

SSC ALTERNATIVES: CRITICS COLLIDE WITH DYSON

I read with interest Freeman Dyson's Opinion column (February, page 77) on alternatives to the Superconducting Super Collider. He expresses his interest and support for further research in elementary-particle physics but suggests that the SSC may not be the best tool—nor even an appropriate tool—to press those investigations further. He therefore suggests that the start of the next accelerator be delayed until some more elegant technology becomes available.

His argument is reminiscent of one that was made just about a year ago. At that time the new ceramic, "high temperature" superconductors were just making their appearance and exciting us all. Many who were fearful that the cost of the SSC would eat into other potential research were quick to suggest that the SSC should be delayed until one could take a better or cheaper next step in that field of physics. All of us are still excited by the new superconductors and are hopeful that they will eventually realize their apparent potential. However, it is fair to say that cooler heads and cooler superconductors have gradually cooled the fervor of the most ardent preachers of delaying the SSC on that account.

Most experts in advanced accelerator techniques agree that the prospects for replacing "conventional" accelerator systems with new accelerator concepts are at least as remote as the application of the new superconductors to accelerator magnets. Nevertheless it is still legitimate to question the rush. Why not wait a decade or two to probe more deeply into the structure of matter? The answer is that such a question is not unique to the SSC. There is almost no scientific inquiry whose postponement could not be suggested on the grounds that it will probably become easier or cheaper in the future with the development of new technologies. To accept that argument is the road to stagnation.

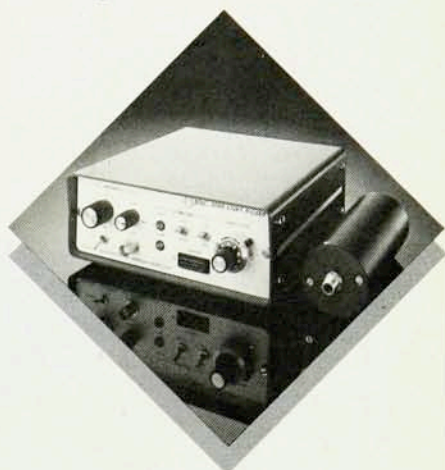
Volumes have been written establishing a strong physics motivation

for the SSC. Few scientists have challenged the importance of the questions that lie immediately ahead to be answered. Dyson does not contest that. The argument, then, appears to come down to a cost-benefit analysis. Many scientists are awed and frightened by the idea of an investment of several billion dollars in a research facility, and several billion dollars is a substantial investment. Admittedly this nation has many gnawing problems that beg for investments of that magnitude, but the long-term, fundamental solutions to most of those problems rest on our regaining the leadership we have lost. To do that we must regain the courage and the daring that have stood us in such good stead in the past. The national debt and deficits are almost irrelevant in that context. To recapture our vitality we can and must undertake promising new initiatives. The SSC is one such venture.

One common trait of nay-sayers is that they tend to tote up the costs of undertaking a new project while ignoring the costs of not proceeding. Postponement of the SSC would be quite deadly to prospects for continuing progress in man's longstanding and highly productive investigations of the structure of matter. "Big" science is not bad science, and "small" science is not necessarily good science. In fact "big" and "small" are not meaningful categorizations of research. True, today's accelerators are big in anyone's lexicon. But research is done on big accelerators by university faculty members and their graduate students. High-energy physics still provides a major attraction to, and a rigorous training ground for, young scientists, engineers and technicians, most of whom carry into industry and other fields the skills they have developed in pursuit of elementary-particle physics.

New information on elementary-particle physics is not produced by an accelerator alone. Over a period of decades a highly complex infrastructure has been developed that supports

**The ideal way
to stabilize PMT
systems and
calibrate
phototubes.**



Use the new BNC Light Pulser.

Now it's a simple matter to calibrate and check out photomultiplier tubes and other light detecting systems. The BNC Model 6000 Light Pulser, with either a 490 or 568 nm optical source (as shown), generates stabilized pulses of light. It's ideally suited for measuring drift and temperature effects, and can be part of a gain stabilizing system.

Light pulses are stabilized for both power output and color. The output is monitored and corrected to maintain a constant energy, and the LED source is thermoelectrically-cooled.

This state-of-the-art instrument can also be used with a variety of programmable instruments, such as amplifiers and power supplies, to form the basis of a stabilizing system. Call John Yee at BNC for more details.

