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LAWRENCE BERKELEY LABORATORY
YEAR-END-REPORT ON HEAVY-ION FUSION PROGRAM

D. Keefe

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HI-FAN-18

LAWRENCE BERKELEY LABORATORY

YEAR-END-REPORT ON HEAVY-ION FUSION PROGRAM*

FISCAL YEAR 1977

SEPTEMBER 30, 1977

* Work supported by Division of Laser Fusion and Division of Physical Research, US-ERDA.

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1. INTRODUCTION

This is the first year-end report on the Heavy-Ion Fusion program at the Lawrence Berkeley Laboratory and is in response to the request for a "final report" as stated in the directive of March 4, 1977, from Dr. C. Martin Stickley to LBL Director Dr. Andrew Sessler. This has been an unusual year in that direct ERDA funding became available only late in March, 1977, so that we are reporting on a program which has grown almost from a standing start to its present level in a matter of six months. The LBL directorate made available discretionary funds to allow preliminary planning efforts to get under way in this promising new area. Part of these early efforts included preparation of a study proposal "Heavy-Ion Fusion - Proposal for a Program at Lawrence Berkeley Laboratory, (September, 1976)" which included not just the topics later funded and reported on herein, but also proposed activities in other areas such as ion-ion and ion-gas interactions, ion-matter energy loss, cryogenic acceleration systems, etc., all of which will have bearing on the design of an ultimate system.

In choosing the direction of our research and development program we tried first to single out those features that presented essentially new problems in accelerator design as opposed to those that we felt more comfortable about handling in a straightforward way. Among the latter are repetition rate, power conversion efficiency, creation of megajoule beams, and experience in engineering, estimating, meeting construction schedules, operating with high availability and having adequate control systems for the large scale igniter system that will be required. At least some of these features will present new challenges to other proposed igniter technologies e.g., lasers, REBs, ion diodes. The essentially novel problems

facing the accelerator scientist we identified as the need for (a) large charge per pulse (or high current) and (b) high beam-power on target. The required currents are one to two orders of magnitude beyond our present experience for heavy ions, and the power much more than that; the power in particular presents a new (but visible) frontier because accelerators for experiments usually seek to provide the lowest possible power for users.

We have been addressing these problems on three fronts:

- First, an intensive theoretical program was launched to try to understand the conditions for safe propagation of intense beam currents in focussing systems, such as continuous and interrupted solenoid lens systems, and quadrupole strong-focussing systems. Analytic methods have led to significant advances in understanding of the new problems; with computational techniques a large amount of new information has been generated on space-charge-dominated transport phenomena; also, at this time a new LBL particle numerical simulation code is almost ready to give new results. In the last few months a rewarding exchange has taken place with a group at the Naval Research Laboratory, who have adapted existing numerical simulation codes there to study this problem.

- Second, because the Bevalac is an operating heavy ion linac and synchrotron facility with an ongoing R & D effort and in expectation of imminent upgrading to bring it up to a uranium-ion capability, it was a natural choice to make an addition to these activities to examine low-β rf accelerating structures and ion sources suitable for HIF. These studies have shown that the requirements for an rf injector for HIDE are just a short step away from those now being designed for the SuperHilac third injector which is soon to be constructed. The multi-aperture ion-source work has progressed to the point of demonstrating currents of heavy ions suitable for HIDE, but not yet for a power plant.

• Third, an experimental program on intense beam propagation was clearly of high priority. Experiments scaled in particle mass, for example, electron table-top devices, even proton models, were rejected because of the large extrapolation factors in favor of proceeding directly to heavy ions. While multi-ampere beams of gaseous ions, e.g. Xe, have been produced at LBL with CTR sources, we have chosen for the moment to construct a large aperture contact-ionization source of Cs^{+1} which should be free of troublesome gas-load problems. A drift tube system employing pulse-power units is planned to accelerate a beam of about one ampere to 2-3 MV (total charge $\approx 2\mu C$). A quadrupole transport system of some 24 magnets (12 periods) will be installed to study transport characteristics (such as emittance degradation). We have arranged to borrow much of the required equipment but have started to install the added power supply facilities needed to supply the electrical requirements. Other experiments to take place in the future will involve instability studies, beam bunching and neutralization.

We have benefitted by interaction with visiting scientists from other laboratories -- D. Tidman (University of Maryland) spent two months here, I. Hofmann (Max Planck Institute for Plasma Physics, Garching) will be with us for a year and W. Herrmannsfeldt (SLAC) is participating in the program on a 50% basis. In addition, V.K. Neil (LLL) and R. Cooper (LASL) are participating in the theoretical studies.

A workshop on Low-β High Intensity Accelerating Structures was held at LBL on June 1-3, 1977; the program and list of attendees is included as Section 6.

2. THEORETICAL AND DESIGN STUDIES

2.1 Transport of Intense Beams

An extended study was made of the transport of intense beams. The work falls into two categories; first, a survey of the properties of matched beams as given by numerical integration of the Kapchinskij-Vladimirsky envelope equations[1] and second, a stability analysis of such beams under the influence of both linear and non-linear fluctuations in the self-induced electric fields.[2]

For the calculation of matched beams we followed a scaling procedure similar to that suggested at the first HIF workshop[3] and established the relation of the numerical coefficients in the scaling relations to the degree of modification of beam dimensions and oscillation frequencies due to space charge forces. These results alone would indicate that transport is quite feasible in the multi-GeV, kilo-ampere range under consideration, but that vacuum transport at D.C. source energies may be restricted to a few amperes. The stability calculations, however, indicate some serious restrictions. For transport systems composed of quadrupoles or discrete solenoids, we find that as the current increases a series of short ranges of instability appear and above a certain critical current the motion is unstable for all currents. For reasons we do not yet understand, this extended range of instability begins at a current such that the individual betatron frequency

1). G.R. Lambertson, L.J. Laslett, and L. Smith, IEEE Trans. on Nucl. Science, N.S. 24, June 1977, p. 993.

2) L. Smith, S. Chattopadhyay, L.J. Laslett, LBL-6771, HIFAN Notes 13, 14, and 15. Sept. 1977.

3) E.D. Courant, ERDA Summer Study of Heavy Ions for Inertial Fusion, Final Report, December 1976, p. 72.

is depressed to about 40% of the zero intensity value, independent of that value and of the type of focusing system.

The theoretical analysis is restricted to the rather unrealistic Kapchinskij-Vladimirsky distribution function in transverse phase space. We are developing a numerical simulation code to permit a broader study at LBL; in the meantime, Irving Haber, at the Naval Research Laboratory, has verified some of our results with his codes and we anticipate a continued collaboration with him while using our more modest code for orientation purposes.

2.2 Cesium Ion Beam Propagation Experiment Design

The design of the cesium gun and a transport system which should allow us to investigate experimentally both stable and possibly unstable beam propagation has been completed. The gun design was done by William Herrmannsfeldt, of SLAC, using his EGUN code, and the feasibility of matching and transporting the beam from the gun using a set of quadrupoles already on hand was examined at LBL with the help of the TRANSPORT. The transportable current appears to be restricted to about 1 ampere at 2 MeV, as is the gun, but the planned quadrupole system is flexible enough to permit operation in both what we currently believe to be stable and unstable configurations thus allowing experimental examination of instabilities for a real beam.

2.3 Longitudinal Bunching

Understanding and control of the longitudinal behavior of an intense beam bunch in the presence of an externally applied accelerating fields, its own space-charge field, and fields generated by interaction of the beam with the surrounding structures is of great importance in both circular and linear high current accelerators. Development of a computer program to explore this behavior by direct integration of the Vlasov equation in the two-dimensional longitudinal phase space was begun some time ago in collaboration with LASL with the original goal of studying the design of an accumulator ring for high power pulses at LAMPF. In recent months this program has been modified and applied to studies of longitudinal motion in induction linacs. Early runs in test situations have led to improvements and the program yields results of the expected character for such problems. It is expected that the program will become increasingly useful as design studies for HIDE and for full-scale systems become more specific.

