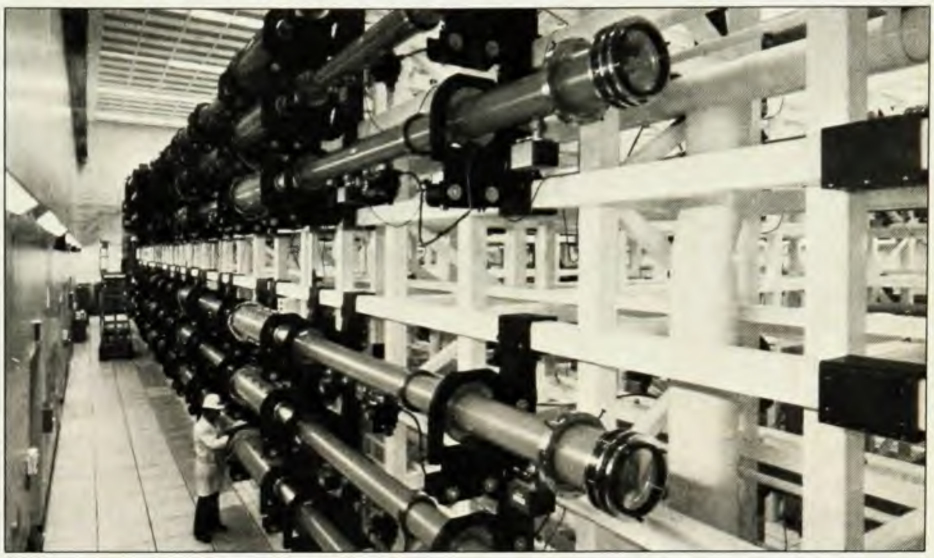
search & discovery

Laser-fusion devices at Livermore and Rochester use Nd glass

Fusion research with solid-state lasers entered a higher-power regime recently as the Lawrence Livermore Laboratory began operating its 20-beam, 20–30 terawatt (10^{12} watts) neodymium–glass laser system. The design and current status of the facility were described by the associate director of Livermore, John L. Emmett, and others at the Conference on Laser and Electro-Optical Systems held in San Diego in February. After having successfully fired all twenty arms of the system at 10 kilojoules with a pulse of 1 nanosec, the Livermore group was changing the configuration for shorter (down to 0.1 ns) pulses, installing the final pieces of diagnostics and hardware, and aligning the lasers on a target in groups of five. A photograph of the target chamber appears on the cover of this issue of PHYSICS TODAY. The power of 1.7 TW attained by the first beam had confirmed hopes that all twenty beams would collectively reach the upper limit of the design power.



The Shiva laser–fusion facility at Lawrence Livermore Laboratory incorporates twenty neodymium–glass laser beams with total power likely to reach 30 terawatts. The cover of this issue shows the target chamber where all beams will be focussed. This photograph shows six beam lines.

While Livermore is clearly the pioneer at the highest power levels, other groups both in the US and abroad are planning, constructing and operating neodymium–glass lasers of various powers and designs. One such system is expected to be completed late this summer at the University of Rochester. The University's Laboratory for Laser Energetics, directed by Moshe Lubin, is building a six-beam, 3-TW facility, called Zeta, which will constitute the first phase of a 24-beam, 12-TW Omega system, scheduled to be operating by the early 1980's.

Livermore. As a very appropriate namesake, the Livermore Laboratory selected the multi-armed Hindu god, Shiva, who has a third eye from which shines a ray of destruction. Just as the god Shiva is associated with both destruction and creation, the new Shiva facility is concerned with the destruction of a deuterium–tritium (D–T) fuel pellet for the ultimate creation of energy. The goal of Livermore's laser fusion program is to achieve both power production and weapons construction. In laser-fusion schemes, the radiant energy ablates the outer layer of a pellet as small as a few microns in diameter. The outward expansion of this layer implodes the D–T fuel inside to densities perhaps a thou-

continued on page 20

Portable "super spring" has apparent length of 22 km

Mechanical isolation of equipment is a long-standing problem for experimenters. For example, in 1895, Sir Charles Vernon Boys was working in Oxford, determining Newton's gravitational constant. He generally worked on Sunday night between midnight and 6:00 am. According to Boys, "The daytime, of course, is out of the question, owing to the rattling traffic on the stones in St. Giles', about a quarter of a mile away." Boys was also troubled by rail traffic, wind, and even an earthquake.