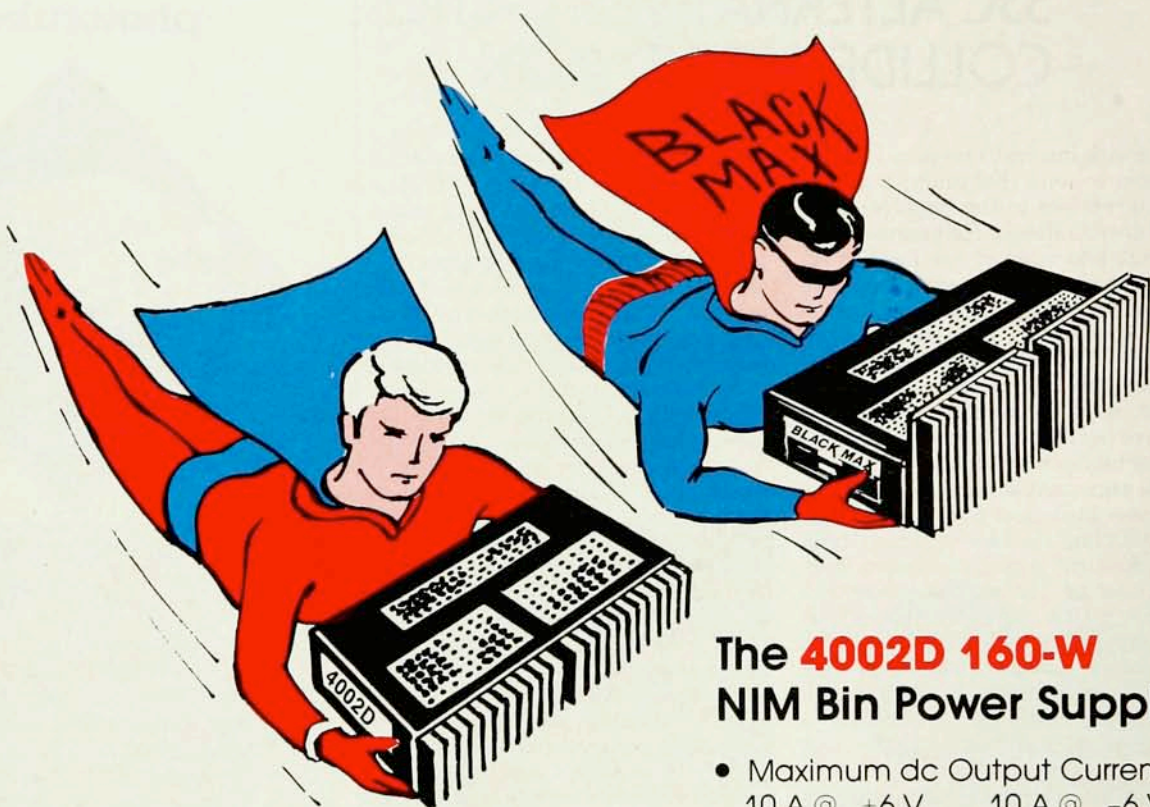


Berkeley Nucleonics Corp.

1121 Regatta Square
Richmond, CA 94804
(415) 234-1100

Circle number 8 on Reader Service Card

Meet the Newest Member of the **BLACK MAX**TM Family



The **4002D 160-W** NIM Bin Power Supply

- Maximum dc Output Currents
10 A @ +6 V 10 A @ -6 V
3 A @ +12 V 3 A @ -12 V
1.5 A @ +24 V 1.5 A @ -24 V
- Currents available **simultaneously** from **both** positive and negative supplies
- Combined maximum power rating of **160 watts** at 50° C
- **No** fans or filters to maintain

Have the BLACK MAX family join **your** team.

Call the USA **HOTLINE, 800-251-9750**, or contact your area representative:



EG&G ORTEC

100 Midland Road, Oak Ridge, TN 37831-0895 U.S.A. • (615) 482-4411 • 499-3119 EGG OKRE UI

CANADA
(416) 475-8420

FRANCE
01-60.77.93.66

WEST GERMANY
089-926920

ITALY
02-7610267

JAPAN
03-638-1506

THE NETHERLANDS
030-887520

UNITED KINGDOM
0344-423931

145 offices in 76 countries

Circle number 9 on Reader Service Card

research in this field. It involves a whole world, not only of accelerator specialists, but of theoretical physicists, particle physics experimenters, detector specialists, data-handling experts, pattern recognition specialists, *et cetera, et cetera*. There is no way in which this interwoven set of skilled and creative individuals could be placed "on hold" while an uncertain possibility for improving one or another of the pieces is fully explored. Any such delay would surely lead to atrophy and dismemberment of the existing infrastructure.

There is general agreement that SSC physics is important and that the SSC will provide information essential to further progress. There is general agreement that the SSC, as designed, is a technically sound instrument that will be able to function as proposed. The United States can certainly choose to abdicate its traditional leadership role in research of this kind. Such a decision would be characteristic of many we have made in recent years, decisions that seem to be leading us down a path of lost self-confidence and decreasing competitiveness in the highly competitive world of science and technology in which we used to excel.

EDWIN L. GOLDWASSER
Superconducting Super Collider
Universities Research Association
Berkeley, California
and University of Illinois,
Urbana-Champaign

3/88

The exciting possibility of a TeV-energy e^+e^- collider has captured the imagination of a large number of accelerator and high-energy physicists. In the January issue of *PHYSICS TODAY* (page 26) Andrew Sessler writes about the accelerator R&D that will eventually form the basis of such a collider, and in the February issue Freeman Dyson emphasizes the importance of this work and raises the question of whether it offers an alternative to the SSC.

The Department of Energy asked the same question when formulating plans for and deciding to proceed with the SSC, and I served as the chairman of a High Energy Physics Advisory Panel subpanel charged with addressing it. The report was completed in December 1985 and endorsed by HEPAP. The substance was presented to a broad cross section of the particle physics community during the opening session of the summer study of the APS division of particles and fields at Snowmass, Colorado, in 1986. It is available to the public from the National Technical Information Service as DOE/ER-0255, "Report of the

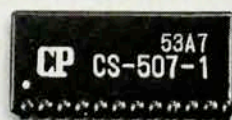
HEPAP Subpanel on Advanced Accelerator R&D and the SSC" (December 1985).

The first paragraph of the executive summary of the report reads: "The field of advanced accelerator research is flourishing with innovative ideas. Most of these hold promise for the future possibility of a multi-TeV, electron-positron linear collider capable of investigating processes involving fundamental particle masses which the Superconducting Super Collider will bring under study. However, the state of development of this research is such that it does not offer an alternative to present SSC plans. At least 10 years of development is needed for these advanced concepts to evolve into designs for practical, engineered devices in the multi-TeV energy region. There is no guarantee that this can be done successfully, and the costs are uncertain. At the present time, there is no persuasive evidence that such a collider ever could be built at a cost less than that of the SSC."

