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TWO-MILE ACCELERATOR PROJECT

1 January to 31 March 1971

Quarterly Status Report

STANFORD LINEAR ACCELERATOR CENTER
STANFORD UNIVERSITY
Stanford, California 94305

PREPARED FOR THE U. S. ATOMIC ENERGY COMMISSION
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ABSTRACT

A status report on the Stanford Linear Accelerator Project covering the period January 1, 1971 to March 31, 1971 is presented. Topics included are accelerator and research area operations, accelerator and research area equipment development, and physics research equipment development.

Previous reports in this series of Quarterly Status Reports:

SLAC-1,	1 April - 30 June 1962.
SLAC-8,	1 July - 30 September 1962.
SLAC-10,	1 October - 30 December 1962.
SLAC-16,	1 January - 31 March 1963.
SLAC-18,	1 April - 30 June 1963.
SLAC-23,	1 July - 30 September 1963.
SLAC-27,	1 October - 31 December 1963.
SLAC-30,	1 January - 31 March 1964.
SLAC-32,	1 April - 30 June 1964.
SLAC-34,	1 July - 30 September 1964.
SLAC-42,	1 October - 31 December 1964.
SLAC-45,	1 January - 31 March 1965.
SLAC-48,	1 April - 30 June 1965.
SLAC-53,	1 July - 30 September 1965.
SLAC-59,	1 October - 31 December 1965.
SLAC-65,	1 January - 31 March 1966.
SLAC-69,	1 April - 30 June 1969.
SLAC-71,	1 July - 30 September 1966.
SLAC-73,	1 October - 31 December 1966.
SLAC-80,	1 January - 30 June 1967.
SLAC-85,	1 July - 30 September 1967.
SLAC-87,	1 October - 31 December 1967.
SLAC-89,	1 January - 31 March 1968.
SLAC-90,	1 April - 30 June 1968.
SLAC-93,	1 July - 30 September 1968.
SLAC-98,	1 October - 31 December 1968.
SLAC-105,	1 January - 31 March 1969.
SLAC-110,	1 April - 30 June 1969.
SLAC-112,	1 July - 30 September 1969.
SLAC-116,	1 October - 31 December 1969.
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INTRODUCTION

This is the thirty-fifth Quarterly Status Report of work under AEC Contract AT(04-3)-400 and the twenty-ninth Quarterly Status Report of work under AEC Contract AT(04-3)-515, both held by Stanford University. The period covered by this report is from January 1, 1971 to March 31, 1971. Contract AT(04-3)-400 provides for the construction of the Stanford Linear Accelerator Center (SLAC), a laboratory that has as its chief instrument a two-mile-long electron accelerator. Construction of the Center began in July 1962. The principal beam parameters of the accelerator in its initial operating phase are a maximum beam energy of 20 GeV, and an average beam current of 30 microamperes (at 10% beam loading). The electron beam was first activated in May 1966. In August, 1970, a beam energy of 22.1 GeV was achieved. Beam currents up to 82 milliamperes peak (47 microamperes average) have been obtained.

The terms of Contract AT(04-3)-400 provide for a fully operable accelerator and for sufficient equipment to measure and control the principal parameters of the electron beam; in addition, provision is made for an initial complement of general-use research equipment with which it is possible to perform certain exploratory studies, such as measurement of the intensity and energy distribution of various secondary-particle beams.

Contract AT(04-3)-515, which went into effect January 1, 1964, provided support for the various activities at SLAC that were necessary in order to prepare for the research program which is being carried out with the two-mile accelerator, and also provides for the continuing operation of the Center after completion of construction. Among the principal activities covered in the scope of Contract AT(04-3)-515 are theoretical physics studies, experiments performed by the SLAC staff at other accelerators, research-equipment development programs (such as particle separators, specialized magnets, bubble chambers, etc.), and research into advanced accelerator technology.

I. ACCELERATOR OPERATIONS

A. Operating Hours

Manned Hours	January	February	March	Quarter
Physics Beam Hours(1)				
Machine Physics	43	---	40	83
Particle Physics	328	---	330	658
Total Physics Beam Hours	371	---	370	741
Nonphysics Hours				
Scheduled Downtime (Maintenance, Startup)	29	---	16	45
Unscheduled Downtime (Equipment Failure, Tuneup, etc.)	40	---	93	133
Total Nonphysics Hours	69	---	109	178
TOTAL MANNED HOURS	440	---	479	919

B. Experimental Hours(2)

1. Particle Physics

(3) Beam Line	Sched. Hrs. Electronic Experiments (a)	Electronic Experimental Hrs.		% $\left(\frac{b}{a}\right)$	Actual Bubble Chamber Hours	Test and Checkout Hours		Total Experimental Hours	
		Actual Hours (b)	(4) Charged Hours			Act. Hrs.	Chg. Hrs.	Actual Hours	Charged Hours
A	726	505	738	69.6	---	38	38	543	776
B_N	---	---	---	---	---	177	177	177	177
B_C	---	---	---	---	81	221	221	302	302
B_S	---	---	---	---	---	355	355	355	355
C	22	18	24	81.8	---	333	271	351	295
Total	748	523	762	69.9	81	1,124	1,062	1,728	1,905
2. Machine Physics								91	91
TOTAL EXPERIMENTAL HOURS								1,819	1,996

(1) Number of hours accelerator is run with one or more beams excluding accelerator beam tuneup and other nonphysics beam time.

(2) Number of hours an experiment is run including actual beam hours and beam downtime "normal to the experiment."

(3) Refer to Fig. 1 for beam line location.

(4) Charged hours are represented by the formula $T_c = T_0\left(\frac{R+20}{200}\right)$ where T_c = charged hours, T_0 = total hours beam was available to the experimenter for both checkout and data taking, and R = the average pulse repetition rate. Maximum for $\left(\frac{R+20}{200}\right)$ is 1.5 even if the calculated amount exceeds this value.

C. Overall Experimental Program Status

1. Electronic Experiments

Approved research hours at beginning of quarter	3,516
Hours charged during the quarter	762
New hours approved during the quarter	738
Approved hours remaining at end of quarter	3,492

2. Bubble Chamber Experiments

	40" BC	82" BC
Approved pictures at beginning of quarter	1,750 K	3,153 K
Pictures taken during the quarter	174 K	---
New pictures approved during the quarter	174 K	2,850 K
Approved pictures remaining at end of quarter	1,750 K	6,003 K

D. Beam Intensity	January	February	March	Quarter
Peak	82 mA	---	50 mA	82 mA
Average	2.6 μA	---	4.5 μA	3.6 μA
E. Klystron Experience				
Total Klystron Hours	107,257	---	112,214	219,471
Number of Klystron Failures	4	---	7	11
F. Data Analysis				
Spark Chamber Events Measured	14,911	14,463	20,829	50,303
Bubble Chamber Events Measured	23,993	25,064	20,256	69,313
G. Computer Operations				
Manned Hours				
Computation Hours				
SLAC Facility Group	91	75	89	255
Users Groups	432	416	510	1,358
Total Computation Hours	523	491	599	1,613
Noncomputation Hours				
Scheduled Maintenance	108	103	122	333
Scheduled Modifications	10	---	---	10
Unscheduled Downtime and Reruns	15	13	9	37
Idle Time	---	3	4	7
Utility Failure	---	---	1	1
Total Noncomputation Hours	133	119	136	388
TOTAL MANNED HOURS	656	610	735	2,001

H. Special Operating Features

1. Beam Knockout

The beam knockout was run for a total of 527 hours with various experiments during the quarter.

2. Power Supplies

The 3.4 MW power supply was run for 26 hours with the 82" bubble chamber, for 240 hours with the analyzer magnet in beam line 14 and for 12 hours of magnet testing, a total of 278 hours.

The 5.0 MW power supply was run for 181 hours with the 40" bubble chamber, for 3 hours of testing with the 54" spark chamber and for 13 hours of testing with the 2 meter spark chamber, a total of 197 hours.

The 5.8 MW power supply was run for 456 hours with the spectrometer magnets and for 16 hours of testing with the 2 meter spark chamber, a total of 472 hours.

The motor generator facility was run for 375 hours with the 40" bubble chamber and for 7 hours with the analyzer magnet in beam line 14, a total of 382 hours.

3. Record Power and Current Attained

In January new records of 880 kW average beam power and peak current of 82 mA were attained.

II. EXPERIMENTAL ACTIVITY

Figure 1 is a research area plan drawing showing the location of the various experiments. Table 1 is a list of presently approved high energy physics experiments.* The right-hand column of Table 1 gives the status and activity of each experiment during the period. Figure 2 is a tentative long-range schedule.

