limit for the amount of petroleum in the earth. One simply asserts that the volume of petroleum in the earth can not be greater than the volume of the earth 6.8×10^{21} barrels. At the 1970 rate of production of 1.67×10^{10} barrels per year held constant with no growth this amount of oil would last 4.1×10^{11} years.

In the eighty years from 1890 to 1970 world production of petroleum grew 7 percent per year. If this historic rate of growth of consumption were to continue, all of the oil in a tank the size of the earth would be used in 344 years!

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11/21/77

The final frame—*eppur si muove*

An Elegy Written In A Non-Inertial Frame of Reference
(With Apologies to Thomas Gray, Author Of "Elegy Written In A Country Church Yard" 1751)

The Theory tolls the knell of parting rays,
  Light bending in the influence of G;
The Old One homeward plots his world-like ways,
  and leaves our frame in constancy of c.

Now fade fictitious forces on the light,
  And every frame equivalency holds,
Nor gravitation wheels the planets' flight,
  Space curvature inertial pathways mold.

Beneath Newtonian trees still apples fall,
  Provided we the proper axes keep;
But other choices will their motion stall,
  Consigning them to relatively sleep.

Let 'Humanists' not mock the Physicists' toil,
  Their abstract joys in animate devotion;
Nor 'Jet-Set' hear with a disdainful smile,
  The convoluted annalen of motion.

The force of gravity, inertia's power,
  And mass responding, particle and wave,
They fall alike from Galileo's tower,
  Paths of Newton—can appearances be saved?

Full many a gem of purest ray serene,
  The dark unfathomed caves of space-time bend;
Full many a λ blue-born have we seen,
  Red-shifted at their journey's end.

Far from the gravitating mass's pull,
  Their Doppler-shifted courses do they stay;
Along a field line stretched taut full,
  They keep the constant fastness of their way.

Though at rest with the distant stars,
  Fixed in ertial frames we prove,
Gravity's strength defies all bars;
  Eppur si muove! And still it moves!

For who to dumb forgetfullness a prey,
  To the old philosophers' demise resigned,
Embraces new philosophy today,
  Nor casts one longing, lingering look behind?

Here rest their heads upon the lap of earth;
  Giants to both the cultures not unknown;
Fair Science frowned not on their humble birth,
  Let Humanists regard them as their own.

While still we seek their merits to disclose,
  Their final frame is in that dread abode,
Where all alike in trembling h repose,
  Perchance engaged in games of dice with God.

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10/5/77

Cosmology in the dark

The article about cosmology by Beatrice Tinsley (June, page 32) is a delightful exercise of the intellect. I have a simpler, down-to-earth explanation based on the Hubble variable.

According to modern mysticism,[1] the radius of universe is 10.4×10^{22} kilometers, corresponding to a symbolic time of 1.1×10^{10} years. The radius of Earth is 6.38×10^{3} kilometers. The ratio of former to latter is 1.63×10^{19}.

When the Hubble variable was discovered[2] in 1926 it had a value of 500 kilometers per second per megaparsec. During a past half century this variable has gradually declined[3] to 50.3 kilometers per second per megaparsec. The radius of universe is inversely proportional to the magnitude of this variable. Accordingly, the universe is expanding by a factor of 100 per century. Dividing this factor into above ratio discloses that the expansion began here on Earth 961 years ago; or 1015 AD during the Dark Ages. Obviously, western cosmology was born in the dark and has been there ever since.

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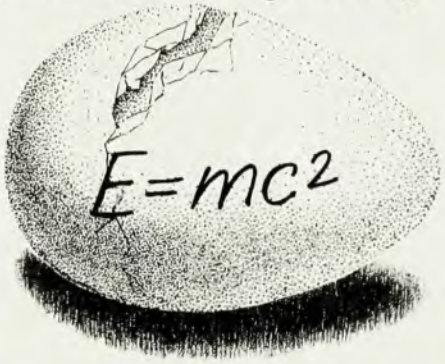
Investment Energy

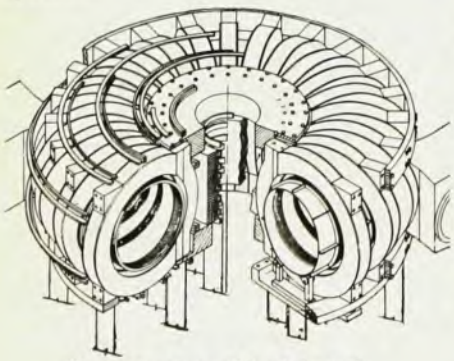
What kind of power is needed to "seed" the energy sources of the future?



THE TECHNOLOGIES which offer the brightest promise of a major contribution to tomorrow's energy economy share a common need. In all cases, a large *investment* of energy is required, before a *return* on investment can be realized.

In most approaches, this investment is an integral part of the production cycle–creating the environment in which energy generation can occur. In others, it's needed to prepare the materials and components that go into the process. But in all cases, the investment is massive...and it must be delivered with exceptional precision and managed with exceptional sensitivity.

UVC has won a position of leadership in this demanding field–through long-term participation in the research, development and testing of advanced energy systems...and the provision of power for high-energy applications in such related areas as particle acceleration, high-voltage power distribution, and laser systems.



Basic structure of the tokamak device (ORMAK) at Oak Ridge.