Two major reasons the subpanel reached that conclusion were that there was no operational experience with linear colliders, and the basic parameters of a multi-TeV-energy machine were unclear because there was no concept meeting the requirements of high-energy physics, which include energy, luminosity, construction costs and operating costs. All have strong influences on an optimized design; acceleration gradient is not the only important parameter. Since the fall of 1985, when we did our study, there has been progress in both these regards, but they are still obstacles. The Stanford Linear Collider is being commissioned. Many of the systems have been performed at a level sufficient to reach the initial luminosity goal of $6 \times 10^{27} \text{ cm}^{-2} \text{ sec}^{-1}$, and operation for high-energy physics is expected to begin this spring. This luminosity goal is five to six orders of magnitude below that needed for a multi-TeV collider, and although successful operation of the SLC is a prerequisite for the evaluation of future linear collider designs, a higher-energy collider requires significant extensions of technology beyond that of the SLC.

Studies at the Stanford Linear Accelerator Center, CERN, KEK and Novosibirsk have clarified the design trade-offs, but several fundamental and almost all engineering aspects of a multi-TeV collider remain to be studied. A lower-energy e^+e^- collider does offer interesting particle physics opportunities even though it does not have the mass reach of the

★NEW PRODUCT★
**CHARGE SENSITIVE
LOW NOISE
PREAMPLIFIER**
MODEL CS 507

**FEATURES**

- Ultra Low Noise
- Very Small Size
- Easy Handling

CS507 is a hybrid IC Charge Sensitive Low Noise Preamplifier utilizing FET at its input stage developed especially for instrumentation employing solid state detectors.

Its circuit is designed versatile thus can improve the characteristics of resolution and noise slope by a joint use with exterior parts.

It is featured in proper usage for a proportional counter and a photomultiplier tube also.

Increase the current of an input stage FET up to 10mA then you will get the performance more advanced.

SPECIFICATION

Transformation coefficient of charge-voltage:
1V/Pico-coulomb Typical
Noise characteristics: 2.2keV (Si) FWHM Typical (at 0pF, shaping constant of 2 μ s)
Noise slope: 20eV/pF (Si) Typical (at FET current of 10mA)
60eV/pF (Si) max.
Capacity slope: 15eV/pF (Si) max. (at FET current of 1mA)
Negative feedback constant: 1000M Ω , 1pF
Output impedance: about 0 Ω and 50 Ω
Test pulse input: 50 Ω , 1pF
Power supply: ± 12 V each 3mA (Typical)
Outer dimension:
33.0 \times 17.5 \times 5.0mm max.
12pins SIP type epoxy molded
Weight: 2.5g

MANUFACTURER:

CLEAR PULSE CO., LTD.