The prime users of the accelerator during the period were:

E-43 — Velocity of Light

E-61 — Forward Angle Electron Scattering

E-68 — Inclusive Pion-Proton Scattering

E-71 — Vector Meson Electroproduction at High Energy

BC-10 — Study of $K_L^0 p$ Interactions

BC-25 — Study of Pomeranchon, Meson and Baryon Exchanges

IC-1 — Test of the Design Concept for a High Energy Gamma Ray or Electron Detector

IC-2 — Test of UVT Lucite Counter

D-16 — Test of Large NaI (Tl) Detectors

D-20 — Large Angle Electron Scattering

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T-15 — Lead Plate Proportional Quantameter Test

T-20 — Test of Lead Scintillator Shower Counter

T-22 — Calibration of Large Cosmic Ray Detector

T-34 — Shower Counter Test

T-35 — High Density Test Exposure of Nuclear Emulsions

T-65 — Tests of Shower Counter for E-65

Y-8 — Tests of Simulated Protection Collimators

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* E-Approved counter experiments
CE-Checkout of equipment associated with counter experiments
BC-Approved bubble chamber experiments
P-Accelerator physics
R-Research area runs
N-Parasite runs
T-General research equipment tests
D-Special short particle physics runs
Y-Beam switchyard tests
S-Survey (usually Health Physics) runs

A. Status of Running Experiments

E-43 — Velocity of Light - G. Masek (UC San Diego)

This experiment took about 12 hours of data on the velocity of gamma rays experiment in January and 10 in March. The previous runs have had limitations in accuracy which were apparent only as discrepancies between two photomultipliers. The March run explored these difficulties by selecting various energy photons and by exploring the effects of optical delays inserted in the beam path. Machine operation was extremely stable during this data taking run. (B. Brown)

E-61 — Forward Angle Electron Scattering - R. E. Taylor (SLAC)

During the March cycle we completed the program begun in the December cycle of inelastic electron scattering from hydrogen and deuterium at a scattering angle of 4° using the 20 GeV spectrometer. Altogether we have data at seven incident energies from 20 GeV down to 4.5 GeV. Each spectrum extends from above the elastic peak down to a secondary momentum of about 2.5 GeV/c. At some points, targets of Be, Cu and Au were also used.

The proportional wire chambers continued to work well. No trouble was experienced with the liquid targets, and the dependence of effective density on incident beam intensity was found to be small, as expected. Operation in the "scan mode", in which the computer automatically steps the momentum down the spectrum in small increments, worked well and significantly increased the amount of time available for data taking. (H. DeStaebler)

E-68 — Inclusive Pion-Proton Scattering - J. Rothberg (U. of Washington)

In January, tests of a prototype multiwire proportional chamber to be used in the experiment were made with pions in the C-beam, augmenting earlier tests made with a radiation source. Indications are that the chamber performed well with instantaneous rates of the order 10^{6} pions/sec. A procedure to shape and to limit the sensitive area of the chamber (to avoid high background rates) was initiated. A separate task was to measure time resolution of a counter which will become part of the time-of-flight system in E-68. Resolution of 1.5 nsec was measured; it is hoped that this time resolution can be improved to ~0.5 nsec. (R. Gearhart)

In March a short initial test was made of the first part of beam line 20. The beam was tuned without difficulty for 12 GeV/c positive particles. The flux at the second focus (located 208 ft from the production target) was measured to be

24 particles per pulse per mA. The production target was one radiation length of beryllium, primary electron energy was 19 GeV, and the momentum acceptance of the secondary beam was ±2%. Further tests of the beam with one of its two rf separators in operation are planned for the next running period.

Installation of major experimental equipment continued through March. The newly completed 70D43 magnet was installed and aligned and the spark chambers and hodoscopes were positioned. Control instrumentation for the Cerenkov counter was completed and tested. Two spark chambers with the necessary HV supplies, triggers and spark gaps were also tested. (F. Winkelmann/H. Romer)

E-71 — Vector Meson Electroproduction at High Energy - C. L. Jordan (SLAC)

During the January cycle, Group A seriously tested the possibility of doing missing mass experiments with the 20 and 1.6 GeV spectrometers detecting the electron and the proton in coincidence. For calibration, we measured elastic e-p scattering and $ep \rightarrow ep\gamma$. The online timing jitter was 2 nsec max. We observed enhancements in the missing mass spectra at the rho mass at several values of q^2 and t. Other measurements not covering the rho mass completely were taken to determine the t dependence of the reaction. At $q^2 = .1\,(\mathrm{GeV/c})^2$, the results were similar to what is observed in the photoproduction of the rho-meson, as would be expected. The size of the signal indicates the feasibility of making significant measurements at high values of q^2 and other missing mass values. (C. L. Jordan)

BC-10 — Investigation of K_2^o Interactions with the 40-Inch HBC - D. Leith (SLAC)

During the January cycle BC-10 took 140 K pictures of K_{2p}^o interactions in the 40-inch HBC. These pictures replace those lost during the December cycle because of bad developing. They were taken (like those of the December cycle) using the scintillation counter hodoscope surrounding the chamber body to detect particles emanating from interactions in the hydrogen, thereby allowing measurement of the flight time of the incident K_2^o. For each picture this counter information was logged onto magnetic tape. All pictures were taken with the chamber pulsing at 2 pps and about 45 K were taken with the HBC flash triggered only when a K_{2p}^o interaction with incident K_2^o momentum less than 2 GeV/c was detected. The pictures were developed at the SLAC Photo Lab facility under carefully monitored conditions to guarantee suitable quality for semiautomatic measurement on the Spiral Reader. (W. B. Johnson)

BC-25 — Study of Pomeranchon, Meson and Baryon Exchanges by Triggering the SLAC 40-Inch Bubble Chamber on Fast Forward Particles - C. Peck (Cal Tech)

The purpose of this experiment is to make a high-statistics investigation of nucleon diffraction dissociation. The SLAC 40-inch hydrogen bubble chamber will be used to detect events of the reaction $\pi^{\pm}p \rightarrow \pi^{\pm}N^*$. For small pion scattering angles, the outgoing pion will pass through the bubble chamber exit window to be analyzed in a spectrometer consisting of wire chambers and a large aperture magnet (40D48). The track will be reconstructed by an online Sigma-2 computer during the 2 - 3 millisecond bubble-growth delay. The picture will be taken only if a nonelastic pion is observed within the solid angle acceptance of the spectrometer. With a 300-K picture exposure we expect a sensitivity of $\sim$ 50 - 100 events per microbarn. During January the new charged particle beam to the 40-inch bubble chamber was constructed, and the wire chamber spectrometer was set up. Beam was available for about four shifts during which a rough initial tuning of the secondary beam was made. Large uncollimated particle backgrounds were observed in the wire chambers, indicating the need for more shielding of the upstream portion of the secondary beam line and/or of the apparatus.

The March running was used to check out the operation of the beam and the spectrometer. About 9000 bubble chamber pictures were taken under various running conditions, for which spark chamber data were simultaneously logged so that results from the two detectors can be correlated. Considerable time was spent in attempts to reduce the large backgrounds from the upstream part of the beam, which remained unacceptably high despite a substantial improvement since the January run. As a result of these studies, plans were made to construct a local shield at the apparatus and also additional shielding revisions are planned for the beam line shielding inside end station B. It is hoped that this will reduce the background by the needed factor of about four. (W. Ford)

IC-1 — Test of the Design Concepts for a High Energy Gamma Ray or Electron Detector - A. V. Tollestrup/R. L. Walker (Cal Tech)

For an experiment proposed for NAL, it is desired to construct a detector capable of measuring the energy and position of γ rays from π^0 or η decay. A design using Cerenkov finger counters sampling longitudinal plane slices of showers by the γ rays in lead plates has been tested in electron induced showers

at SLAC. The detector was full scale in the direction of the beam but contained only two x-coordinate finger counters. The beam was collimated to a width of 2 or 3 mm and beam energies of 4.5, 9 and 15 GeV were used.

Pulse height distributions from one finger counter were measured as a function of the x-coordinate of counter relative to the beam. The showers at all energies were remarkably narrow, the width dominated by the 1 cm width of the counters. Indications are that spatial accuracy measurements can be made to ±1 mm when using the full system. Energy resolutions can be measured with an accuracy of 7% or better at 9 GeV. It is hoped that this can be improved.
(R. Gearhart)

IC-2 — Test of UVT-Lucite Counter - R. Budnitz (LRL, Berkeley)

The purpose of the short parasitic run was to test the performance of a UVT-Lucite counter (dimensions 72" × 18" with an RCA 8575 photomultiplier on one end) when placed in a beam of relativistic electrons. The test was run in the C-beam just upstream of the 82" bubble chamber. Secondary beam intensity was about 1 electron/pulse at a rate of 10 pps. Total running time was ~10 hours.