Analytic studies, based on simplifying assumptions, have also been made of a variety of problems connected with longitudinal behavior of an intense beam bunch in an induction linac. Among the topics considered are control of bunch length and velocity spread during injection; discrete kick effects; longitudinal space charge limits; control of bunch length during main acceleration and strategy for optimizing its variation; tolerances at injection and during acceleration; beam chopping; and post-acceleration bunch compression.

2.4 Design Studies

In recent months considerable effort has gone into consideration of the range of possible construction projects leading to experimental demonstrations relevant to the establishment of confidence that a plant based on heavy-ion fusion can be constructed. This proposed program (HIDE = Heavy Ion Demonstration Experiment) is generally defined as in the cost range up to $100 million and the time range of ≈ 4 years. Results from several parts of the ongoing HIF program at LBL (e.g., source development, low-velocity acceleration design studies, induction linac system studies) will have a direct bearing on the selection and design of the HIDE system. In addition, a preliminary conceptual complete system design employing an induction linac, and a parametric study of synchrotron-system design features, are under way for the presently available suggested pellet target requirements for such experiments. It also appears desirable to consider whether a program based on use or modification of any existing accelerator installation could yeild significant results with comparable or lesser total cost and/or elapsed time, but such possibilities have received only very preliminary study thus far. Accumulation of relevant engineering cost data for general accelerator system elements has been an important activity in recent months.

Results of work on HIDE at LBL will be presented and considered at the BNL HIDE workshop October 17 - 21, 1977

The progress in understanding the parametric and conceptual design features of an induction linac system has been documented in reports presented at the Proton Linac Conference (Chalk River, Nov. 1976) by Keefe[1], at the IUPAP Xth International Conference on High Energy Accelerators (Serpukhov, July, 1977) by Faltens and Keefe[2] and at the Second International Conference

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1) D. Keefe, Proc. Proton Linac Conference, Chalk River, 1976 to be published.

2) A. Faltens, D. Keefe, Applications of Induction Linac Technology to Heavy Ion Fusion, LBL-6453, Proc. Xth Int. Conf. on High Energy Accelerators (Serpukhov, July 1977) to be published.

on Electron and Ion Beam Fusion (Cornell, October 1977) by Faltens, Judd, and Keefe.[3] All these reports stress the importance of having a good understanding of the beam-transport phenomena and how it influences the design. The latter two reports seek to compare and contrast this particular approach with other accelerator and pulse power systems, e.g., resonant versus non-resonant cavities for supplying energy to the beam, and to show that the induction linac is simply another way of using pulse-power units packaged in a different way. The last report emphasizes that the induction linac uses series rather than parallel elements and relies on beam coupling rather than conductive-coupling to create a system with very large equivalent voltage and correspondingly small charge, thus relieving many of the formidable switch problems.

(3) A. Faltens, D. Judd, and D. Keefe, Acceleration Systems for Heavy-Ion Beams for Inertial Confinement Fusion, LBL-6768; to be published in the Proceedings of the Cornell meeting.

3. EXPERIMENTAL INVESTIGATIONS

3.1 Large-Aperture Pulsed 1-ampere Cesium Source

We have begun the development and construction of a large aperture (10 inches diameter) pulsed heavy ion source. This source is designed to produce 2 microsecond bursts of 500 keV Cs^{+1} ions with a current in the one-ampere range. Cs^{+1} ions are produced by directing bursts of neutral Cs atoms onto an iridium hot plate. This development is well underway.

In addition to this we have set up a smaller test system to test components which may influence the design of the large ion source and also to obtain early information about unusual difficulties that might not have been anticipated for the big source. In this test we have installed and tested a puff valve using Xe gas and nude ionization gauge detectors. Hot tungsten wire detectors have now been installed in the system and tests with cesium vapor are underway.

Concurrently an eight-inch diameter iridium plate and a 250 kV sub-microsecond Marx generator have been adapted for use in the test tank. This will permit application of voltages and fields in the presence of Cs ions and vapor comparable with those expected in the large aperture source.

Installation of 3 MVA of 480-volt power is 50% complete. This power will be utilized to power quadrupoles in the beam transport system.

3.2 High-Voltage Marx Generator Modules (500 kV)

The high voltage supply to be used with a drift tube accelerator initially will be a Marx generator, with a design goal of producing a 2 μsec pulse. This unit was constructed by connecting two existing 250 kV Marx generators in tandem, and placing them into a much larger oil tank. The Marx generators had previously been used to generate a sub-microsecond pulse, and had to be modified to extend their output pulse duration and improve their voltage-holding ability for longer times. These modifications consisted of increasing the charging and triggering resistor-string values by about a factor of ten, increasing their dissipation ratings by typically a factor of two, and enclosing the Marx generator within "corona rings" to shield the interior. The effect of these changes was to extend the RC decay time of the Marx.

To generate an approximately square voltage pulse, the load is connected to the H.V. terminal through a resistor, and a crowbar spark gap to ground. The pulse duration is determined by the time at which the crowbar is fired. The entire system was tested in September to 400 kV with variable pulse length ranging from one to ten microseconds. Work is continuing to extend its operating range and to better damp the Marx oscillations. The next major phase of this work will be to connect the Marx to the anode of the large Cesium source and to incorporate the filament isolation transformer and Marx into a common container. As time allows, a Marx generator design specifically for the needs of HIF is being pursued, with the goal of making a more compact system and the ability to make bipolar pulses.

3.3 Tests and Development of "Conventional" Duoplasmatron and Multi-Aperture Heavy Ion Sources

The goal of the program of ion source development for an rf linac has been to produce currents of up to 100 mA of the heavier gaseous ions such as argon and xenon, of good emittance (.02 π cm mr, normalized) and charge state 1^+. Existing facilities and hardware utilized included the 400 kV Bevatron injector, the 750 kV injector for the 50 MeV ESCAR linac, the 100 kV Bevatron test stand, and existing duoplasmatron and multi-aperture sources. We have also benefitted from the experience of the CTR source groups at LBL and LLL, particularly those of K. Ehlers and J. Osher.

At the Bevatron injector beams of 30 mA of neon and 25 mA of xenon were accelerated through the low gradient column to 470 kV, using the Bevatron duoplasmatron source. The beams were pulsed with 0.5 ms duration at 2/sec. No beam emittance or charge state measurements were made in this set-up.

The 750 kV injector with its high gradient column was used to accelerate neon to 500 kV, using the standard duoplasmatron. 15 mA was measured, with an emittance of .02 - .05 π cm mr., normalized, with mainly 1^+ charge state. The transmission was not optimum for Ne^{1+}, but only for Ne^{3+} and above, because of column quadrupole strength limitation. Ne^{3+} was about 1% of the total beam.

