile and torsion properties at elevated temperatures.

Some of the properties are summarized in Table 3. There are some practical difficulties in plant construction, notably that the solution treatment will be around 1100° C and that the precipitation-hardening treatment will be at temperatures of at least 700° C. The weldability of some of the alloys also introduces problems. Attention is being presently given to modifications of this type of alloy to produce a composition of lower cost, as well as one that has adequate high-temperature properties, coupled with good weldability and other characteristics important to fabrication.

Recently a method of increasing the strength of austenitic stainless steel was introduced, whereby the finished vessels were subjected to internal pressures sufficient to initiate cold work and to increase the yield strength of the alloy and allow the use of thinner sections than normal. Previously, high strength in these steels had been obtained by cold-working the standard grades.

Generally, the cold-worked austenitic stainless steels are not very satisfactory as basic materials for chemical plant construction because they are difficult to form, and there is inevitably a permanent loss of strength brought about by thermal effects adjacent to any welds.

The need of aircraft and missile manufacturers for higher strength materials in this group created the demand for improved alloys. Precipitation-hardening again provided the solution to this problem. Also, since sheet materials were the main interest, this approach lent material that would be soft enough to allow ready forming to rather complicated shapes.

Development of precipitation-hardening of stainless steels began with the established 18/8 chromium-nickel alloy as a basic composition; but to meet specific requirements, the range of chromium-nickel contents has been varied considerably.

The steels have been divided into three groups (Table 4). Group 1 rests on the idea that a martensitic type of structure, obtained by conventional hardening, can also be hardened by precipitation with the aid of elements that will dissolve in austenite. Group 2 is austenitic after cooling from the solution heat treatment, but precipitation still takes place in the martensitic type of structure that is formed by another heat

TABLE 3 TYPICAL SHORT-TIME HIGH-TEMPERATURE TENSILE PROPERTIES DETERMINED ON BAR

Alloy	Property	Temperature °C.			
		Room	700	815	900
Nimonic 75	0.2% Proof stress, tons/sq.in.	23	14	---	4
(C 0.08-0.15%, Cr 18-21%,	Maximum stress, tons/sq.in.	52	23	10	7
Ti 0.2-0.6%, Ni balance)	Elongation, % on $4\sqrt{}$ area	44	29	75	80
	Reduction of area, %	62	26	56	61
Nimonic 80A	0.2% Proof stress, tons/sq.in.	40	36	--	13
(C 0.1% max., Cr 18-21%,	Maximum stress, tons/sq.in.	69	47	30	15
Ti 1.8-2.7%, Al 0.5-1.8%,	Elongation, % on $4\sqrt{}$ area	39	15	20	26
Co 2.0% max., Ni balance)	Reduction of area, %	38	19	20	35
	Creep stress *	--	8.2	1.7	--
Nimonic 90	0.2% Proof stress, tons/sq.in.	52	42	--	12
(C 0.13% max., Cr 18-21%,	Maximum stress, tons/sq.in.	80	53	33	15
Ti 1.8-3.0%, Al 0.8-2.0%,	Elongation, % on $4\sqrt{}$ area	33	10	16	31
Co 15-21%, Ni Balance)	Reduction of area, %	42	15	18	67
	Creep stress *	--	11	2	--
Nimonic 105	0.2% Proof stress, tons/sq.in.	52	51	--	20
(C 0.2% max., Cr 13.5-16.0%,	Maximum stress, tons/sq.in.	64	64	--	26
Ti 0.9-1.5%, Al 4.2-4.8%	Elongation, % on $4\sqrt{}$ area	7	10	--	20
Co 18-22%, Mo 4.5-5.5%,	Reduction of area, %	7	12	--	21
Ni balance)	Creep stress *	--	18	5.5	--

* Stress tons/sq.in. to produce 0.2% extension in 10,000 hr.