The setup was to trigger on a double-coincidence of counters (for beam definition) and then to take oscilloscope photographs of the anode pulses from the lucite counter, as a function of position and angle at which the beam traversed the counter. All of the electronics used was transported from LRL, and supplemented by the beam monitoring systems in place.

The result of the study was that we measured the attenuation of light for normally-incident particles to be about 8% per foot in our geometry. Also, measurements were made of the relative light output at nonnormal incidence, and at $\sim 45^{\circ}$, the light was somewhat more (perhaps double) than at normal incidence.
(R. Budnitz)

D-16 — Tests of Large NaI(Tl) Detectors - B. Hughes (HEPL)

In the January cycle we made measurements of the energy loss distributions in the large NaI(Tl) detector of π^+, π^-, K^+, K^-, p, and $\bar{p}$. All the measurements were made at momenta larger than or equal to 9 GeV/c. The detector was 24" in length and 16" in diameter and was insufficient in volume to completely contain the energy of an incident particle. On the average, about 50% of the available energy appeared in the detector. Distinct differences were observed between the pulse height distributions produced by the different particle types, ranging from the relatively broad distributions produced by K^+ and K^- to the relatively sharp

distribution produced by $\bar{p}$. These differences reflect both the different absorption cross sections of the various particles and the characteristic differences in the interactions that these particles undergo in the early states of the total absorption cascade. The effect of increasing the detector length to 31" was also studied for p and $\bar{p}$. These data are relevant to attempts to develop a reliable theoretical description of the total absorption cascade in matter at high energies, and to help to determine the correct dimensions for total absorption scintillation spectrometers for hadrons at these energies.

In a separate investigation we obtained a selection of image intensifier photographs of 15 GeV electron showers in NaI(Tl). The high density of energy deposition makes it relatively easy to photograph the complete profile of the shower. From such pictures it is possible to identify incident electrons, or gamma rays, and to measure their directions. Simultaneously it is also possible to measure the electron or gamma ray energy, either from the photographs or by using photomultiplier tubes coupled to the same crystal. (B. Hughes)

D-20 — Large Angle Electron Scattering - E. Bloom, R. Taylor (SLAC)

Two short runs were performed after completion of E-61 at the end of the March cycle. Although initially these runs were expected to provide data which would supplement the E-49a experiment, circumstances made the runs rather short, and in retrospect the runs were little more than test runs which will be useful in formulating future proposals. The aims of the runs were: 1) to provide data with improved statistical accuracy in the resonance region at high q^2, which is of current interest to studies of duality in electroproduction, and 2) to measure deuterium-hydrogen ratios for inelastic scattering at low values of ω, as a check on recent theoretical speculations that the H_2-D_2 difference observed in E-49a originates from the nuclear physics of the deuteron. While both runs were satisfactory, the data rates are such that not much information was obtained.

NT-3 — Rapid Cycling Bubble Chamber Tests - A. Rogers (SLAC)

Tests of a chamber expanded by means of a standing sound wave of 105 Hertz (termed sonic as distinct from the ultrasonic technique) was tested in beam line 12 using a few positrons per pulse. The chamber was designed and constructed during November and December and consisted of a length of thick walled stainless steel pipe (4 feet long and 2-1/2 inches in diameter) firmly mounted on a commercial shake table. By exciting the chamber axially, it is possible to achieve waves of peak-peak pressures of 600 psi in liquid freon.

The tests were successful in getting track sensitivity over the entire range of conventional freon bubble chamber operation. Some "firsts" that can be reported:

a) First track sensitivity produced by sonic excitation.

b) First operation of a bubble chamber with neither valves nor expansion mechanism in contact with the sensitive liquid.

c) First rapid cycling technique to prove applicable in heavy liquids.

(R. Gearhart)

T-12 — Wire Chamber Spectrometer Checkout - S. Wojcicki (SLAC)

The wire chamber spectrometer system, consisting of the 100D40 magnet, twenty wire chamber planes and associated scintillation counters for triggering, will be used initially for Experiments E-64 ($K_{\mu 3}$ charge asymmetry and Dalitz plot) and E-55 ($K_L \rightarrow \pi^+\pi^-\pi^0$ Dalitz plot). Installation and timing of all scintillation counters has been completed in January. In addition, the interface to the PDP-9 to read in counter and wire chamber data was constructed and tested. Four wire chamber planes and their associated capacitor-diode readout electronics were also operated. With this system, background was investigated and several changes in shielding for beam line 8 were made.

The K^0 spectrometer system was assembled in its entirety for the first time just before the start of the March cycle. During the March cycle beam was taken at a low rep rate (10-30 pps) to test out the whole system and find optimum operating conditions. Several minor problems were found and corrected. Two days of the cycle were spent running with copper regenerator in the beam to determine the resolution of the system. At the end of the cycle, a day was spent running at high rep rate (180 pps) to detect any possible difficulties associated with higher rates. The data taken is being analyzed at the present time and it is expected that the physics experiments will start at the beginning of the April cycle.

(D. Hitlin and S. Wojcicki)

T-15 — Lead Plate Proportional Quantameter Test - D. Yount (U. of Hawaii)

Six multiwire proportional chambers were tested in electron induced showers. Tentative comparisons of the timing signals from the delay lines of adjacent planes indicate that a single chamber can locate a shower core to better than 5 mm.

The six chambers were tested in different configurations, a typical one spacing the planes one radiation length apart and starting three radiation lengths into the shower. This particular arrangement gave an energy resolution of

$(dE/E)_{RMS} = 0.10$ with showers induced by 9 GeV electrons. This extrapolates to $(dE/E)_{RMS} = 0.19/\sqrt{E(GeV)}$ for 16 wire planes. The hope is to ultimately obtain a resolution improved by about 25%. (R. Gearhart)

T-20 — Test of Lead Scintillator Shower Counter - A. Tollestrup, R. Walker (Cal Tech)

Additional measurements relevant to the design of a high energy gamma ray detector were carried out in beam line 6 (end station C).

The problem of light attenuation was studied and although UVT lucite was better in this regard than Pilot 425 plastic, statistical fluctuations in the pulse heights from lucite were considerably worse. Therefore, a choice of Pilot 425 has been made. Also, further checks of the position determining capabilities were made with satisfactory results. (R. Gearhart)

T-22 — Calibration of a Large Cosmic Ray Detector - W. R. Weber (U. of New Hampshire)

A large balloon-borne cosmic ray detector was calibrated at SLAC during the March 1971 cycle. The calibration was done near the second focus of beam line 6 in the C-beam area. Electrons at a rate of less than one pulse and with energies of from 0.5 to 15 GeV were used. Also, pions at 9.1 and 15 GeV/c and protons and antiprotons at 9.1 GeV/c were used. A low level ambient muon flux (generated in the electron dumps) was used as a source of minimum ionizing particles. The detector consists of a scintillator telescope containing a gas Cerenkov counter, a lead glass spectrometer and a penetration scintillator. Around the telescope there is a cylindrically shaped guard scintillator. Pulse height analysis is made on coincidence counts on all elements except the Cerenkov counter. Initial data reduction was performed on the SLAC IBM 360-91 computer, enabling preliminary checks of the data to be made. Final reduction of the data is now being done. It appears that the primary goal, to calibrate the lead glass spectrometer, was successfully accomplished in the energy interval of 1 to 15 GeV. There did seem to be some bothersome backgrounds which are now being analyzed. The background specifically complicates measurement of the tagging efficiency for electrons. (J. Rockstroh and R. Gearhart)

T-34 — Shower Counter Test - S. Aronson (U. of Chicago)

About one shift of beam time was used in beam 6 (end station C) to test a lead-plastic Cerenkov shower counter. The counter was constructed of 16 sheets of 1/4 in. lucite (8" × 23') interlined with 1/4 in. lead sheets. The light was

collected and viewed by a 5 in. photo tube. Two types of light collection were tested: 1) bent light pipe, and 2) air light pipe. The former gave a good e-π separation at 15 GeV/c, while the latter had half the signal output and was considered unsatisfactory. (D. Fryberger)

T-35 — High Density Test Exposure of Nuclear Emulsions - J. Lord (U. of Washington)

High density electron exposures of emulsion plates were made to provide a calibration for a densitometer in order to obtain energy estimates of approximately 1000 GeV gamma rays. Energies of gamma ray initiated showers can be determined by counting electrons at certain locations in the shower and applying the shower theory of Kamata and Nishimura. However, since the energies we wish to estimate are high and consequently electron densities great, photometric methods must be used. Therefore, calibration by use of an electron beam of known flux is extremely valuable. Exposures were made to electrons of 5×10^4 to 10^7 particles per square centimeter at 9 GeV and photometric measurements are being carried out on the plates. The exposures were made in beam line 6 (end station C) and completed in about three hours of beam time. (R. Gearhart)

T-65 — Tests of Shower Counter for E-65 - W. Toner (SLAC)

During this cycle, the attenuated electron beam was again stopped in a quantameter in end station B. The modifications carried out after the end of the December run achieved their purpose, and the attenuation scheme reached its design value of a factor of 10^5. Operation was easy to control and very stable. A large background source in the end station was identified and shielded. Further sources in the B target room were identified. Background muons penetrating the shielding were used to help commission most of the scintillation counters and electronics and one of the two large optical spark chambers to be used in E-65. Multitrack efficiency appears to be very good, and 2000 pictures were taken in order to test the automatic film measuring equipment and programs. (W. Toner)

Y-8 — Test of Simulated Protection Collimators - E. Seppi (SLAC)

Two experiments were carried out on January 22 and 31 in the central beam of the beam switchyard. They are part of the ongoing thorough investigation of the personnel and equipment protection systems. The results should help the radiation safety committee in their decisions on operation of existing and new beam lines.