Recent development had centered on a multi-aperture source. Since the requirement of 100 mA of Xe^{1+} corresponds to a proton current of 1.1 amps, the high output current capability of the multi-aperture source (tens of amperes of protons) matched the requirement better than a single-aperture duoplasmatron or PIG source. A source previously used by the LBL CTR group was kindly loaned to us and was modified by adding an accel.-decel. extraction system like that used by Osher. 13 circular holes of 2 mm dia. within a 1.5 cm diameter are used in the extraction aperture plates. The predicted current is 10 mA Xe^{1+}. Development has been aimed at transporting the beam 1.3 meters to a Faraday

cup using a magnetic quadrupole triplet, and understanding the effect of various source parameters upon beam intensity, divergence and transport. Typical source operating parameters for good transmission are: +20 kV on source, +10 kV on extractor (accel.-accel.), arc pulse 1 ms wide, 2/sec. Langmuir probe measurements show the plasma to be uniform to 5% across the apertures. Beam current is 5 mA at the source and 1.5 mA focused into a 4 cm dia. cup 1.3 m downstream, expected to be mostly Xe^{1+}. The intensity of the low divergence beam is expected to be about 10 mA. Tests with a biased mesh in the beam gave no improvement in transmission, indicating space charge neutralization is probably adequate. Gas pressure measurements along the beam line show pressures in the 10^{-5} torr range, giving a calculated 10% loss due to charge exchange to Xe^{0}. Future measurements are planned on beam divergence, emittance, and charge state distribution. A beam profile monitor and more pumping will be added. A test on krypton using a MATS source was done by Osher at Livermore. A 25 aperture accel.-decel. extraction system was used. A d.c. current of 75 mA at 20 kV was measured calorimetrically at 1.1 meters from the source. The emittance appeared to be comparable to the $.02\pi$ cm mr required. The beam current scaled approximately as $V^{3/2}$ over the range 10-20 kV. This excellent space-charge neutralized transport comes close to meeting the summer study goal.

Also under study is the design of a new type of structure for a high gradient column. In seeking a simple, low-cost design the insulators are made of two flat plates rather than a series of circular rings. A preliminary test is planned using lucite instead of ceramic and a ceramic version would be constructed later if first results are promising.

4. CONCEPTUAL AND TECHNICAL DEVELOPMENT

4.1 Low-Velocity rf Accelerating Structures

A major effort has been underway for some time on optimizing a Wideröe Injector of the GSI π-3π type for the acceleration of U^{+5} for the Bevalac Improvement Program. Several minor changes in previously published structures have raised the designed saturation output current to 8 emA for both Xe^{+3} and U^{+5}, corresponding to particle currents of 2.7 and 1.6 pmA, respectively. We will soon do modeling on a (one-seventh) scale model of the rf structure to determine its rf characteristics, and a prototype quadrupole is being assembled for testing.

The conceptual design efforts have been broadened to include the parameter ranges suited to HIF needs. In particular, it now seems clear how to extend the present design to lower frequency in a straightforward way to meet the particle-current requirements for HIDE. This extended design is consistent with sources under development at present.

Theoretical investigations on the dynamics of a high-intensity beam in generalized rf structures continues using envelope integrations, linearized paraxial equations, and macroparticle methods, all giving comparable results. A couple of machines of the Sloan-Lawrence family have been worked on in some detail, including those which operate on a positive stable phase with no quadrupole focussing in the structure, but the energy spread at the exit is much larger than previously quoted requirements.

4.2 Induction Cavity Loaded with Mixed Iron and Ferrite

Modeling tests of an iron/ferrite mixed material induction cavity have been carried out at low voltage, and a high-voltage test stand is under construction. Initial low voltage test results are promising. The ferrite exhibits its effectiveness in shortening the pulse rise time while the iron is useful in extending the pulse duration. With a proper mixing of iron and ferrite in a given geometry it may be possible to tailor the pulse shape as desired. As the conceptual study of the LIA system progresses, various high voltage elements will be built and tested in order to define desirable pulse-length and voltage combinations.

4.3 Conceptual Engineering and Cost Study for Induction Linac System:

These efforts have concentrated on an example power-plant igniter with a 10 MJ beam energy using 40 GeV U^{+4} ions, and more recently on a system for HIDE. The engineering solutions are rather different for these two cases since for HIDE cost optimization is not as critical a factor and the repetition rate and power budget need not be as tightly constrained. The most interesting design questions center on integrating the magnet transport and the pulsed accelerating systems. Different ferromagnetic loading materials are appropriate at different points along the accelerator and cost information is being developed to determine optimum choices. Our thinking has changed lately on the optimum use of ferrite because of the discovery that the cost of ferrite in large quantities is likely to be very much less than we had earlier assumed. In particular, for the large quantities needed for a demonstration plant estimates a factor of one-tenth less seem realistic.

5. AGENDA OF RECORD, HIF MEETING

JUNE 1-3, 1977

TOPIC: LOW β HIGH-INTENSITY ACCELERATING STRUCTURES

LOCATION: Building 71 (SuperHILAC), Room 290, Lawrence Berkeley Laboratory

WEDNESDAY, JUNE 1

Chairman: D. Keefe

1:30	LBL PROGRAM OUTLINE	D. Keefe/F. Selph
2:00	ANL PROGRAM OUTLINE	R. Martin
2:30	BNL PROGRAM OUTLINE	A. Maschke
3:00	B R E A K	
3:30	CALCULATIONS WITH THE EGUN CODE	W. Herrmannsfeldt
4:00	ELECTRON NEUTRALIZATION	S. Humphries
4:20	COLLECTIVE ACCELERATION OF HEAVY IONS	H. Kim
4:40	DISCUSSION - ELECTROSTATIC ACCELERATORS, COLUMNS AND ION SOURCES	

THURSDAY, JUNE 2

Chairman: H. Grunder

8:30	PARTICLE DYNAMICS CALCULATIONS FOR SPACE-CHARGE-DOMINATED LINACS	J. Staples/R. Kustom
10:30	B R E A K	
11:00	DISCUSSION - ACCELERATING STRUCTURES (HARDWARE)	
12:15	LUNCH (Lower deck reserved at LBL Cafeteria.)	
1:30	APF STRUCTURES FOR HEAVY IONS	D. Swenson
2:00	WORKSHOP SESSIONS	

FRIDAY, JUNE 3

8:30	MEET IN ROOM 290	
8:45	TOUR OF SUPERHILAC	H. Grunder, et.al.
9:30	THIRD INJECTOR PLANS	J. Staples
10:00	WIDEROE LINACS AT GSI	D. Boehne
10:30	CONCLUSIONS - Reported by Chairmen of Workshops	

T. Khoe - Linac Structures

H. Lancaster - RF Power Supply Considerations

D. Clark - Ion Sources

LIST OF ATENDEES

Argonne National Laboratory

R. Burke
T. Khoe
R. Kustom
R. Martin

Brookhaven National Laboratory

P. Grand
J. Keane
A. Maschke

Fermi National Accelerator Laboratory

S. Ohnuma
D. Young

Gesellschaft für Schwerionenforschung (GSI)

D. Boehne

Los Alamos Scientific Laboratory

J. Stovall
D. Swenson

Lawrence Berkeley Laboratory

W. Chupp
D. Clark
A. Faltens
H. Grunder
K. Halbach
G. Kalnins
D. Keefe
G. Lambertson
H. Lancaster
L.J. Laslett
B. Leemann
E. Lofgren
R. Richter
F. Selph
L. Smith
J. Staples
R. Yourd
E. Zajec