Since the experiments of Boys, gravitational and high-precision experiments have become considerably more sophisticated, but for many, mechanical isolation is still a problem. At the Joint Institute for Laboratory Astrophysics, James E. Faller, Robert L. Rinker and Mark A. Zumberge are developing a portable absolute gravimeter, which they hope will have an accuracy of a few parts in 10^9. This corresponds to a height sensitivity of about 1 cm. The group feels that this type of gravity-measuring capability will, in addition to complementing leveling and extraterrestrial methods in the study of tectonic deformation, prove valuable for earthquake prediction, goethermal exploration, volcano surveillance and subsidence studies.

Super spring. One essential component of the new gravimeter is a mechanical isolating device developed by Faller and Rinker that they call a "super spring," which has an electronically achieved length of as much as 22 km, giving a period of 300 sec; the super spring provides mechanical isolation from disturbances above 0.003 Hz.

The super spring isolator makes use of the fact that a mass suspended from a long spring is effectively isolated (from vibrations) for all frequencies higher than the system's natural resonance, and for any given frequency, the lower the resonance of the mass and spring, the better the isolation. But to isolate against the Earth's natural microseismic background spring lengths are required to be 1 km or more.

As Faller and Rinker explain their electronically generated super spring, one

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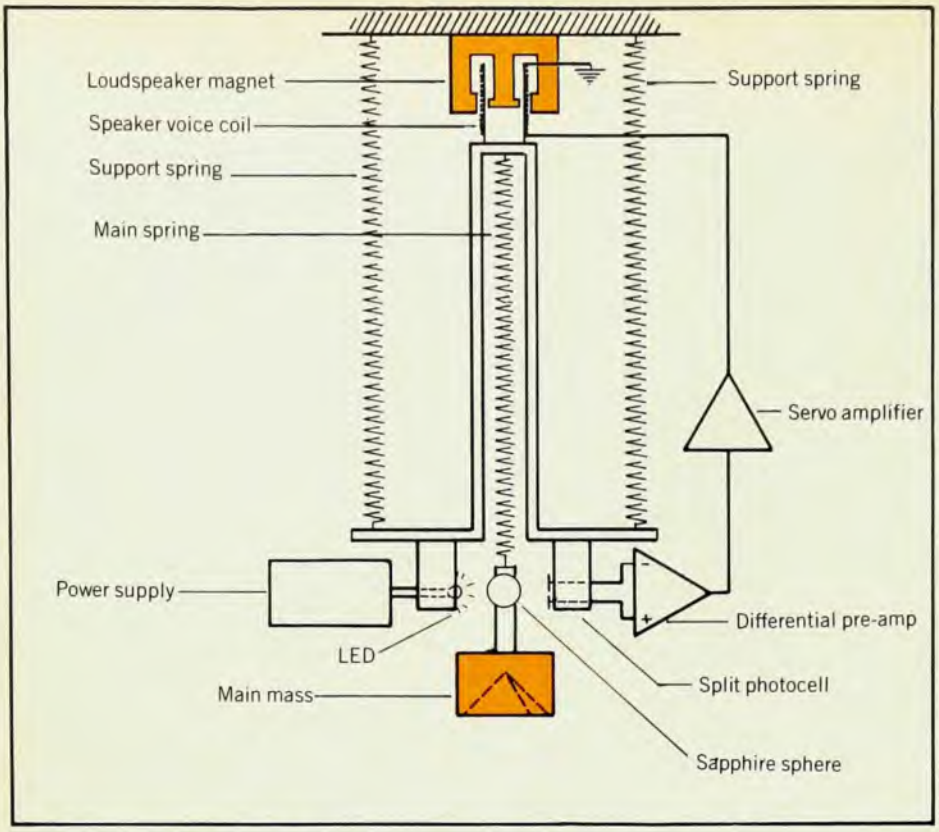

Super spring developed at JILA is a mechanical isolating device with an electroncially achieved length as great as 22 km and a period up to 300 sec, although the "main spring" shown in the drawing is physically only 30 cm long. The device is to be used in a portable absolute gravimeter.

can imagine a mass hanging on the end of a spring that extends 1 km vertically. The mass will oscillate with a 60-sec period, and of course the coils of the spring will also oscillate. The coils close to the mass will have an amplitude roughly equal to the amplitude of the mass; the coils far from the mass will have an amplitude less than that of the mass. In fact, the coils near the top will scarcely be moving at all. If one were to grasp the spring 30 cm above the mass and move that point on the spring just as it moved when the lower mass was in free oscillation, the motion of the mass would not be affected. One could then cut off the top of the spring and be left with a 30-cm long spring that has the same resonance and behaves in all ways as if it were a spring 1-km long. The JILA pair uses a servo system to produce such a virtual point of suspension.