The purpose was to test destructively and examine a series of simulated protection collimators, beam stoppers, and emergency beam shutoff devices. All targets were uncooled and tested in air. Specific attention was given to the measurement burnthrough times, temperatures, and modes of failure.

Six targets were tested at an average incident beam power of 360 kW; another 6 targets were tested at 500 kW; and one target, beam stopper ST-60, was tested in a real life situation at 880 kW. Burnthrough times varied from a low of approximately 0.5 seconds for a 20 radiation-lengths-long pure tungsten target to a high of 49 seconds in the case of a 50 radiation-lengths-long OFHC copper beam stopper. Various beam shutoff devices responded within times varying from 0.2 to 10.5 seconds. A more detailed report is under preparation and will be issued later. (D. Walz)

B. New Experiments

A meeting of the Program Advisory Committee was held on February 5-6, 1971. The following new experiments and supplementary run requests were approved: E-56a (Supplement) Search for Short-Lived Sources of Neutrino-Like Particles - M. Schwartz; BC-6 (Supplement) Study of the One Pion Exchange Contribution to γ-Nucleon Scattering (in 82-inch Deuterium Bubble Chamber) - W. M. Bugg; BC-11 (Supplement) Resonance Production with Polarized Photons from the Laser Beam - I. O. Skillicorn; BC-35 (Supplement) γ-d Interactions at 3.5 and 5.5 GeV with Polarized Photon Beam - R. W. Birge - R. T. Poe; BC-45, ω-ρ Interference and A_2 Splitting Study with π^+p at 3.8 GeV/c - G. Goldhaber; BC-47, Resonance Formation with Polarized Photons from the Laser Beam- A. H. Rosenfeld.

The next scheduled meeting of the SLAC Program Advisory Committee will be held on May 7 and 8, 1971. The next meeting after that will be in August, 1971.

Summaries of Newly Approved Experiments

E-56A (Supplement) — Search for Short-Lived Sources of Neutrino-Like Particles - M. Schwartz (SLAC)

Experiment 56 was designed to search for new sources of highly penetrating neutral radiation. Among the possibilities which were considered in the original proposal and in subsequent discussion were:

a) Short-lived neutrino sources such as heavy leptons and intermediate bosons.

b) Neutral, neutrino-like objects having magnetic moments.

c) Photon-like particles coupled to conserved quantum numbers like strangeness.

The experiment is carried out by allowing the full beam to enter the beam dump and looking downstream after about 200 feet of earth shielding. A hole 35 feet deep was excavated behind the hill of the beam dump and 20 tons of spark chamber with trigger counters were placed therein.

In the course of the high energy running, particularly at 18 and 19 GeV, a number of events were observed which are quite hard to explain in terms of the expected neutrino background. Calculations indicate that about one neutrino interaction should be observed per coulomb with a typical neutrino energy of the order of 1 GeV. This rate is observed; in addition unusual events appear which seem offhand to fall into two categories: 1. High multiplicity stars with a large mesonic component. The multiplicity would indicate that one must have at least four or five GeV neutrinos to make these and even for such neutrinos they would be highly anomalous. We have a total of six such stars. 2. Events having no visible muon. There are two clear cases of this at 18-19 GeV and one uncertain case at 17 GeV.

The results so far are of sufficient interest to warrant additional running time. Some major changes will be made in the trigger requirement so as to remove the strong bias toward high energy events. The time structure of the radiation which is giving rise to a small but nonnegligible singles rate in our counters will be explored in some detail. This counting rate is beam correlated and seems to be quite independent of the general level of skyshine.

BC-6 (Supplement) — Study of the One Pion Exchange Contribution to γ-Nucleon Scattering (in 82-inch Deuterium Bubble Chamber) - W. M. Bugg (U. Tenn)

We propose a 400,000 picture extension to Experiment BC-6 (3 GeV γ interactions in 82-inch deuterium chamber) (200,000 pictures completed in June, 1970). The primary purpose of this extension is to systematically explore the evidence for exotic exchange processes in γ nucleon interactions. Several experiments have purported to observe the effects of exotic exchange, perhaps the oldest of these being forward Δ^- production in the reaction $pn \rightarrow \Delta^{++}\Delta^-$ at 3.7 GeV/c reported by the University of Tennessee — Oak Ridge Group. These experiments may generally be divided into 3 classes: 1. Those with two particles in the final state stable against strong interaction decay, e.g., $\pi^- p \rightarrow K^+ \Sigma^- \bar{p}p \rightarrow K^+K^-$. These

cross sections are in general very small and have so far yielded little indication of exotic exchange with the possible exception of the reaction $\bar{p}p \rightarrow \bar{\Sigma}^{-}\Sigma^{-}$. (2) Those with resonances in the final state such as $\pi^{-}p \rightarrow K^{+}Y^{*-}$ $pn \rightarrow \Delta^{-}\Delta^{++}$. Here, cross sections are consistently greater but it has been pointed out, e.g., by Berger et al., that kinematic effects associated with one meson exchange and s channel resonances can simulate exotic exchange. (3) The above effects are primarily observed through peripheral production of states requiring exotic exchange in their production and are therefore proportional to the squares of the exotic amplitude. It is also possible to observe interference between exotic and nonexotic amplitudes.

A high statistics deuterium bubble chamber experiment examining the final states $\gamma n \rightarrow \pi^{-}\Delta^{+}$, $\gamma n \rightarrow \pi^{+}\Delta^{-}$, $\gamma n \rightarrow \pi^{0}\Delta^{0}$, with proton spectator, $\gamma p \rightarrow \pi^{-}\Delta^{++}$, $\gamma p \rightarrow \pi^{+}\Delta^{0}$ with neutron spectator, should yield more conclusive results.

It is estimated that with the extension the experiment will yield about 1000 each of $\pi^{+}\Delta^{-}$ and $\pi^{-}\Delta^{++}$ events and approximately 1/3 as many $\pi^{-}\Delta^{+}$ and $\Delta^{+}\pi^{0}$ events, sufficient number for checking the production ratios and in addition making it possible to study the effect of exotic exchange on production angular distributions and decay correlations.

BC-11 (Supplement) — Resonance Production with Polarized Photons from the Laser Beam - I. O. Skillicorn (SLAC)

An additional exposure of 700,000 photographs in the 82" hydrogen bubble chamber to the frequency doubled laser Compton backscattered polarized photon beam at 9.3 GeV was approved. The purpose is to study in detail vector meson production in an energy region where diffractive processes may dominate. The complete exposure at this energy will give 230 events/μb.

BC-35 (Supplement) — γ-d Interactions at 3.5 and 5.5 GeV with Polarized Photon Beam - R. W. Birge and R. T. Poe (UC LRL and UC Riverside)

This experiment originally asked for 10^{6} pictures of which 300 K were approved. An additional 200 K have been approved, for a total of 500 K as requested in Supplement 1. The following is a summary of the purpose of the experiment.

Photoproduction reactions in the GeV range have become feasible and have been fruitfully studied only in recent years. The study of these reactions not only yields results of inherent interest such as the direct photon-vector meson couplings, but it also makes possible the study of certain aspects of strong interactions which are difficult or even inaccessible in the usual hadronic collisions.

The recent (polarized) γ-p experiments at SLAC have enabled a detailed study of the mechanisms involved in the photoproduction reactions. Such investigations of exchange mechanisms will provide us better understanding of high energy reactions, and are quite important in assessing the range of validity of various theoretical models, in particular, vector meson dominance and Regge-pole theory.

This experiment is to be a high statistics study of photoproduction reactions with polarized photons in deuterium. Several important features of this present experiment are:

1. Highly polarized ($\sim$ 95%) photon beam: In the study of exchanged systems in photoproduction reactions, the use of a linearly polarized photon beam allows us to determine the relative contribution of opposite J-parity exchange systems.