Lawrence Livermore Laboratory

R. Bangerter
R. Briggs
V.K. Neil

6. HEAVY ION FUSION NOTES

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Number	Author	Title	Date
HI-FAN-1		Heavy-Ion Fusion: Proposal for Program at Lawrence Berkeley Laboratory Proposal #35	9/76
HI-FAN-2 (LBL-5388)	D. Keefe	Linear Induction Accelerator for Heavy Ions	10/76
HI-FAN-3 (LBL-5543)	Edited by R.O. Bangerter W.B. Herrmannsfeldt, D.L.Judd, L. Smith	ERDA Summer Study of Heavy Ions for Inertial Fusion	7/19/76
HI-FAN-4 (LBL-5552)	L. Smith, G. Lambertson, L.J. Laslett	Transport of Intense Ion Beams	3/16/77
HI-FAN-5 (BEV-3201)	D. Keefe	Linear Induction Accelerator to Produce Intense Short Pulses of Very High Ions	April 1976
HIFAN-6	J. Staples	High-intensity low-beta r.f. Accelerating Structures	3/77
HIFAN-7	D. Keefe	The Transport-Limited Current: Thin-lens Approximation to FODO Structure with Space Charge Effects	3/24/77
HI-FAN-8	D. Keefe	Influence of the Target Requirements on the Beam Parameters of the Igniter Heavy-Ion Accelerator	3/30/77
HI-FAN-9	L.J. Laslett	Summary of $F\bar{O}D\bar{O}$ Coefficients	4/11/77
HI-FAN-10 (LBL-6453)	A.Faltens, D. Keefe	Applications of Induction Linac Technology to Heavy Ion Fusion	7/77
HI-FAN-11	L.J. Laslett	The "Figure of Merit", $Q'/u_m 2/3$, for Beam Transport Through a Periodic Quadrupole Lens System	9/9/77
HI-FAN-12	D. Neuffer	Cs^+ Beam Transport Through A Periodic Quadrupole Lattice	9/1977
HI-FAN-13	L. Smith	Stability of the K-V Distribution in Long Periodic Transport Systems Part I - General Formulation	10/4/77
HI-FAN-14	S. Chattopadhyay	Stability of the K-V Distribution in Long Periodic Transport Systems Part II - Equations Used for Numerical Computation	10/17/77

HEAVY ION FUSION NOTES

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HI-FAN-15	L.J. Laslett I. Hoffman	Stability of the K-V Distribution in Long Periodic Transport Systems, Part III -- Computational Results	10/12/77
HI-FAN-16	C. Leeman	Investigation of Parameters for a Synchrotron-Based HIDE Concept	10/13/77
HI-FAN-17		Informal Quarterly Report on Heavy Ion Fusion Program April 1977 - June 1977	8/4/77
HI-FAN-18		Report on Heavy-Ion Fusion Program Fiscal Year 1977	9/30/77
HI-FAN-19	J. Staples	Notes on Low Beta Acceleration	10/77
HI-FAN-20	A. Faltens	The ERA Injector Electron Accelerator	Jan. 1970
HI-FAN-21	A. Faltens, D. Judd D. Keefe	Acceleration Systems for Heavy-Ion Beams for Inertial Confinement Fusion	Oct. 3, 1977

7. ILLUSTRATIONS

Figures 1 and 2: The set-up to test the cesium puff-valve and voltage gradient limits.

Figures 3 and 4: The former Astron-injector source box now being modified for the 500 kV pulsed cesium source.

Figures 5 and 6: Views of the 500 kV long-pulse Marx generator which utilizes components from the former ERA injector impulse Marx generators

Figure 7: Schematic of pulse-power, non-resonant accelerating gap: Tests with mixed iron and ferrite have been made.

Figure 8 and 9: Multi-aperture "conventional" Xenon source. There are 13 aperture holes each 2 mm in diameter.