In the JILA system, two side springs (see figure) support a movable bracket from which the mass-supporting spring (of approximately 30 cm length) is hung. The output of a light-emitting diode is focussed through a sphere near the bottom of the spring onto a split photodiode to sense displacements of the central spring. The output from the two halves of the photodiode is amplified and differenced, producing an analog signal that is proportional to the displacement of the mass with respect to this bracket. This signal, processed by a servo-compensated amplifier, drives a loudspeaker voice coil, which in turn supplies the needed force to cause it to (nearly) track the motion of the bottom weight. Because the top of the spring is attached to the bracket, the top moves almost the same amount as the bottom. (The precise degree of tracking is determined by the gain setting of the servo system; thus by changing the gain, the length of the spring and the period can be varied.) Faller and Rinker note that once the various internal modes of the spring have either died down or been damped, using for example, an external magnet, the spring is essentially stationary in inertial space and as a result, the only mode that remains excitable is the fundamental.

The JILA team is unaware of other attempts to make a long-period spring electronically. In principle, periods as long as 55 minutes should be possible, corresponding to a spring length equal to half the Earth's radius. However, at this length the change in force on the mass for a small displacement due to the gradient in the Earth's gravity field is greater than the spring's restoring force, Faller said. As a result, the system would be unstable.

The portable absolute gravimeter being developed at JILA uses the method of free fall, in which one element of an optical interferometer is dropped. The super spring will be used to isolate the gravimeter (or one element in it) and thereby permit measurements at the level of a part in 10^9. If the instrument were not isolated from the environment, the resulting accuracy would be parts in 10^7, limited by the Earth's surface motion (which appears as noise).

Relative gravimeters that measure differences in g but not g itself have been used to establish values of g at a variety of positions to locate ore deposits and so forth; the LaCoste-Romberg gravimeter and the Warden gravimeter, both of which are available commercially, use a so-called zero-length spring in a hinged mechanical system to achieve a weak restoring force on a test mass. Therefore, they could be (and have been) used as the basis of a mechanically (as opposed to electronically) synthesized isolator. Mechanical gravimeters have been used to determined vertical tectonic movements occurring over short periods of time (weeks) in relatively confined areas (tens of kilometers) both in Japan and Canada. In such cases, relative readings are sufficient. However, Faller said, by the nature of their construction they are subject to both abrupt changes and drift.

He told us that the absolute gravimeter being developed at JILA, which is supported—so to speak—by a super spring, uses the fundamental standards of length and time in its method of measurement. Thus, he said, it will have the dc stability necessary to study directly long-term geophysical processes. At the same time, he feels the instrument will provide a stable reference for relative devices.

—GBL

Panel promotes electron-beam studies of nucleus

Noting new technical developments and consequent new opportunities for research, a panel has recommended increased funding over the next few years for the field of nuclear research using intermediate-energy electron accelerators. The Study Group on the Role of Electron Accelerators in US Medium Energy Nuclear Science, headed by Robert S. Livingston (Oak Ridge), has also recommended that the nuclear-physics community give serious consideration to the construction (beginning as early as 1981 or 1982) of a new national electron accelerator with a 100% duty cycle, energy of 1 to 2 GeV and electron-beam current of approximately 100 μA.

The panel's report is a follow-up to studies made in 1974 by the joint AEC–NSF Committee to Review US Medium-Energy Science headed by Roger H. Hildebrand (PHYSICS TODAY, December 1974, page 77) and in 1977 by the NAS–NRC Ad-Hoc Panel on the Future of Nuclear Science headed by Gerhart Friedlander. The report was presented at the first meeting last October of the newly organized DOE–NSF Nuclear-Science Advisory Committee (NUSAC) (PHYSICS TODAY, February 1978, page 77).

The study group recalled that the US had an early lead in studies using elec-