TABLE 4 PROPERTIES OF SOME COMMERCIAL PRECIPITATION HARDENING STAINLESS STEELS

Heat treatment	Steel type	Nominal composition						Tensile properties of fully heat-treated material		
		C	Cr	Ni	Cu	Mo	Others	Temp.	U. T. S., tons/sq. in.	% Elong.
Group 1 - Martensitic Martensitic on cooling to room temperature. Single ageing at 425-600°C. following this	Stainless W	0.07	17	7	-	-	0.7 Ti	Room	85-100	2-8
								400°C.	65	--
	Armco 17-4 P.H.	0.07	15.5-17.5	3-5	3.5	-	0.25-0.45 Nb	Room	85-95	--
								400°C.	70	--
Group 2 - Semi-austenitic (1) Heat treat at 700-800°C and either refrigerate at -73°C. or cold work	Armco 17-7 P.H.	0.09	16-18	6.5-7.5	-	-	0.75-1.5 Al	Room	80-95	6-12
								400°C.	-	--
(2) Age at 400-565°C.	F.V. 520	0.07	14-18	4-7	1.3	1.3	0.5 Ti	Room	80-85	12
								400°C.	65	--
Group 3 - Austenitic Single precipitation treatment at 650-760°C. after quenching from solution treatment temperature	Armco 17-10 P	0.12	17	10	-	-	0.25 P	Room	65	20
								400°C.	-	--
	Armco 17-14 Cu Mo	0.12	16	14	3	2.5	0.25 Ti, 0.45 Nb	Room	40	45
								400°C.	30	--
	Armco 22-4-9	0.4-0.6	25-23	3-5	-	-	7-10 Mn, 0.3-0.5 N_2	Room	75	9
								400°C.	50	--

treatment that is applied previously to the precipitation treatment. Group 3 steels remain austenitic in all conditions, and the hardening is obtained by the precipitation of carbides.

The resistance of these steels to forming and welding is of importance because of the need to fabricate. The martensitic steels of Group 1 are hard in the 'solution-treated' condition and are difficult to form; but their welding response is generally good. The Group 2 steels are the most useful because their forming can be made after the solution treatment when the material is in the soft austenitic condition. Welding response of this group is also fairly satisfactory. Aged to their maximum strength, Group 2 steels are susceptible to stress-corrosion cracking, a tendency that can be remedial by averaging at the sacrifice of some strength and hardness. The steels of Group 3 have less satisfactory general corrosion resistance and are not very suitable for welding fabrication.

Many steels have high tensile properties. As the content of carbon, the most significant element in steels, is raised, the tensile strength can be increased by heat treatment. Many low-alloy high-tensile structural steels may have tensile strengths only a few tons better than mild steel -- the usual figure for mild steel is around 26 tons/in.^{2} (24 metric tons) -- but usually with a sizable increase in yield strength.

For mechanical engineering components, there are specifications for steels with tensile strengths of around 100 tons/in.^{2} (90 metric tons). These figures are obtained by the heat treatment quench and temper, which involves three steps. First the steel is heated to the austenitising temperature, which takes all the carbides into solution. In the second step the steel is quenched, and the austenite is transformed into martensite. In a third step the steel is tempered, or re-heat treated, to obtain some degree of toughness and ductility.

The difficulties of obtaining high-tensile properties in steels used in the fabrication of chemical plant are the physical problems of heat-treating fabricated structures, the risk of distortion and cracking during the heat treatment, and the complications during welding.

There are numerous ways of modifying conventional techniques of quench and temper that will minimize the risks of distortion and cracking. Those generally accepted are martempering, austempering, ausforming, and maraging. Only the maraging steels will be considered here. It was mentioned previously that carbon was the most significant element; as this is increased, the tensile strength increased, but resistance to impact and ductility decreases. The degree of usefulness of carbon is determined by its adverse effect on toughness. The martensitis-type structure of conventional steels after hardening and tempering remains machinable up to a tensile strength of 85 tons/in.^{2} (77 metric tons). Above that figure, machining had to be carried out before the heat treatment. Hardening from a high temperature may result in distortion and/or cracking. Fabrication and assembly of high-strength steels are difficult because of the thermal effects introduced by welding; these may result in fissures or cracks in the weld area and necessitate a re-heat treat after welding if it is required to develop the maximum strength.

All maraging steels utilize a series of hardening processes similar to those mentioned for austenitic stainless steels. Martensite formed in the iron-nickel alloys is used instead of the usual iron-carbon type of martensite. This iron-nickel type is only moderately hard but very tough. Titanium, niobium, and molybdenum are used for the precipitation-hardening of this martensite. Most of the maraging steels undergo martensitic hardening when cooled to room temperature; but some steels remain austenitic.

The first stage of hardening of the austenitic types must be either by cold work or some further heat treatment to promote the formation of the iron-nickel martensite. The final strengthening of the alloy is made possible by subjecting the martensitic matrix of all the steels to a low-temperature precipitation-hardening treatment. The control of quality and the level of impurities in these steels is very important; vacuum melting may be necessary for optimum results.

Table 5 gives some details of two steels commercially available. The ease with which their properties can be obtained and the fact that the steels can be fabricated and welded without damaging these properties have aroused great interest.