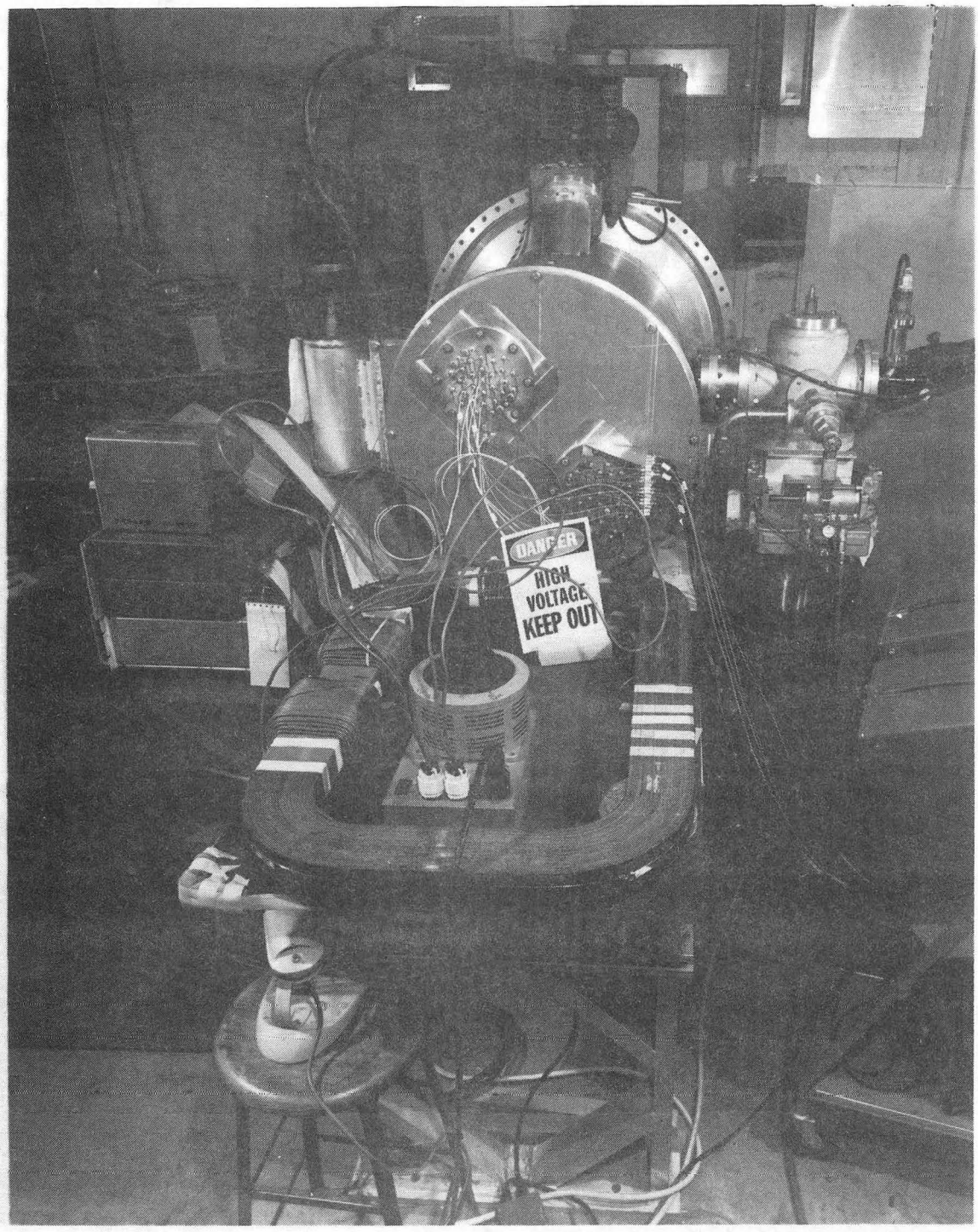

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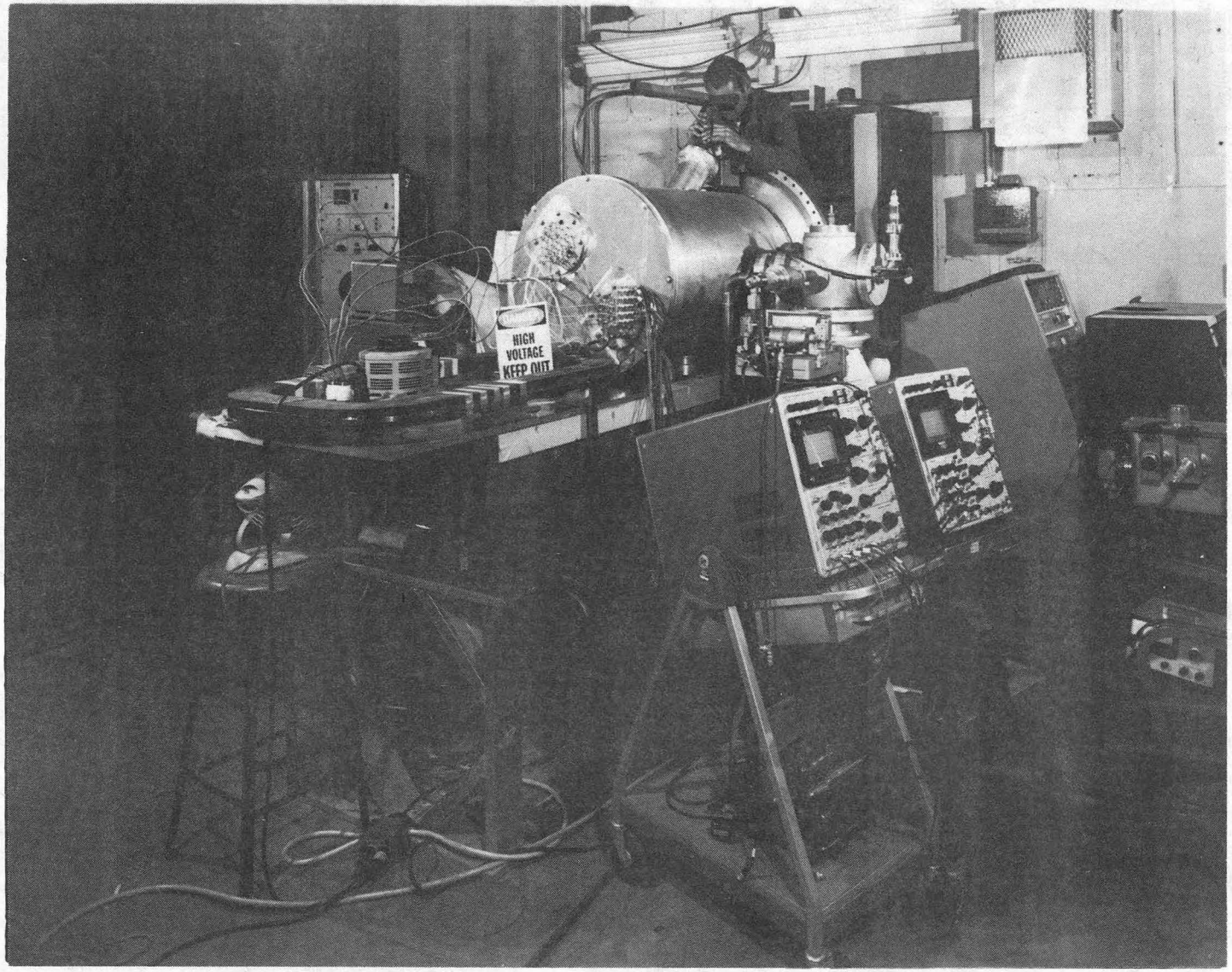
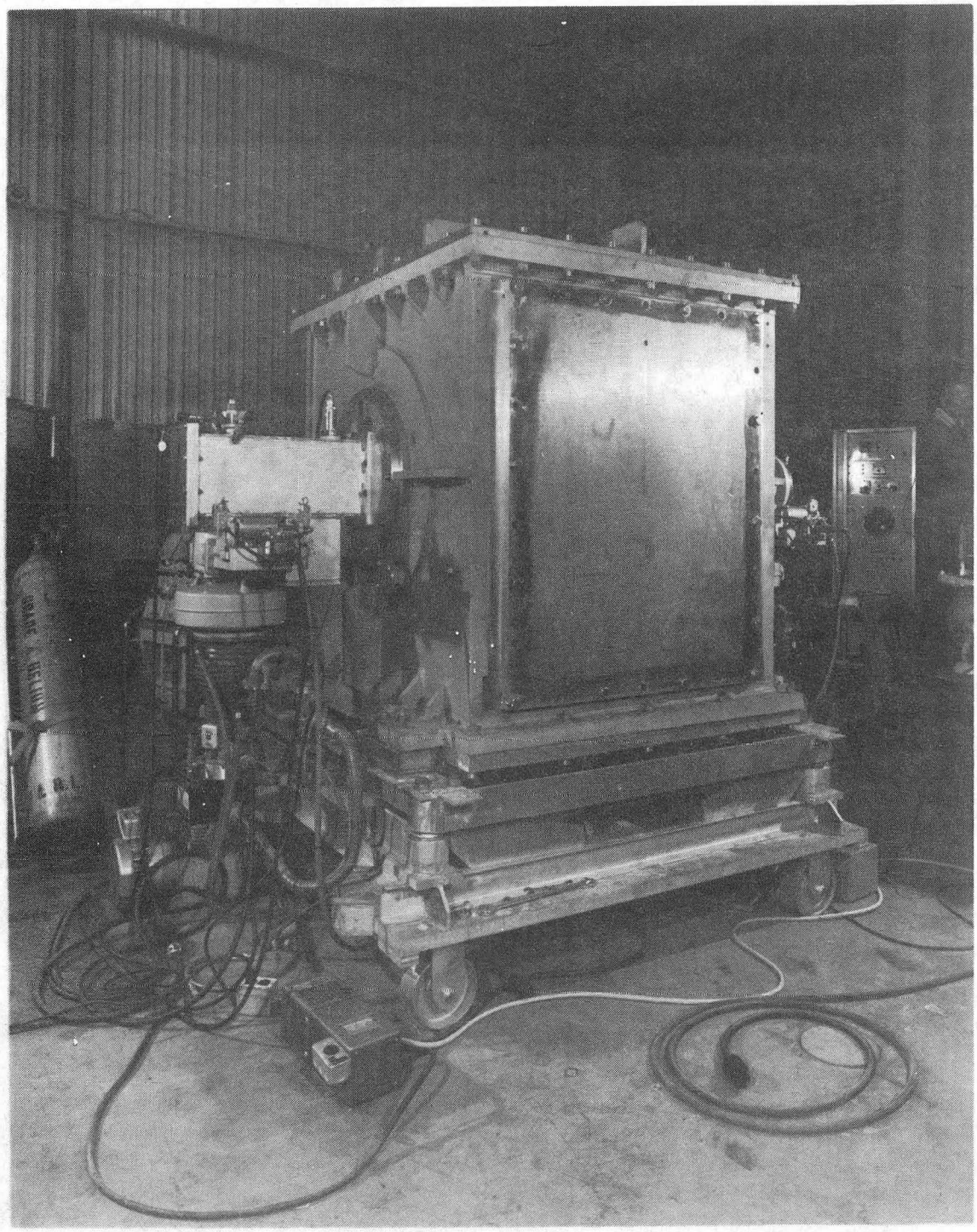
Figure 1