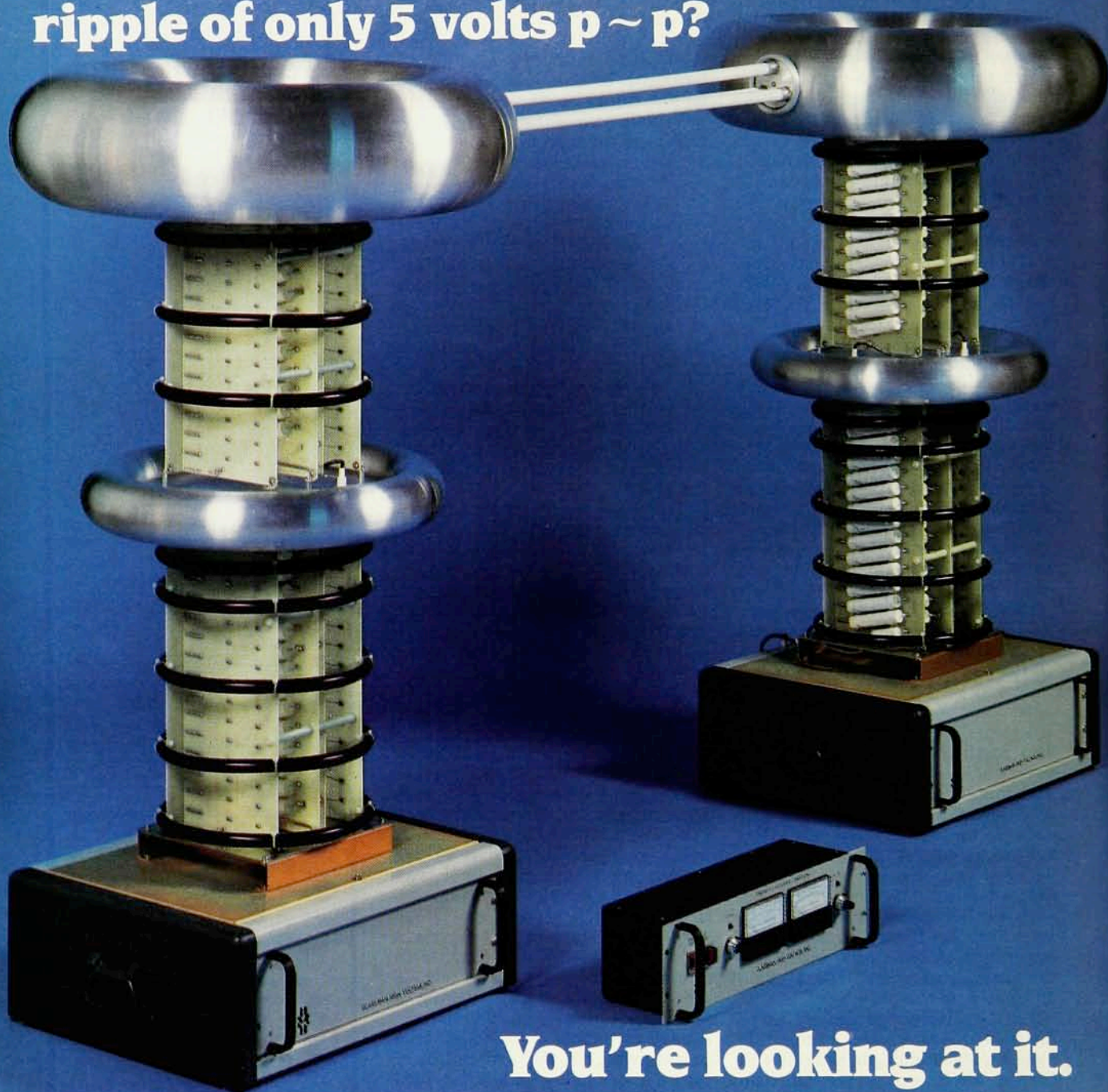
6-25-17, CHUO, OHTA-KU, TOKYO 143 JAPAN

SALES AGENT:

KATSURA CO., LTD.

PALACE OCHANOMIZU
2-3-2, HONGO, BUNKYO-KU, TOKYO 113 JAPAN
TEL: 03-816-3611 FAX: 03-816-3713
TELEX: J25473 (KATSURA J25473)

Is it possible to build a 300kV/1mA switching power supply with output ripple of only 5 volts p ~ p?



You're looking at it.

Not only is it possible—it's a standard option we offer for any PG series open stack model (100kV and higher). Of course, before we built this one, a lot of people thought it couldn't be done with an air insulated switching design—at least not at a reasonable cost.

But we gave it our best shot and even surprised ourselves. This unit actually exceeded the required specifications by a substantial margin.

Best of all, its cost was only about one third, and the size and weight (less than 200 pounds) are just a tiny fraction of existing line frequency designs with comparable specifications.

Today the supply pictured here is a part of the injection deck of a particle accelerator in the nuclear physics lab of a major university. We have since built a number of other PG-LR units, which also meet similar specifications.

The next time you are faced with a high voltage requirement with no reasonable solution, call us. One of our "best shots" could give you exactly what you need, without consuming your entire budget.

Innovations in high voltage power supply technology.

GLASSMAN HIGH VOLTAGE INC.

Route #22 (East) Salem Industrial Park, P.O. Box 551, Whitehouse Station, N.J. 08889
(201) 534-9007 • TWX 710 480-2839



Circle number 11 on Reader Service Card

SSC, and most accelerator physics and engineering problems are less severe at lower energies. For that reason some physicists are optimistic that a parameter list and initial cost estimate for a collider with 0.5 TeV per beam will be developed soon. These could serve as an R&D focus, and a conceptual design backed up by some engineering studies could be available in the mid-1990s. However, this work is at an early stage, and such a machine does not have the SSC's mass reach. I still concur with the conclusion that advanced accelerator research does not offer an alternative to the SSC.

I join Sessler and Dyson as a strong supporter of advanced accelerator research. Quoting from the last paragraph of the executive summary of the report: "There are important reasons to support and pursue work in advanced accelerators. Many substantive issues in addition to available energy arise when comparing electron-positron and hadron-hadron colliders. The relative simplicity of electron-positron annihilation events makes experimental programs possible which are not accessible with proton machines. Historically the complementarity in research at electron-positron and proton accelerators has led to major advances in high-energy physics. In the future, an electron-positron linear collider, operating in the energy range comparable to the SSC, may be attractive. In addition, linear colliders offer the long-range prospect of energies beyond those of the SSC. Intensive advanced accelerator research in the coming years will be required to bring these possibilities to fruition."

ROBERT SIEMANN
Cornell University
Ithaca, New York

3/88

In the past, physics facilities have sometimes been built because it became technically possible to extend significantly the range of some parameters, such as energy, and sometimes for a definite goal, such as finding antiprotons or W^\pm and Z bosons. Normally such facilities have been proposed and built with some, but not extensive, review. Now that the cost of new facilities has become so large, the review process has become very important. As may well be imagined, the particle physics community, more than anyone, wanted to be sure that the SSC would achieve the needed scientific goals and that there were no reasonable alternatives. To be as sure as possible, many activities were undertaken.

In addition to extensive normal

research activities in the past decade that naturally came to focus on the need to study small cross sections at high energies, the division of particles and fields of The American Physical Society convened large, international studies at Snowmass, Colorado, beginning in 1982. In 1982 the focus was on what kinds of facilities could best achieve the scientific goals of particle physics. High luminosity emerged as an essential requirement, in addition to high energy. In 1983 a High Energy Physics Advisory Panel subpanel proposed the SSC as the logical facility to develop. From 1984 to 1987 the accelerator, detector and physics aspects of the SSC were intensively studied,¹ with a resulting increase of confidence that the SSC could achieve the goals set for it. An important advantage of the SSC is that both its energy and its luminosity can be significantly increased if motivated by physics results after a decade or two of experimentation.

At every stage alternatives were considered. In particular, a HEPAP subpanel under Robert Siemann of Cornell, reporting in December 1985, concluded that for the foreseeable future a multi-TeV, electron-positron linear collider was not a serious alternative to the SSC. [See Siemann's letter above.] Two and a half years later it is still not possible to say whether the problems that need solving to develop very-high-energy e^+e^- colliders will be solved or at what cost. Indeed, it is not at all clear that multi-TeV e^+e^- colliders will be less expensive than pp colliders per TeV of useful energy. At best we may hope that when the SSC is a mature facility it will be possible to construct a multi-TeV linear e^+e^- collider if the physics questions lead that way.