2. Isovector and isoscalar amplitudes: The photon contains both isovector and isoscalar parts. By combining a γ-n reaction with its charge symmetric counterpart γ-p reaction, one can study the relative contributions and the interference of these two parts of the photoproduction amplitude. Thus, this experiment and the SLAC γ-p experiment complement each other.

3. High statistics and practical advantages: The proposed 1000 K exposure will yield $\sim$250 events per μbarn at each energy, roughly an order of magnitude over the present available γ-d bubble chamber data from DESY. We believe that detailed information on differential cross sections and resonance decay distributions at two energies is more useful for studying the t-channel behavior than less detailed information at many momenta. The high statistics also makes possible a meaningful study of a large class of reactions, including strange particle production.

From a practical point of view certain γ-n reaction channels whose γ-p counterparts are not accessible to bubble chamber techniques can be studied. These include for example, $\gamma n \rightarrow p\pi^-\pi^0$ or $p\pi^-\pi^+\pi^-\pi^0$ whose γp counterparts ($\gamma p \rightarrow n\pi^+\pi^0$ or $n\pi^+\pi^-\pi^+\pi^0$) have two neutral secondaries and thus cannot be constrained. Similarly $\gamma n \rightarrow p\pi^-\pi^+\pi^-$ is 4-constraint (4C) while $\gamma p \rightarrow n\pi^+\pi^-\pi^+$ is 1C. This distinction could be important when unambiguous identification of the reaction is required.

BC-45 — <u>ω-ρ Interference and A_2 Splitting Study with π^+p at 3.8 GeV/c - G. Goldhaber (UC LRL, Berkeley)</u>

This is a high statistics high-resolution bubble chamber experiment on the reactions $\pi^+p \rightarrow \pi^+\pi^-\pi^+p$ and $\pi^+p \rightarrow \pi^+\pi^-\pi^0\pi^+p$ at 3.8 GeV/c in the 82-inch SLAC bubble chamber. The request was for 1.5 million pictures to be taken over a 1-1/2 year period. Of this request 750 K is approved for running.

The three main goals of this experiment are: (1) Study of the ω-ρ interference. In the channel $\pi^+ p \rightarrow \pi^+ \pi^- \Delta^{++}$ associated with a change in angular distribution. Indications are that there is a reduction in the $\cos^2 \theta$ distribution (where θ is the Jackson angle for ρ^0 decay) in the mass bin corresponding to the ω, as well as in the $\cos \theta$ term; i.e., the asymmetry. The reduction in $\cos^2 \theta$ can be understood in terms of a partial cancellation of the ρ amplitude by the $\omega \rightarrow 2\pi$ decay amplitude. If the new experiment bears out the reduction in the asymmetry term as well, we may in addition be able to learn about the ϵ; i.e., the 0^+ 2π state, as well. Furthermore, we should be able to study the interference effect as a function of t' and obtain further insight into the production mechanisms for $\rho\Delta^{++}$ and $\omega\Delta^{++}$. (2) Study of the structure of the A_2. The reaction $\pi^+ p \rightarrow A_2^+ p$ at 3.8 GeV/c is well suited for studies of the A_2 structure since the production cross section is large (about 170 μb in the $\pi^+\pi^-\pi^+$ decay mode). We would like to explore A_2 splitting, and in particular study the relation between A_2 splitting and momentum transfer.
(3) Study of ω Production and the ω Decay Dalitz Plot. We have observed an as yet unexplained dip in the $(d\sigma/dt')\ \rho^{00}$ at $t' \sim 0.15$. For the understanding of this effect it is important to study the other (smaller) density matrix elements as a function of t'. Our present data hints of either structure or fluctuations in the other matrix elements. A factor of ten in the number of events should clarify this point. Furthermore, in the t' region 0.08 - 0.2 $(\mathrm{GeV/c})^2$ we have observed a charge asymmetry on the ω decay Dalitz plot. The observed asymmetry is $\alpha = 0.18 \pm 0.05$ and a fit to the X projection with a matrix element of the form $\vec{q}(1+BX)$, with $\vec{q} = \vec{p}_{\pi^+} \times \vec{p}_{\pi^-}$, gives a value $B = 0.67 \pm 0.22$. In this experiment we hope to obtain a confirmation of this effect and in particular study the t' dependence in greater detail.

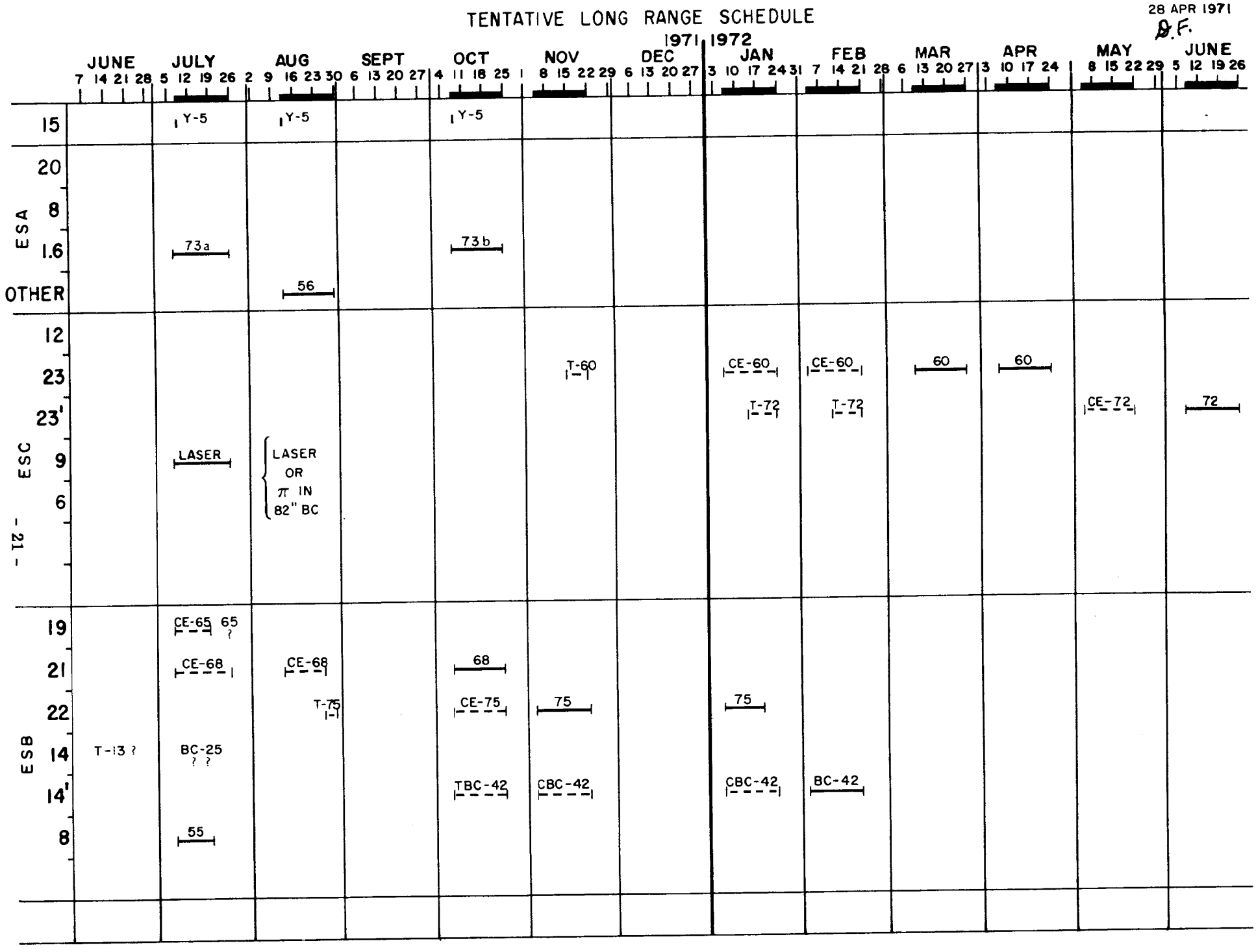
BC-47 — Resonance Formation with Polarized Photons from the Laser Beam - A. H. Rosenfeld (UC LRL, Berkeley)

As originally proposed this experiment requested 1.6×10^6 photographs in the 82" hydrogen bubble chamber exposed to the laser Compton backscattered polarized photon beam at energies between 0.6 and 1.2 GeV. This experiment was approved for 800 K photographs. The purpose of the experiment as originally proposed contained "high" energy and "low" energy portions. Only the low energy portion has been approved.

A summary of the experiment is as follows: From πp elastic scattering it is known that in the cm energy range 1400 MeV to 1800 MeV there are many resonances.