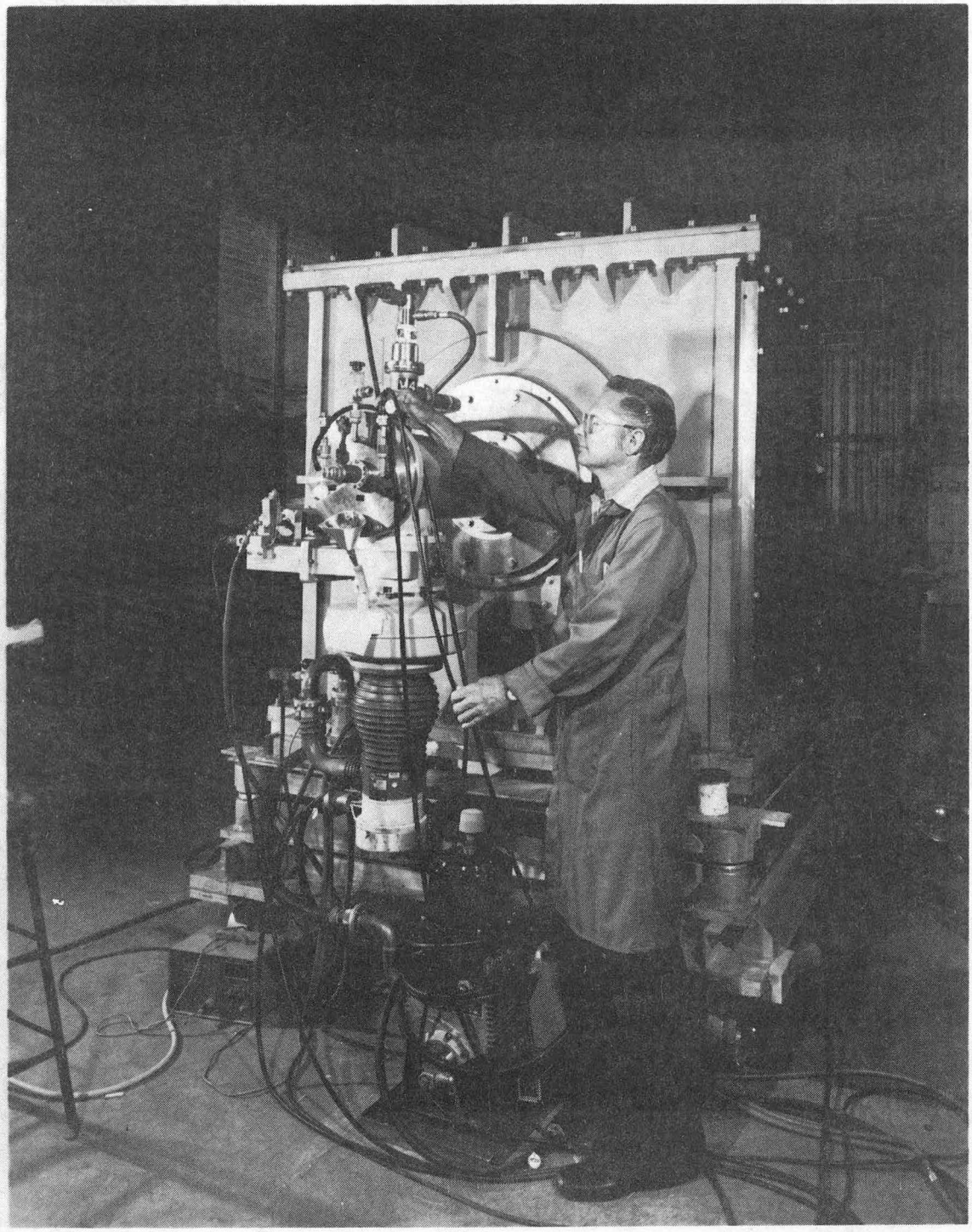
CBB 7710-9787

Figure 2



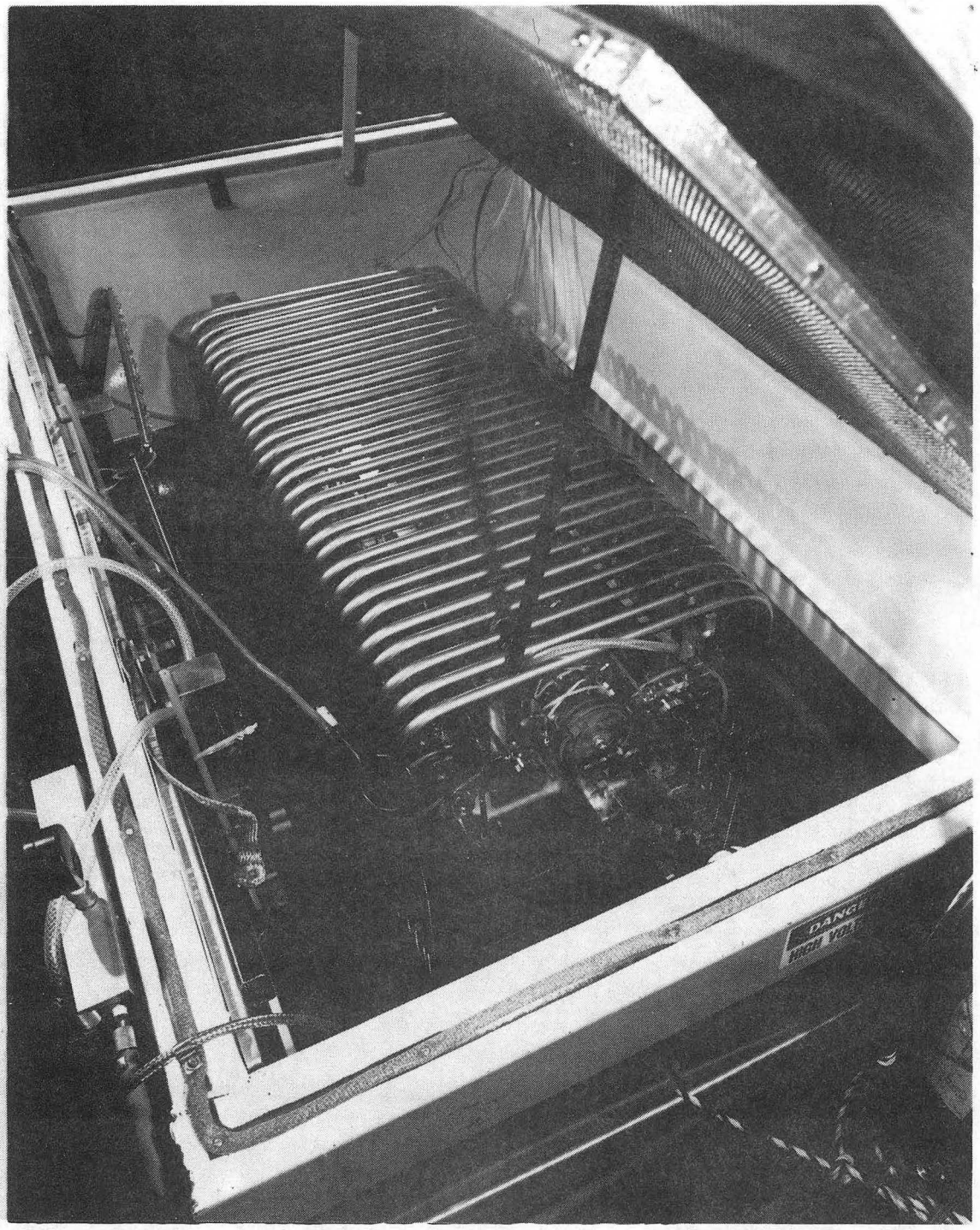
CBB 7710-9795

Figure 3



CBB 7710-9793

Figure 4



CBB 7710-9785