In particular, the luminosity problem is an uncompromising one that may be fatal for such techniques. For such an accelerator to be of use for particle physics, it must be possible to use it to study the kinds of cross sections that appear in gauge theories. The typical unit for such cross sections is that for $e^+e^- \rightarrow \mu^+\mu^-$, which is about $10^{-37} \text{ cm}^2/\text{s}$, where s is the square of the center-of-mass energy and is in units of TeV^2 . To be competitive scientifically with the SSC, an e^+e^- collider must have a center-of-mass energy larger than about 3.5 TeV. Since most cross sections fall with s , the luminosity must increase correspondingly. In addition (contrary to what Freeman Dyson suggests) studies show that backgrounds generally grow worse at electron colliders as the energy increases, due to two-photon processes,

COUNTER INTELLIGENCE

New 207X-03 interfaces counter to printer, terminal or computer.



207X-03

- Provides 8-digit readout to EIA RS-232C device
- Fits inside counter—no NIM space required
- Assigns I.D. numbers to chain of 1-99 units
- Multiplexes independent counting systems
- Provides for computer control of Start, Stop and Reset

2071A

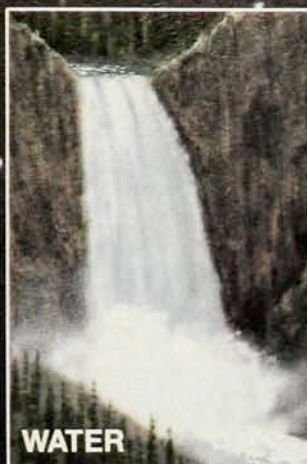
- Two Counters and Timer
- Preset Count or Time
- 100 MHz Count Rate capability
- Adjustable Discriminators
- Independent Gating of Inputs

Circle number 12 on Reader Service Card

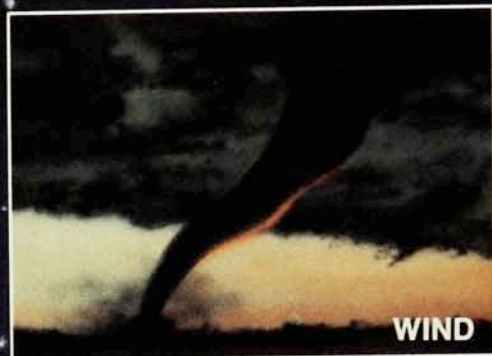
CANBERRA

Canberra Industries, Inc.
One State Street
Meriden, CT 06450
(203) 238-2351 TX: 643251

Energy Sources



WATER



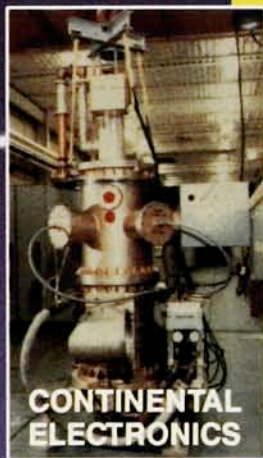
WIND



EARTH



FIRE



**CONTINENTAL
ELECTRONICS**

For advanced research programs, scientists need a reliable and powerful energy and frequency source. You can't harness nature's RF energy, that's why science turns to Continental Electronics.

Our modulators, pulsed power supplies and power amplifiers are a common thread in physics experiments and laboratories all over the world. We're the power and frequency behind many linear accelerators, plasma physics research and fusion and fission materials studies.

Scientists turn to Continental because we can build RF power systems to their specifications. When it comes to customized RF energy and frequency sources, science turns to Continental Electronics. We're the energy source science can count on.

For more information, contact:

varian®

continental electronics division

P.O. Box 270879 Dallas, Texas 75227
Telephone: 214-381-7161 Fax: 214-381-4949

Circle number 13 on Reader Service Card

two-W processes and the large number of additional final states that are possible. To deal with the backgrounds by using appropriate cuts, even higher luminosities are required. A few interesting cross sections do not fall with s , but their scales are set by the weak interactions and again require large luminosity for detection. Further, for the kinds of collisions that will be studied in the future, evidence and studies from CERN and SLAC indicate that the traditional "cleanliness" of e^+e^- colliders decreases relative to hadron colliders and that for many investigations the two kinds of colliders are comparably clean. This is because for collisions at large momentum transfers the hadronic debris is unimportant, and because an increasingly large fraction of e^+e^- collisions have undetected energy from radiated photons. Although for all of these reasons higher luminosity is required as the energy increases, confining the beams to tiny regions to get high luminosity is very difficult. Beam spreads of at most tens of angstroms in one or both transverse dimensions are required. We all hope it is possible to solve those problems, but no one can say how long it would take even with an intense effort.

To return to the initial remarks, it is important to realize that the SSC cannot be a "flop." Calculations that any interested physicist can follow through show that if the quanta of the Higgs field (which many theorists believe provides the mechanism for particles to get mass) exist, then they can be produced and detected at the SSC. If they do not exist, it can be determined experimentally that they do not. In that case the interactions of W bosons have to deviate from the perturbative predictions for their behavior, and they can be studied at the SSC. The correctness of these statements is not obvious, but emerged from the studies mentioned above and from the research of a number of people before, during and after the studies.