While the "payout" on investment in some of the fields in which we're involved may be a decade or even a generation away, we know that these are ventures of historic importance, and deserving of our best talents and highest efforts.

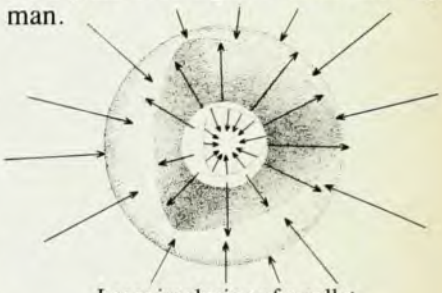
Fusion Through Plasma Heating and Magnetic Confinement

Progress continues toward the goal of achieving controlled thermonuclear reactions by the heating of isotopes of hydrogen (available in limitless quantities in the world's oceans) to stellar temperatures. Methods of maintaining such astronomical temperatures for sufficient periods of time include various 'magnetic confinement' schemes. The most promising of these are being investigated with reactors of the so-called tokamak (ORMAK) designs.

UVC equipment is presently in use, powering the neutral injection systems for heating of such reactors, at the Oak Ridge National Laboratory, Princeton University, The University of California at Livermore and Berkeley, and at private corporations funded by ERDA. These units, supplying energy for particle acceleration and deceleration, include the largest, highest-power equipment ever delivered by UVC.

Fusion Through Laser Implosion

Another dramatic approach to controlled fusion involves the ignition of thermonuclear reactions by subjecting tiny pellets of hydrogen isotopes to intense bursts of laser light. UVC has developed a wide variety of power supplies for laser fusion experiments ... including work being done at the Livermore laboratories of the University of California, where an effort is under way to generate the most powerful pulses of light ever created by man.



Laser implosion of a pellet.

Uranium Enrichment for Nuclear Power Generation

The 'enrichment' of uranium, by the separation of specific isotopes from the natural metal, is essential for the manufacture of the rods which fuel most types of nuclear fission reactors. Here, too, a laser application holds great promise for bringing new efficiency and economy to what has been an extremely costly and difficult process.

And here again, UVC power supplies are playing an important role in bringing this new technique to fruition.

What Can We Do For You?

Whether you're concerned with advanced energy systems or more conventional power problems, you too may profit from UVC's uncommon competence. If you'd like to discuss how we might add some Investment Energy to a project of your own, please call or write:

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Electron microscope center

Several letters and articles have appeared in recent issues on the subject of high-resolution electron microscopy, but so far no one has pointed out that a national facility involving participation of several groups (Arizona, Stanford, et al.) is under consideration and has been for several years. In fact a workshop on the subject of atomic-resolution electron microscopy (ARM) was sponsored by ERDA and held at Berkeley in October of 1976. Copies of the report of this meeting are available upon request (LBL #5722).

ARM facilities are already well under way in several foreign countries—notably Japan, France, Germany and the United Kingdom. It would be absurd if the United States were not to develop such capabilities independently in the immediate future. The technology is here and the cost (approximately $\$10^7$) is moderate compared to many similar projects in the basic sciences. We anticipate that in fields such as atomic and solid-state physics, chemistry, materials science and biology (although the restriction on resolution here is mainly due to irradiation damage not instrumentation) the availability of ARM will see an explosion of new scientific information sorely needed to solve many critical problems.

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Second-hand abstracts

For a few years recently I have been watching with anxiety the gradual change in style of *Physics Abstracts*. For quite a long time the abstracts published in PA were simply reprinted from the originals submitted by the authors together with their published papers—the only responsible way of doing this job. Lately, however, there is an increasing tendency to print second-hand abstracts, or abstracts-of-abstracts, written by hired persons. Of course I can trust that they are serious and reliable persons very carefully chosen by the editors. But to be able to read with full understanding and abstract appropriately 10 to 20 articles every two weeks is a job that would require a giant genius.

The initials under the abstracts suggest that all the articles from one field in a particular journal are all abstracted by the same person. Usually those papers are connected only in a very wide sense (for example, all papers on general relativity) and have very little in common. One cannot expect a single man to be able to have a sufficient grasp of such a variety of problems, and so the second-hand abstracts are simply written on the basis of the authors' abstracts and convey a very superficial and insufficient understanding of the genuine content of the article. As a result, the abstracts give too little information or simply falsely represent the article. I know this from personal experience since this sort of thing happened to the abstract of my own article that appeared in *J. Math. Phys.*

I make intensive use of PA to make sure that no important paper from my field of research (theory of relativity) has been overlooked because it was published in a little known journal or hidden under a misleading title in one of the main journals. I think many other scientists do the same. To be successful in our attempts we must have full confidence in the information published by the PA. If the editors of the PA think the authors' own abstracts are too long, then the solution is very simple: produce a new instruction for the authors, and attach it to the papers that everyone obtains from editors of journals after submitting his paper. No one is able to abstract a paper more appropriately than the author himself.

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Character error

In our discussion of which way electron charge "flows" upon formation of interstitial compounds (September, page 34) we inadvertently listed Engel-Brewer theory as predicting Ti^+C^- ionic character for the compound TiC. It is well known[1,2] that this theory makes the opposite prediction. We regret any confusion this error may have caused.

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