Their couplings to photons, however, are only poorly known. Partial wave analyses of $\gamma p \rightarrow N\pi$ are currently only about as good as πp analyses were before good polarized target data became available, i.e., before the great breakthrough of 1964-1965. Thus, the γ coupling of the Roper Resonances N* (1470, P_{11}) is now barely known. Polarization measurements made so far with counters amount to only a total of ~10,000 equivalent counts (almost all below K=850 MeV photon energy), and are equivalent to ~20,000 events produced by 100% polarized photons in an HBC. The low-energy half of the proposed run will produce 40,000 new such events. In the higher range 900 MeV < K < 1.2 GeV (1688-MeV resonances) no polarization data is presently available. Here, in the second half of our run, we expect 14,000 events.

FIG. 1--Experiment locations.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TBC-42
CBC-42
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BC-42
55

FIG. 2

TABLE 1

TABLE OF PROGRAMMED EXPERIMENTS

Number	Title	Authors	Date Approved	Status
E-43	Velocity of Light Experiment	UCSD G. Masek	12/14/68	Running
E-55	Study of Dalitz Plot for the Decay $K_L^o \rightarrow \pi^+\pi^-\pi^o$	SLAC H. Saal U. C. SANTA CRUZ D. Dorfan UNIV. COLORADO U. Nauenberg	5/23/70	Setup
E-56a	A Search for Short-Lived Sources of Neutrino-Like Particles	SLAC D. Fryberger, A. Rothenberg, M. Schwartz, T. Zipf UNIV. OF PENNSYLVANIA E. Beier, A. Mann, E. Rybaczewski U. C. SANTA CRUZ D. Dorfan	10/14/70 Ext. 2/5/71	Setup
E-60	Hyperon Production in K^-p Interactions	SLAC K. Bunnell, R. Mozley, A. Odian, J. Park, B. Swanson, F. Villa, L. Wang U. C. RIVERSIDE S. Fung, A. Kernan, R. Poe, T. Schalk, B. Shen LRL-BERKELEY M. Alston-Garnjost, R. Bangerter, A. Barbaro-Galtieri, F. Lynch, F. Solmitz	12/12/69	Planning
E-61	Forward Electron Scattering	SLAC E. Bloom, R. Cottrell H. DeStaebler, C. Jordan, M. Mestayer, H. Piel, R. E. Taylor	2/21/70	Running/ Complete
E-63	Measurement of K_L^o and Neutron Total Cross Sections on Nuclear Targets	STANFORD UNIV. J. Crawford, R. Ford, E. B. Hughes, L. Middleman, L. H. O'Neill, J. Otis	3/21/70*	Inactive
E-64	Study of the Decay $K_L^o \rightarrow \pi^\pm\mu^\mp\nu$	SLAC D. Fryberger, D. Hitlin J. Liu, M. Schwartz, S. Wojcicki U. C. SANTA CRUZ D. Dorfan	3/21/70	Setup/ Checkout

Table of Programmed Experiments (cont'd) - 2

Number	Title	Authors	Date Approved	Status
E-65	Study of Electroproduced Hadrons	SLAC B. Dieterle, W. Lakin, F. Martin, E. Petraske, M. Perl, J. Tenenbaum, W. Toner	3/21/70	Setup
E-66	Inelastic Photoproduction of Charged Pi and K Mesons in the Forward Direction	SLAC A. Boyarski, S. Ecklund, B. Richter, R. Siemann	3/21/70	Planning/ Setup
E-68	Inclusive Pion-Proton Scattering	UNIV. OF WASHINGTON J. E. Rothberg, R. W. Williams, K. K. Young, A. Schenck, L. Sompayrac, M. Delay	5/23/70	Parasiting
E-70	Measurement of the Asymmetry in Compton Scattering on the Proton	SLAC R. Anderson, D. Gustavson, J. Johnson, I. Overman, D. Ritson, B. Wiik CORNELL R. Talman NORTHEASTERN UNIV. R. Weinstein HARVARD D. Worcester	8/15/70	Inactive
E-71	Vector Meson Electroproduction at High Energy	SLAC E. Bloom, R. Cottrell, H. DeStaebler, C. Jordan, M. Mestayer, G. Miller, H. Piel, R. E. Taylor UCSD C. Prescott	8/15/70	Running/ Completed
E-72	Deep Inelastic μ-p Scattering	U. C. SANTA CRUZ D. Dorfan, C. Heusch, B. Liberman, C. Prescott, A. Seiden	11/14/70	Planning
E-73	Phi-Photoproduction	SLAC R. L. Anderson, D. Gustavson, J. Johnson, I. Overman, D. Ritson, B. Wiik UNIV. OF WISCONSIN R. Prepost D. Tompkins HARVARD D. Worcester	11/14/70	Planning
E-75	Q Region Study in $K^+p \rightarrow K^+\pi^+\pi^-p$	SLAC R. Carnegie, R. Cashmore, E. Kluge, D. W. G. S. Leith, H. L. Lynch, S. Williams, F. Winkelman, R. Giese, B. Ratcliff, H. H. Williams	11/14/70	Planning

Table of Programmed Experiments (cont'd) - 3

Number	Title	Authors	Date Approved	Status
BC-6	Study of the One Pion Exchange Contribution to γ-Nucleon Scattering (in 82-Inch Deuterium Bubble Chamber)	U. OF TENNESSEE. W.M. Bugg	Ext. 2/5/71	Inactive
BC-8	Exposure of the 82 Inch Hydrogen Chamber to a Beam of π^+ Mesons at 7.0, 11.0 and 14.0 GeV/c	PURDUE D.H. Miller	Ext. 3/21/70	Inactive
BC-10	A Proposal to Investigate $K_2^o p$ Interactions with the 40 Inch HBC	STANFORD B.C. Shen, D.W.G.S. Leith, A.D. Brody, W.B. Johnson, R.R. Larsen, G.A. Loew, R. Miller, W.M. Smart	5/11/68	Running/ Complete
BC-11	A Bubble Chamber Experiment with the Polarized Laser Induced Photon Beam (Extended 10/3/69)	SLAC J. Ballam, G. Chadwick, Z. Guiragossian, P. Klein, A. Levy, M. Menke, K. Moffeit, J. Murray, C. Sinclair, I. Skillicorn, G. Wolf U.C. BERKELEY H. Bingham, B. Equer UCLRL M. Rabin, W. Podolsky, A. Rosenfeld	5/11/68 Ext. 2/5/71	Inactive
BC-18	A 4.25 GeV γ-Deuterium Experiment in the SLAC 40" Bubble Chamber and with Polarized Photons in the 82" Bubble Chamber	WEIZMANN INSTITUTE Y. Eisenberg, B. Haber, U. Karshon L. Lyons, E.E. Ronat, A. Shapira, G. Yekutieli	9/28/68	Inactive
BC-19	γ-d Experiment with an Annihilation Beam of 7.5 GeV in SLAC 40" Bubble Chamber and with Polarized Photons in the 82 Inch Bubble Chamber	TEL-AVIV UNIV. G. Alexander, I. Bar-Nir, A. Brandstetter, S. Degan, J. Grunhaus, A. Levy, Y. Oren	Ext. 3/21/70	Inactive
BC-25	Study of Pomeranchon, Meson and Baryon Exchanges by Triggering the SLAC 40" Bubble Chamber on Fast Forward Particles	CAL TECH A. Dzierba, W. Ford, R. Gomez, P. Oddone, C. Peck, J. Power, C. Rosenfeld, A. Tollestrup LRL-BERKELEY R. Ely, D. Grether	6/18/69	Setup/ Checkout
BC-28	A 5 GeV/c $\pi^+ p$ Experiment in the SLAC 82 Inch HBC	WEIZMANN INSTITUTE Y. Eisenberg, B. Haber, U. Karshon, E. Ronat, A. Shapira, G. Yekutieli	8/6/69	Inactive