In addition to this rather specific goal concerning the study of "Higgs physics" and the origins of mass, the SSC extends the ranges of mass scales and interaction scales where a "surprise" could occur by factors of 10-100. Of course no one knows whether a surprise will occur, but even the absence of new phenomena over such a large scale would be a tremendous constraint on ideas and would likely be very fruitful, similar to the way the absence of certain rare kaon decays led to the prediction of the charmed quark and a good estimate of its mass

(the "GIM" mechanism).

Progress in answering the questions of particle physics requires data on particle interactions in the TeV region. No easy way is known to get such data. An advantage of the SSC is that it is based on known technology, and it can be built on schedule and for the expected cost, so that we can move ahead. Even then the lengthy time scale, requiring almost a decade before the physics begins to emerge, is unavoidable. The particle physics community has strongly supported research on alternative acceleration techniques in hopes that some approach would become feasible as a tool to study particle interactions. It is true that if one waited long enough, alternative technologies might lead one to proceed differently. However, if this time scale is as great as the expert studies suggest, the US will have retired from forefront research in this field by that time, for one cannot now foresee any manner of addressing comparable physics issues during the period when the SSC would otherwise be the premier world facility. Progress requires the periodic injection of significant new data to maintain the knowledge base and talent that now exist and to attract bright young people to careers in elementary-particle physics research. Supporters of particle physics such as Dyson should certainly be concerned about the deleterious effects of a potentially lengthy period in which the research frontier is not being advanced. If there were any better way to address the scientific goals set for the SSC, or if there were any alternative way to achieve them, we would be trying it.

Reference

1. R. Donaldson, J. G. Morfin, eds., *Proc. of the 1984 Snowmass Wksp. on the Design and Utilization of the Superconducting Super Collider*. R. Donaldson, J. Marx, eds., *Proc. of the 1986 Snowmass Wksp. on "Physics of the Superconducting Super Collider."* *Proc. of the Wksp. "From Colliders to Supercolliders,"* Madison, Wisc., in *Int. J. Phys. A* 2, 1055 (1987). R. Donaldson, M. Gilchriese, eds., *Proc. of the 1987 Berkeley Wksp. on "Experiments, Detectors and Experimental Areas for the Supercollider."*

MARTIN EINHORN
GORDON KANE

University of Michigan
Ann Arbor, Michigan

3/88

In the February issue, Freeman Dyson stated his opposition to the construction of the SSC, advocating instead an electron-positron linear collider using laser acceleration
continued on page 132

Cryopumps For High Vacuum Applications



Complete Line of Closed-Cycle Cryopumps

- 4 Inches to 48 Inches
Flange Sizes
- 400 to 60,000 Liters per
Second Pumping Speed (Air)
- Multi Pump
Operation Capabilities
- ☐ Mountable in Any
Orientation
- ☐ Absolutely Oil Free
High Vacuum
Capabilities
10⁻³ to 10⁻¹¹ Torr
- ☐ Low Maintenance
Intervals
- ☐ Water and Air Cooled
Compressors
- ☐ Field Serviceable

LABORATORY ASSISTANCE AVAILABLE FOR SPECIAL CRYOGENIC REQUIREMENTS AND DEVELOPMENT

Circle number 14 on
Reader Service Card



LEYBOLD
VACUUM PRODUCTS INC.
5700 Mellon Road
Export, PA 15632
(412) 327-5700 Ext. 528

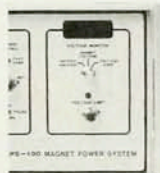
SUPERCONDUCTING MAGNET SYSTEMS



- ❖ Full line of standard magnets
- ❖ Custom designs
- ❖ Fields to 12 tesla



- ❖ Standard and custom cryostats
- ❖ Variable temperature systems
- ❖ Low loss refrigerated systems



- ❖ Magnet power supplies
- ❖ Liquid helium and nitrogen monitors
- ❖ Cryothermometers
- ❖ IEEE-488/RS-232C interfaces

FREE
GUIDE



CRYOMAGNETICS, INC.

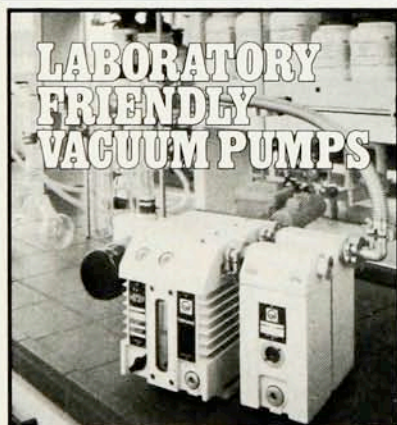
(615) 482-9551

TELEX 883 945

FAX (615) 483-5891

P.O. BOX 548, OAK RIDGE, TN 37831 USA

Circle number 78 on Reader Service Card



Get the Facts On TRIVAC® B

- Compact Design
- Low Noise Level
- High Vapor Tolerance
- No Oil Backstreaming
- Solvent Resistant Seals

**Ask for the
7 Golden Rules for use in
Chemical Laboratories**

Leybold
Vacuum Products, Inc.
Export, PA 15632
412-327-5700
Ext. 528



Circle number 79 on Reader Service Card

LETTERS

continued from page 15

techniques. In his advocacy of electron colliders over proton colliders, he cited the productivity and cost effectiveness of SPEAR and CESR as examples of the superiority of electron colliders.

As an experimentalist who has conducted research at a substantial number of the world's accelerator laboratories and as a former administrator who was intimately involved with the construction of CESR, I am dismayed at the lack of understanding of such issues portrayed in Dyson's Opinion column.

Succinctly, my amazement at the recommendations made is that Dyson, who is world renowned for his understanding of space and time, has neglected time as a factor for consideration in the planning of facilities. As the Book of Ecclesiastes states, "There is a time for everything," and the wise man knows this statement well.