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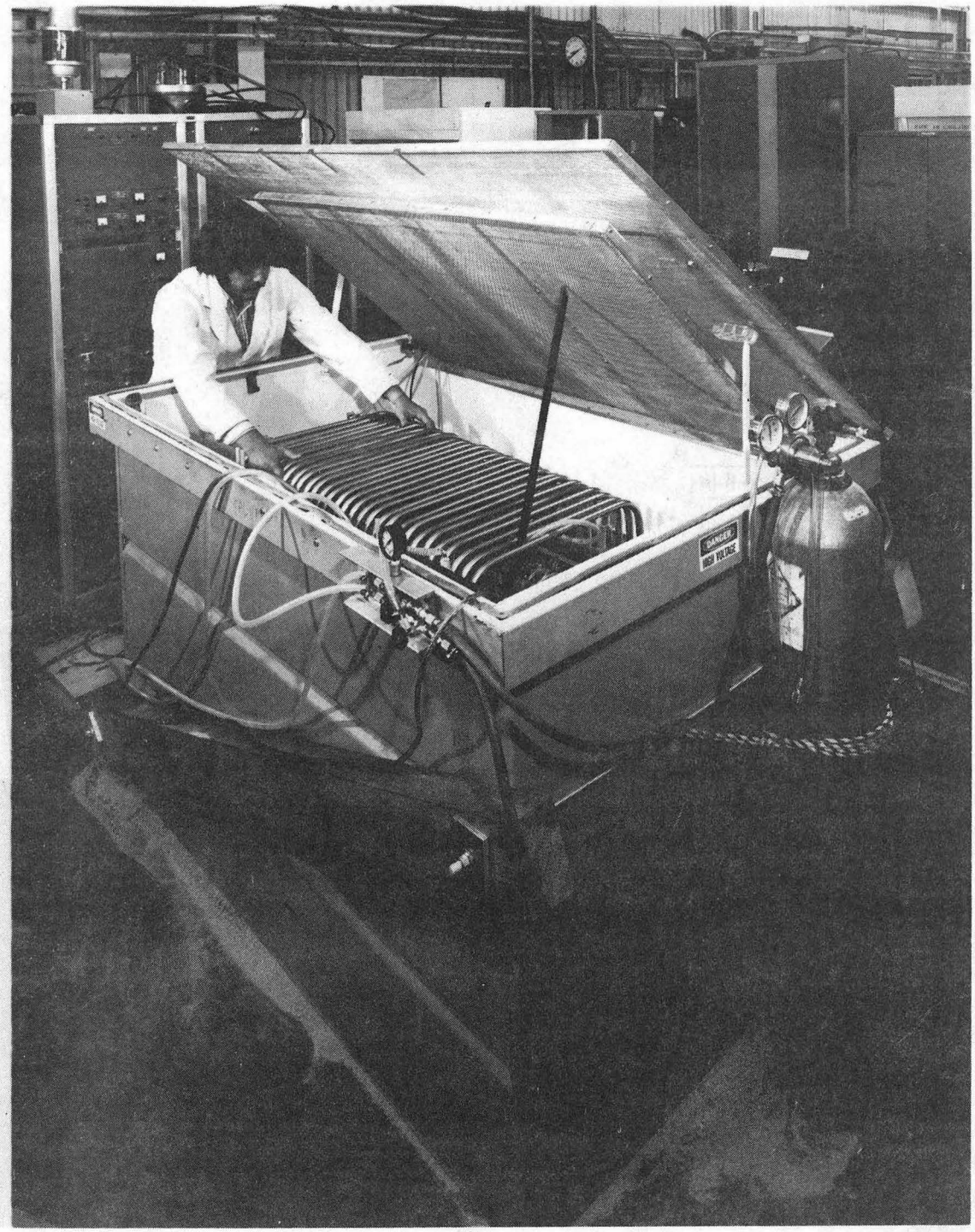


CBB 7710-9783

Figure 6

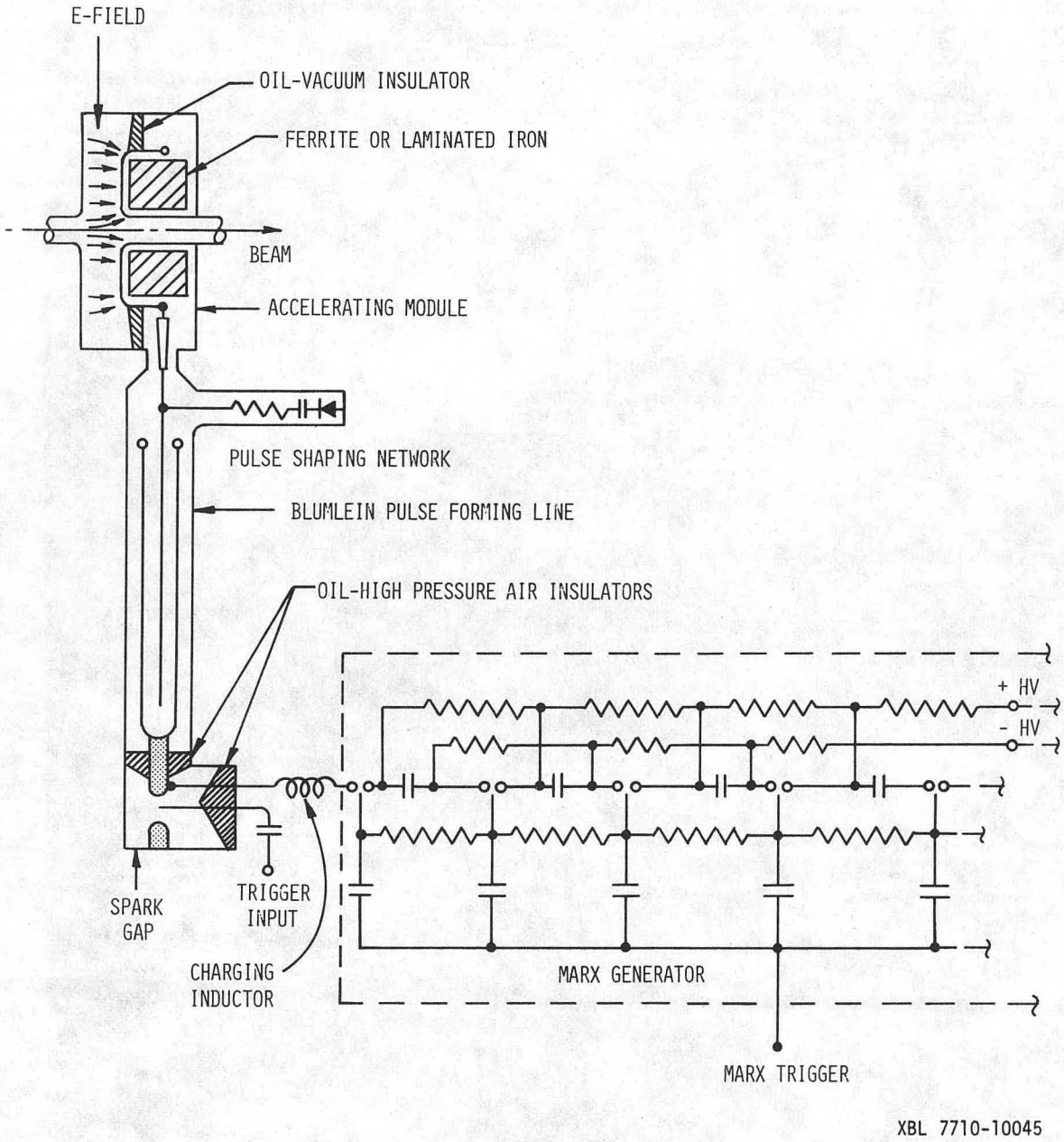
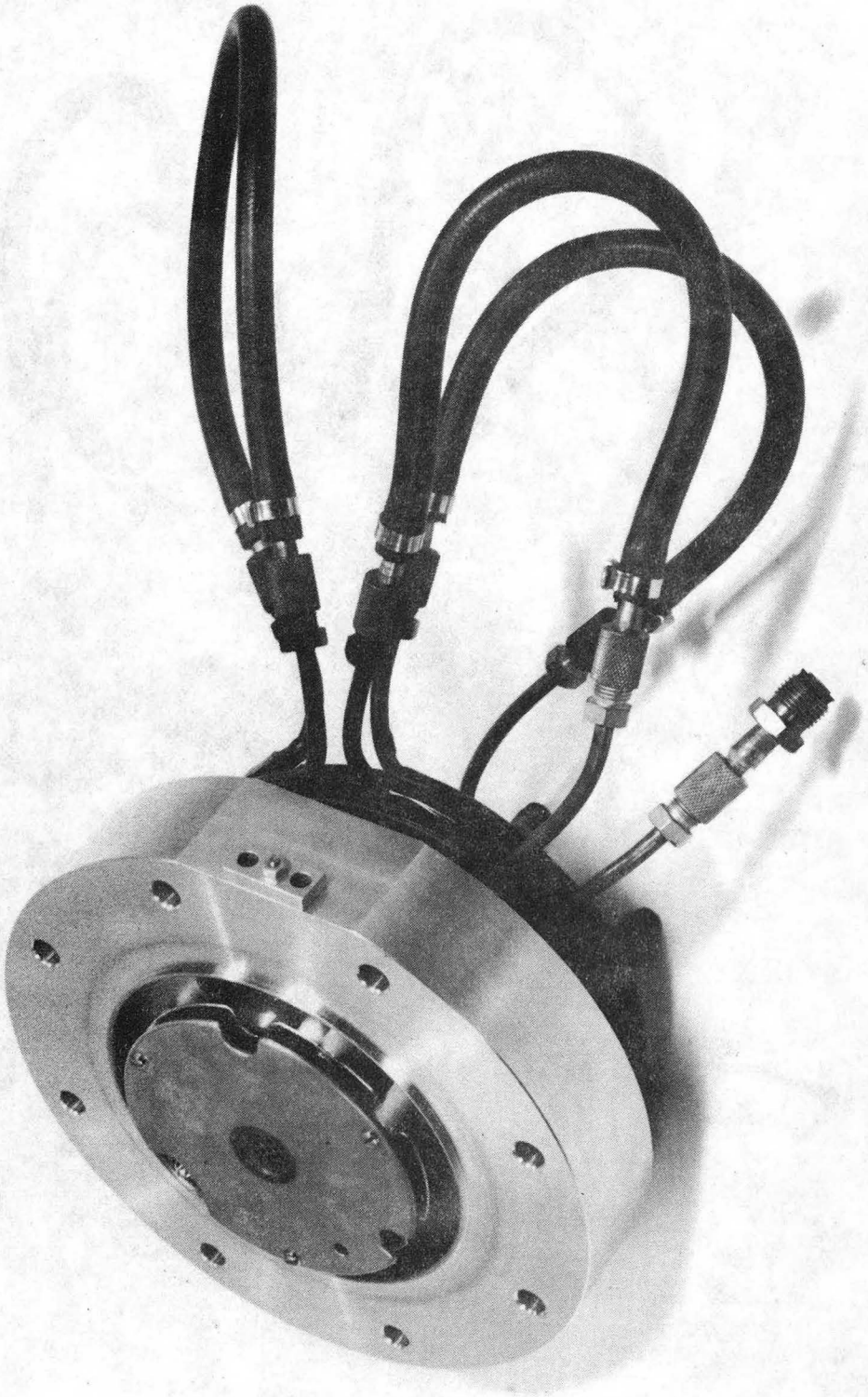