Table of Programmed Experiments (cont'd) - 4

Number	Title	Authors	Date Approved	Status
BC-30	Λp Interactions in the Momentum Interval 1-5 GeV/c	LRL BERKELEY G. Trilling, J. Kadyk, G. Goldhaber, J. Hauptman	12/12/69	Setup
BC-34a	K^-d Interactions Around 12 GeV/c	JOHNS-HOPKINS UNIV. C. Chien, B. Cox, D. Denegri, L. Ettlinger, G. Goodman, R. Mercer, A. Pevsner, R. Sekulin, R. Zdanis	8/15/70	Inactive
BC-35	γ-d Interactions at 3.5 and 5.5 GeV with Polarized Photon Beam	U. C. RIVERSIDE S. Fung, A. Kernan, R. Poe, T. Schalk, B. Shen U. C. BERKELEY R. Birge, R. Ely, G. Gidal, D. Grether, G. Kalmus, W. Michael	3/21/70 Ext. 2/5/71	Inactive
BC-38	A Study of π^+d Interactions at 15 GeV/c	FLORIDA STATE UNIV. J. Albright, A. Colleraine, S. Hagopian, V. Hagopian, J. Lannutti, G. Yost UNIV. OF PENN. J. Bensinger	8/15/70	Inactive
BC-39	Study of π^+ Interactions in Hydrogen at 15 BeV/c	COLUMBIA C. Baltay, L. Gerschwin, W. Cooper, S. Csorna, M. Habibi, M. Kalelkar STATE UNIV. OF NEW YORK N. Yeh, A. Gaigalas	8/15/70	Inactive
BC-40	8.0 and 14 GeV/c, π^+ and π^- Exposures in the SLAC 82 Inch HBC	MIT Z. Carmel, F. Dao, B. Feld, R. Hulsizer, V. Kistiakowsky, I. Pless, V. Simac, F. Triantis, T. Watts, J. Wolfson, R. Yamamoto, D. Ballantyne, M. Hodous, A. Nakkasyan, A. Napier, R. Singer, P. Trepagnier	8/15/70	Inactive
BC-42	Bubble Chamber Study of Deep Inelastic Muon Scattering	SLAC E. Bloom, R. Cottrell, H. DeStaebler C. Jordan, M. Mestayer, H. Piel, R. Taylor, J. Ballam, G. Chadwick, P. Seyboth, I. Skillicorn, H. Spitzer U. C. SANTA CRUZ C. Prescott	8/15/70	Planning

Table of Programmed Experiments (cont'd) - 5

Number	Title	Authors	Date Approved	Status
BC-43	A Study of π^-d Interactions at 15 GeV/c	UNIV. OF WASH. P. Bastien, L. Kirkpatrick, H. Lubatti UC BERKELEY H. Bingham, W. Fretter	8/15/70	Inactive
BC-44	Measurement of the Total Hadronic γp Cross Section at Photon Energies Between 0.5 and 1.2 GeV	DESY G. Knies, P. Soding, G. Wolf	8/15/70	Inactive
BC-45	ω-ρ Interference and A_2 Splitting Study with π^+p at 3.8 GeV/c	UC BERKELEY/LRL BERKELEY G. Goldhaber, J. A. Kadyk, G. H. Trilling, G. S. Abrams, K. W. J. Barnham, A. Firestone	2/5/71	Inactive
BC-47	Resonance Formation with Polarized Photons from the Laser Beam	LRL BERKELEY R. G. Moorhouse, W. Podolsky, M. Rabin, A. Rosenfeld, G. Smadja, R. D. Tripp SLAC G. Chadwick, R. Gearhart, M. Menke, K. Moffeit, J. Murray, P. Seyboth, C. Sinclair, I. O. Skillicorn, H. Spitzer	2/5/71	Inactive
IC-1	Test of the Design Concepts for a High Energy Gamma Ray or Electron Detector	CAL TECH A. V. Tollestrup, R. Walker	1/13/71	Running
IC-2	Test of UVT-Lucite Counter	LRL-BERKELEY R. Budnitz		Running
D-16	Tests of Large NaI(Tl) Detectors	HEPL B. Hughes	5/29/70	Inactive
D-18	Pion Yield Test	UCSB D. Caldwell		Planning/ Setup
D-19	Measurement of Photofission Cross Sections of U-238 and Th-232	SLAC G. Svennson	12/8/70	Inactive
D-20	Large Angle Electron Scattering	SLAC E. Bloom, R. E. Taylor		Running/ Complete
NT-3	Fast Cycling Bubble Chamber Development	SLAC H. Barney, R. Blumberg, A. Rogers, S. St. Lorant	12/15/68	Planning/ Parasiting
R-8	30 kW μ-Target	SLAC D. Walz	12/30/70	Completed

Table of Programmed Experiments (cont'd) - 6

Number	Title	Authors	Date Approved	Status
T-12	Wire Chamber Spectrometer Checkout	SLAC S. Wojcicki	6/11/69	Setup/ Checkout
T-13	40 Inch Bubble Chamber Neon Fill Test	SLAC R. Watt	4/24/70	Inactive
T-15	Lead Plate Proportional Quantameter	UNIV. OF HAWAII D. Yount	12/16/70	Checkout/ Running
T-19	Beam 19 Checkout for E-65	SLAC W. Toner/J. J. Murray		Running
T-20	Test of the Design Concepts for a High Energy Gamma Ray or Electron Detector	CAL TECH A. V. Tollestrup, R. Walker	1/13/71	Inactive/ Running
T-21	Test of UVT-Lucite Counter	LRL BERKELEY R. Budnitz		Inactive
T-22	Calibration of a Large Cosmic Ray Detector	UNIVERSITY OF NEW HAMPSHIRE W. R. Weber, J. Rockstroh		Running
T-34	Shower Counter Test	UNIVERSITY OF CHICAGO S. Aronson	3/9/71	Running/ Complete
T-35	High Density Test Exposure of Nuclear Emulsions	UNIVERSITY OF WASHINGTON J. Lord	3/2/71	Running
T-65	Tests of Shower Counter for E-65	SLAC W. Toner	6/29/70	Running
Y-5	SPEAR Transport Test	SLAC		Inactive
Y-8	Test of Simulated Protection Collimators	SLAC E. Seppi	1/19/71	Running

Running = Experiment is in data collection phase and was a prime user of accelerator time.
Checkout = Experiment is in checkout phase and used accelerator time for checkout purposes.
Setup = Experiment was being setup in the research yard.
Inactive = Experiment was inactive in the research yard.
Construction = Experiment and/or beam is under construction.
Ready to Run = Experiment ready for future scheduled run.
Parasiting = Used parasite beam time.
Completed = Experiment completed.
Special Test = Special test run performed.
Planning = In design and planning stage.

*Approved for checkout only.

III. EXPERIMENTAL FACILITIES

Development

1. End Station B

During the quarter installation work proceeded on the secondary beam transport systems in end station B. This end station was opened for three day shifts per week during the March operating period to allow for completion of the installation work on beam lines 14, 20, and 19 (Fig. 3 is a drawing of experimental beam paths at SLAC as of January 28, 1971) which will initially be used by Experiments BC-25, E-68, and E-65, respectively. Beam lines 14 and 19 were nominally complete early in the operation period but were plagued by numerous background and alignment problems which required considerable work by the installation crews. During the period the portion of beam line 20 inside end station B was completed and some initial checkout was performed. Considerable work remains to be done in the checkout and completion of these beam lines.

2. End Station A

During the February down period several jobs which had accumulated in end station A were taken care of. The rails were modified to permit the 20 GeV spectrometer to move to 21°. This entailed grinding of welds and extending one rail which carries the earthquake brace. Extensive surveying was done on the 20 GeV spectrometer to try to understand its distortions and pointing error. Considerable improvement was achieved. Trial circuits were built and tested to allow the computer to control the pressure of the two gas Cerenkov counters located in the 20 GeV shield. Construction was started on a large elaborate carriage to be used by Group F in Experiment E-73.

The final stage of relocation of the equipment in the Counting House was completed by the end of the quarter. The second XDS9300 computer was put into operation and was used for E-71.

3. Hydrogen Bubble Chamber Operations

Approximately 150,000 of the BC-10 pictures taken in the 40" bubble chamber in December were not usable because of large changes in density of the film between the time it was exposed and the time it came out of the developer. BC-10 consequently re-ran part of its experiment in January. There were 173,874 exposures made, yielding 140,000 pictures. The chamber was initially