The successes of SPEAR and CESR were spectacular at least in part because the timing was right. In both cases, the decisions to develop the facilities were the result of the initiative and drive of a few individuals who correctly perceived the situation and seized upon the opportunity to construct the facilities without a broad consensus from the scientific community or formal approval for construction projects. The potential gains were high, the costs were low and the timing was right.

The exact opposite is the case with Dyson's recommendation. No linear accelerator using laser acceleration techniques has ever been built, nor has the feasibility even been demonstrated. The duration of time needed to develop these areas into practical devices is totally unknown, as are the attendant costs. This is clearly not the time to consider these concepts as viable alternatives to the SSC.

One other time factor needs to be taken into account, and that is the time derivative referred to as momentum. Several years ago it was recognized that new facilities needed to be constructed if the pace of exploration was to continue. A High Energy Physics Advisory Panel subpanel recommended the consolidation of the options into a single facility, the SSC. I did not agree with that decision then, feeling that the time scale was too long at that time and that an intermediate facility prior to the SSC was necessary to maintain momentum. The outcome of Dyson's proposal would be to further lengthen the time before a new facility became available, with the inevitable conse-

quence being the decay and conceivably the demise of the US high-energy program in the foreseeable future. I cannot but question whether Dyson has projected his thoughts into the future and clearly foresees what the consequences might be of following his recommendations. The arguments do not appear to ring true and generate instead further questions as to the rationale behind the negative attitude toward the SSC.

A. ABASHIAN

*Virginia Polytechnic Institute
and State University
Blacksburg, Virginia*

2/88

DYSON REPLIES: I thank my critics for helping me to achieve my purpose, which is to start a discussion of alternatives to the SSC. I do not expect to convert them to my way of thinking, nor do they convert me to theirs.

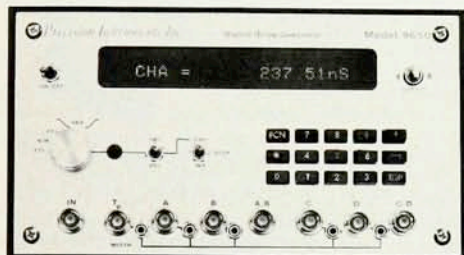
I see the basic issue between us to be whether we regard the world of particle physics to be one-dimensional or multidimensional. I am not advocating a huge monolithic effort to build an electron-positron collider as an alternative to the SSC. I am advocating continued exploration of the frontiers of particle physics in many directions. If the universe of particles is one-dimensional, with energy the only relevant variable, then the frontier is a single point and a single machine can explore it. I say that the universe of particle experiments is at least three-dimensional, the three most important variables being energy, accuracy and rarity. Rarity means the fraction of particle collisions that produce the particular process that the experiment is designed to study. To observe events of high rarity we need an accelerator with high luminosity and a detector with high discrimination.

I am not denying that energy is important. Let us by all means build accelerators of higher energy when we can do so cost-effectively. But energy is not the only important variable. I did a little historical study of particle physics discoveries for which Nobel Prizes were awarded. I found that roughly one-third of the discoveries were on the energy frontier, one-third were on the accuracy frontier and one-third were on the rarity frontier. In some rough sense, the three frontiers are equally promising places to look for new laws of nature. Only one-third of the frontier lies in the direction of higher energy. My alternative to the SSC is a mixture of many different programs, looking for opportunities to do great science on all three frontiers.

UNMATCHED PRECISE TIMING 10ps to Secs

25ps rms jitter, 25ns insertion delay, four delays & seven outputs

The unique interruptible ramp timing system (Patent Pending) of the 9650 series Digital Delay Generators, provides a combination of the shortest insertion delay and lowest jitter available together with a full range of features and options. Select from two models, both under \$4000.



- TTL & 10V into multiple loads & NIM
- All outputs variable width
- 0-100sec, 10ppm or 0.3ppm stability
- 0-2MHz trigger plus autoscan & burst
- GPIB or RS232 external control

Precision Instruments Inc.

P.O. Box 11235, Knoxville, TN 37939
(615) 690-5608 TLX 55-7444

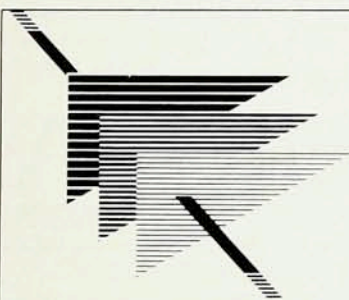
Canada
Canberra Packard Ltd.
Tel: (613) 592-6108

France
Instrumat
Tel: (6) 928 27 34

Germany
Tennelec GmbH
Tel: (089) 6115060

U.K.
Alrad Instruments Ltd.
Tel: (0635) 30345

Circle number 80 on Reader Service Card



OPTCON '88 is the first jointly sponsored event to address the needs of all professionals with interest in optics and its applications: technicians, engineers, and pure and applied research scientists. The exhibition, core program, and associated conferences are sponsored by the five major professional and trade associations with activities in optics, optical technology, applications of optics, laser technology, applications of lasers, and electro-optics.

OPTCON '88

October 30–November 4, 1988
Santa Clara Convention Center
Santa Clara, California

Sponsored by:

Laser Association of America (LAA)

Laser Institute of America (LIA)

Lasers and Electro-Optics Society of IEEE (LEOS/IEEE)

Optical Society of America (OSA)

SPIE—The International Society for Optical Engineering

OPTCON '88 will consist of the following elements:

- A major technical exhibition
- Focus lectures and panel discussions
- A short course program
- Product presentations
- An employment center

Associated conferences sponsored by LIA, LEOS/IEEE, OSA, and SPIE.