E-FIELD
OIL-VACUUM INSULATOR
FERRITE OR LAMINATED IRON
BEAM
ACCELERATING MODULE
PULSE SHAPING NETWORK
BLUMLEIN PULSE FORMING LINE
OIL-HIGH PRESSURE AIR INSULATORS
+ HV
- HV
SPARK GAP
TRIGGER INPUT
CHARGING INDUCTOR
MARX GENERATOR
MARX TRIGGER
XBL 7710-10045

Figure 7



CBB 770-10198

Figure 8

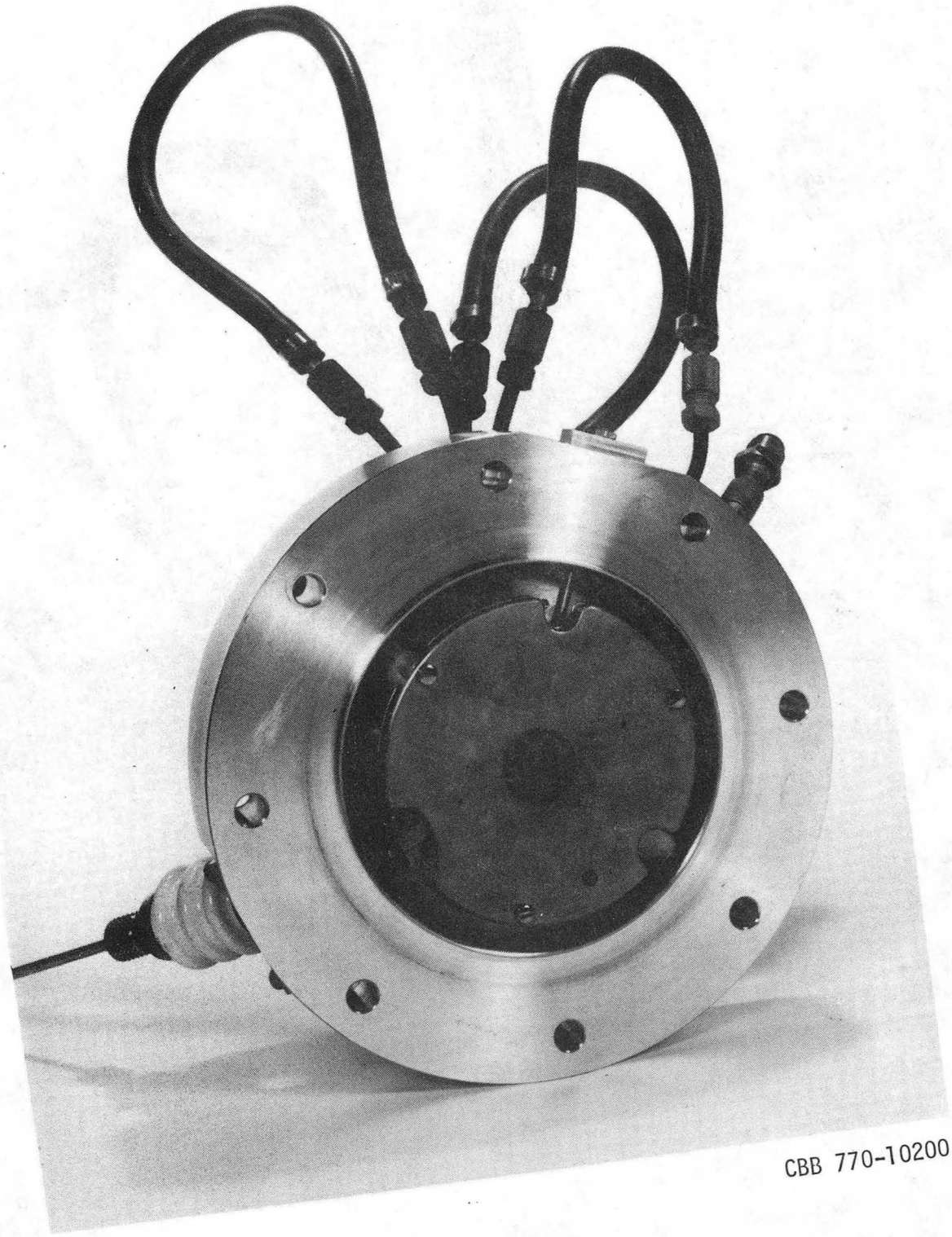


Figure 9

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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