Most aluminum-, copper-, and nickel-base alloys keep their impact properties at sub-zero temperatures. However, steels may be subject to brittle fracture, whereby catastrophic failure may result as the temperature is reduced. By careful control of the carbon and manganese ratio in mild steels, it is possible to ensure satisfactory impact properties at temperatures down to -50° C. For operation at lower temperatures nickel steels have been found most useful; 3½ per cent nickel steel can be utilized at temperatures down to -100° C and 9 per cent nickel steel down to 196° C. The austenitic chromium-nickel steels will serve at temperatures down to -200° C. (Source: Chemical and Process Engineering, April 1963)

TABLE 5 PHYSICAL AND SOME MECHANICAL PROPERTIES OF MARAGING NICKEL STEELS

Property	18% Ni-Co-Mo * (Ni 17-19%, Co 7-8.5%, Mo 4.6-5.1%, Ti 0.3-0.5%, Al 0.05-0.15%, Fe balance)	25% Ni-Ti-Al (Ni 25-26%, Ti 1.3-1.6%, Al 0.15-0.35%, Nb 0.3-0.5%, Fe balance)
Modulus of elasticity, 10^6 p.s.i.	26.5 - 27.5	24.5
Modulus of rigidity, 10^6 p.s.i.	10.2	--
Poisson's ratio	0.3	0.31
0.2% Proof stress in compression, tons/sq.in.	110	--
Shear strength, tons/sq.in.	64	--
Density, lb/cu.in.	0.290	0.286
Thermal expansion coefficient (20-480°C.), 10^{-6}/°C.	10.1	11.2
Change in length caused by maraging, %	0	-0.10

* Determined on steel with 0.2% proof stress of 112 tons/sq.in.

PHYSICS

COMPRESSED GAS ENGINES FOR HELIUM LIQUEFACTION. The Soviet Institute of Physical Problems has developed a new type of engine, with 80 per cent adiabatic efficiency, driven by compressed gas for the expansion of helium. The engine was developed in connection with the technical application of low-temperature effects that can be realized only by means of liquid helium, such as obtaining high vacuum (10 sup -8 mm Hg) in large volumes, utilizing superconductive solenoids for generation of strong magnetic fields, employing superconductors to obtain uhf resonators with a high Q-factor, and utilizing superconductive elements in computers (cryotrons). The high efficiency of the engine is due to the application of plastic coatings on the pistons, which allow the clearance between the piston and cylinder to be reduced to 5 m. The engine can operate for long periods at high efficiency without significant wear of the piston coating.

The Institute has built two helium liquefiers in which the expansion engines are assembled in a two-engine cascade cycle. One liquefier has a capacity of 4-5 liters/hr, the other about 30 liters/hr. The liquefiers consist of a Dewar casing in which a high vacuum is created, heat exchangers, two engines for helium expansion, and a collector for liquid helium. The machine liquefies up to 25 liters He/hr and utilizes liquid nitrogen only for absorptive purification of technical helium, consuming approximately 3 liters/hr. To liquefy one liter of helium, power of 2 kw/hr is required. (Source: Library of Congress, A.I.D. Press, No. 26, August 5, 1963.

THEORETICAL PHYSICS

PLASMOID PROPERTIES INVESTIGATED

In magnetic traps filled with heat plasma, the properties of plasmoids obtained by means of a coaxial electrodynamic injector have been experimentally investigated. The injector's operational mode, governed by the initial voltage over the capacitor bank U_0, the quantity of gas M, the kind of gas injected, and the delay time Δt between the injection and the gas discharge, determines the speed, energy, momentum, and other properties of plasmoids. Hydrogen, deuterium, and helium were used.

Magnetic probes revealed that the first discharge of gas occurs in the region of the injector openings. The plasmoid egresses from the injector with a U_0 and M determined velocity. In certain modes characterized by a small quantity of injected gas, the plasmoid splits into two or more separate plasmoids, each traveling with a different velocity.

Average masses, densities, and total number of particles were calculated and found to be in agreement with data obtained by thermal probing techniques. No separations were observed in plasmoids that were spectroscopically measured (those of small velocities and high plasma densities). (Source: Library of Congress, A.I.D. Press, No. 19, July 26, 1963).

NUCLEAR PHYSICS

EFFECT OF UV RADIATION ON MICROORGANISMS. Interest in the bactericidal properties of ultraviolet (UV) has developed from concern over contamination of other celestial bodies by terrestrial organisms and from the problem of spaceship sterilization. The intensity of UV radiation, which is most bactericidal at a distance of one astronomic unit from the Sun, is $2 \cdot 10^3$ ergs/cm^2. Sensitivity of microorganisms to UV radiation varies, but the lethal dose for the most resistant forms is approximately 440,000 ergs/cm^2.

Since the penetrating capacity of UV radiation is low, insignificant amounts of organic or mineral substances (dust particles carrying bacterial spores in space) may protect the bacterial cell. (Source: Library of Congress, A.I.D. Press, No. 23, July 31, 1963).

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