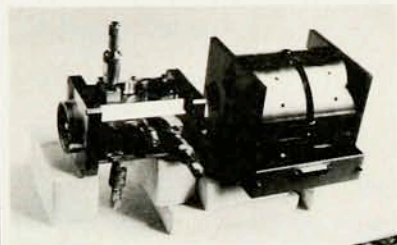
For additional information on the **OPTCON '88** program, the technical exhibition, and the associated conferences of LIA, LEOS/IEEE, OSA, and SPIE, write to:

OPTCON '88
c/o Optical Society of America
1816 Jefferson Place, NW
Washington, DC 20036
(202) 223-8130

Microbeam Lens

Focus your
0.5 MeV to 100 MeV
ion beam to a
1 μ spot.

RBS, ERD, and PIXE scan

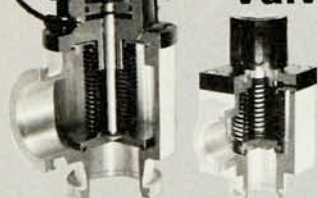


Slits and Magnetic Quadrupole
Doublet

DYER ENERGY SYSTEMS, Inc.
4 Fox Run Rd
Bedford, MA 01730
(617) 275-7622

Circle number 81 on Reader Service Card

Laboratory Friendly Vacuum Valves



**Building-Block Versatility
For Rough and Medium
Vacuum**

- ☐ Interchangeable Manual and Electropneumatic Drives
- ☐ Aluminum and Stainless Steel Bodies
- ☐ International Standard KF® and ISO Port Sizes
- ☐ Leak Rates Less Than 1×10^{-9} mbar ltr/sec

**Get the Facts
NOW! Ask for
our applications
brochure.**



LEYBOLD
VACUUM PRODUCTS, INC.
5700 Mellon Road
Export, PA 15632
(412) 327-5700 Ext. 528

Circle number 82 on Reader Service Card

In conclusion, I urge my critics to remember that the universe is, as the biologist J.B.S. Haldane said, not only queerer than we suppose but queerer than we *can* suppose. There is no illusion more dangerous than the belief that the progress of science is predictable. If you look for nature's secrets in only one direction, you are likely to miss the most important secrets—those that you did not have enough imagination to predict.

FREEMAN DYSON

Institute for Advanced Study

Princeton, New Jersey

4/88

SSC: Opinion Splitter

One of the many considerations in a decision about the proposed Superconducting Super Collider project should be the extent to which physicists favor this project. The physics community in the United States is well represented by the membership of The American Physical Society. Unfortunately this society has no mechanism for polling its membership on an issue.

I therefore undertook such a poll myself. Because I had to rely on my own personal resources, the sample had to be modest. It was selected on the basis of a pattern of location in the directory of The American Physical Society. The questionnaire was sent to 247 names.

The letter included a brief explanation of the poll, a slip to be returned with the vote, and an addressed but unstamped return envelope. The slip to be returned contained the following text:

"Return this portion in the attached addressed envelope."

"In view of the circumstances as I perceive them, I am/am not (cross out one) in favor of the construction of the Superconducting Super Collider as projected in the present plans submitted to Congress."

The forging of ballots was guarded against in two ways. The return envelope was addressed with a rubber stamp, the forging of which would be difficult. In addition, the return slip was embossed with a personal "ex libris" embosser, the forging of which would also be difficult. A cursory inspection of the returns indicated no cause for anxiety about forging.

By the deadline of 5 February 1988 (six weeks after the original letters were mailed), 26 original letters had been returned to me as undeliverable and unforwardable. Thus 221 ballots presumably reached the addressees.

Of these, an astounding 109 re-

sponded. Such a 49% return, with only one mailing and no return-paid provisions, appears to indicate that the issue is of interest to physicists.

Of the 109 responses, 2 were illegal in that the addressed return envelope did not accompany the ballot, in spite of the underlined request. Of the 107 valid ballots, 59 (55%) were in favor of construction, 45 (42%) were opposed and 3 (3%) were undecided.

Of those 107 ballots, 87 came with US postmarks and 20 with foreign postmarks, the latter presumably from foreign members of The American Physical Society.

Among the 87 domestic returns, 46 (53%) were in favor of construction, 39 (45%) against and 2 (2%) undecided. Correspondingly, among the foreign respondents, 13 (65%) were in favor, 6 (30%) against and 1 (5%) undecided.

Considering the modest size of the sample, one can conclude that the community of physicists, as represented by the membership of The American Physical Society, is about evenly divided on the issue of the construction of the SSC.

Insofar as the SSC issue affects all scientists in the United States, it would be of interest also to have a similar poll of scientists outside physics.

MICHAEL J. MORAVCSIK

University of Oregon

Eugene, Oregon

4/88

Remembering Richard Feynman

Thank you for publishing Richard Feynman's article on his "inside view of the Challenger inquiry" (February, page 26) when you did. I realize that it was only by a quirk of fate that its appearance coincided so closely with his passing. Still, you could not possibly have printed a better epitaph if you had tried. The article embodied the essence of Feynman's character that made him a physicist's physicist. He is sorely missed.

ROBERT J. BARKER

Air Force Office of Scientific Research

2/88

Washington, DC

What Washington, DC, needs is for an army of Feynmans to descend and start investigating everything in sight. What Richard Feynman had to say about NASA could be said about a lot of organizations, including the many faltering private-sector companies in the US that once were global leaders. When the leadership starts listening only to those who tell it what it wants to hear, decline is