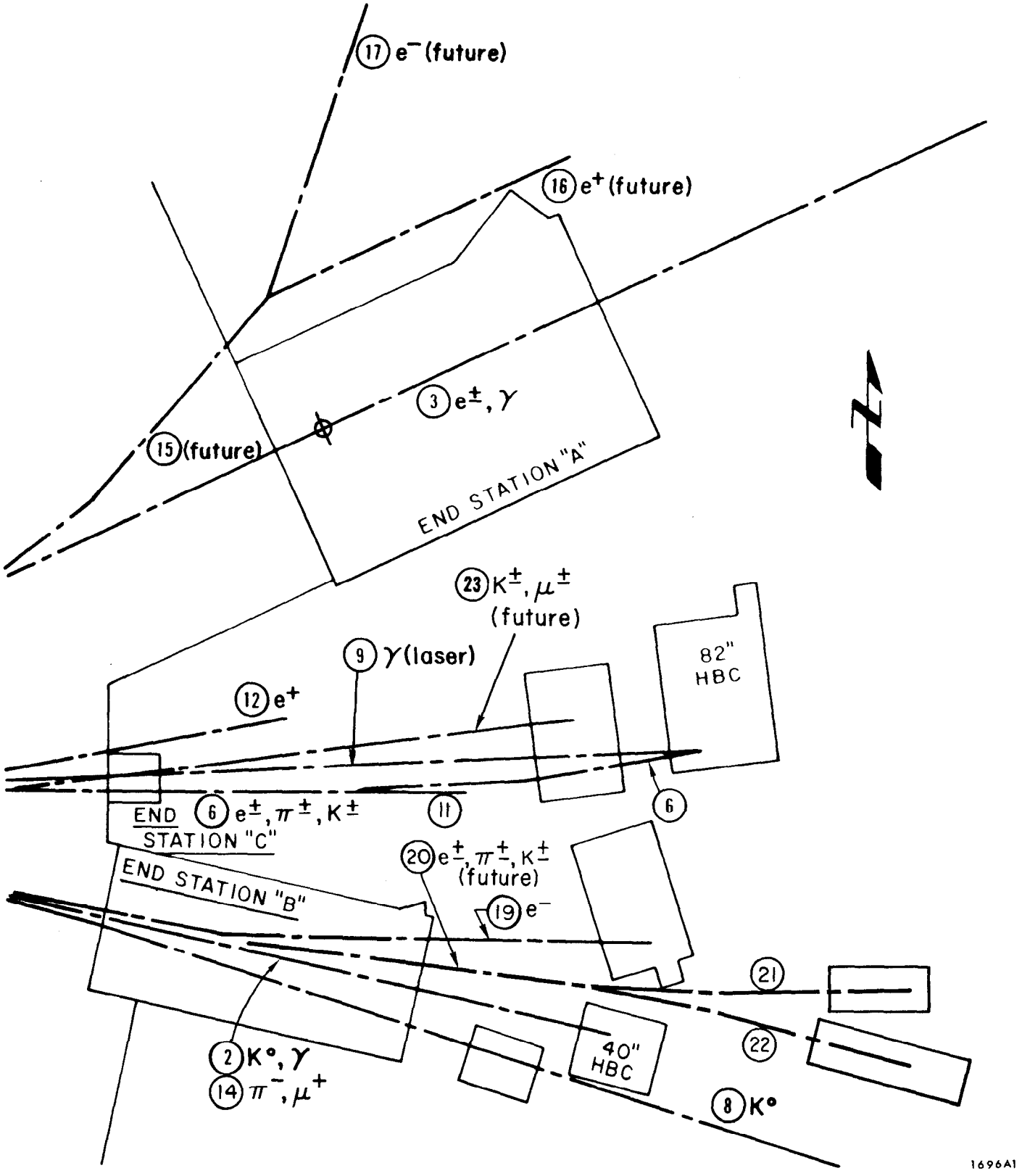

FIG. 3--Experimental beam paths at SLAC, January 28, 1971.

cooled down with liquid hydrogen and then was switched to the new refrigeration system for the first test of the complete chamber, valve vessel, and refrigeration system.

Higher than anticipated heat loads, due to losses from the valve vessel, were encountered. Modification to the chamber valve vessel system was made in February to reduce the effect of this problem.

The chamber was cooled down and operated during the March cycle, using the new refrigeration system. This system reduced the time- and manpower-consuming filling and transporting of a liquid hydrogen trailer to one or two trailers per month, compared to three or four per day when trailers were used as the source of refrigeration. TBC-25 used the chamber to take 8,858 pictures during the March cycle. At the end of the month the chamber was warmed up and opened for the installation of a modified inflatable gasket and other minor chamber modifications that will allow further rapid cycle testing.

The 82" hydrogen bubble chamber did not operate during the period. The installation of major components in the extensive modifications of the chamber was completed. The chamber was reassembled with the BC-30 platinum target installed at the end of March. Cooldown procedures for the April-May cycle have started and it is anticipated that the chamber will be ready for operation as scheduled during the April-May cycle.

4. Power Supply Operations

On March 2 the 4160 rectifier transformer on PQ 202, one of the 567 kW power supplies for the spectrometer, failed. It was removed and sent out for repairs.

A transformer in another 567 kW supply (PQ 201) failed on March 11. It was decided to recall the first transformer and build a good one from the components of the two failed units. The SLAC magnet shop completed the job within a week. When tested, there was evidence of corona discharge inside the coils, but it was decided to install it. The unit will be put into service on April 1.

IV. ACCELERATOR IMPROVEMENTS

Installation of the pulsed alpha magnet and its power supply, accomplished in February, completed installation of the off-axis injector. The accelerator is now capable of simultaneous use of the on-line and off-axis injectors on a pulse-to-pulse basis.

The first pair of redesigned pulsed focusing quadrupoles was installed in Sector 28 with 90 feet between magnets during the February shutdown and was successfully tested during the March run. Fabrication of the balance of the magnets is to start in April, with installation of the last pair scheduled for September 1971. Design of the modified pulsed quadrupole power supply has been approved and drawings are being prepared for the bid package. Request for bids for the pulsed quadrupole and pulsed steering power supplies is to be mailed by the end of April or early May requesting delivery by September 1971. The pulsed steering and focusing system is to be operational by the end of the calendar year.

Improvements to the position monitor system were completed during the quarter. Conversion boxes to convert 115 V ac current to 110 V dc current were fabricated and installed, utilizing the 115 V ac system as a power source, but retaining the 110 V dc switches already in use. Controls are activated by a 24 V dc system passing through the main frame.

Consolidation of the two control rooms continued during the quarter and development work to correct the design problems of the touch panel progressed. Fabrication of a small two-channel working model of an ultrasonic touch panel was begun and will be tested on completion. If tests are satisfactory, it is planned to build a 10 × 13 channel model to fit a 17" TV screen to be installed in June and tested during the July run. A working model of a crossed-wire matrix was started during the quarter and will be completed by mid-April. It is planned to install two 10 × 13 channel models on 14" TV screens in June for testing during the July run.

An input multiplexer for touch panel connections to the computer was fabricated and installed during February.

Improvements to the profile monitor system in the beam switchyard were completed during the quarter. Installation of the last four conversion boxes was completed in January and final cross-connects were completed in February.

Installation of the magnet warning system was completed in March. The system provides a flashing red light when magnet power is on and the switchyard is open.

Expansion of the data system to improve and speed up reporting to and from CCR and the computer of various signals along the machine continued during the quarter.

Fabrication of mechanical and electronic components for the pulsed phase closure system was completed during the quarter. It was determined, in testing the system, that new high power latching circulators capable of handling 5 kW peak would be needed to replace those originally used in the system which saturated and leveled at a power level of about 1.5 kW peak. New circulators were ordered for delivery in May and the system will be installed in June.

Improvement to the pulse generation system continued during the quarter. Upgrading of oscilloscope triggering was continued.

Work on the DAB rack and cabling expansion was resumed during the quarter. Cable was drawn from stores and will be installed in April between Building 209 and the Main Control Center. Rack rearrangement in the Main Control Center is proceeding as time and conditions allow.

V. KLYSTRON STUDIES

A. Development

1. High Power Klystrons

The main activity during this quarter has consisted of minor modifications in the tube structure with the purpose of improving yield. Last quarter the output nose radius was increased as reported; no tubes built with the larger radius on the 4th and 5th cavity noses have exhibited rf breakup. Similarly the radius of the focus electrode is being increased to decrease the high voltage gradients and accordingly decrease the probability of arc-overs in the gun region. To date not enough data is available to draw definite conclusions as to the optimum radius.

Plans have been implemented to increase the production facilities of the SLAC klystrons in view of the decision to procure future tubes from only one vendor and have approximately one-half of the complement of tubes on the machine built at SLAC. Very few tubes have been received from vendors pending resolution of our contract negotiations and approval of our recommendations by AEC.

2. Klystrons for Superconducting Accelerator

The new tube built with a smaller beam diameter and a new output circuit has been tested. Although the stability is better than experienced previously there appears to be still either detuning of the output or multipactor in the ridge guide in the output which results in unstable conditions for average power in excess of 10 kW at long pulse length. Preliminary tests indicate an efficiency of about 36%, much lower than theoretical expectation. We hope to obtain 40% by retuning the 3rd and 4th cavities.

The oxide cathode diode is still operating after approximately 9300 hours, in spite of a slight emission drop which was corrected by a heater power increase.

3. High Power Windows

Operating experience has been very good from a window standpoint with only 2 failures on the machine and 1 SLAC window failure during acceptance testing. This last failure was due to interlock malfunction which allowed operation into poor vacuum.

4. Special Tests

Special tests have been performed as follows in an attempt to determine the feasibility of operating the accelerator at peak powers of 50 - 60 MW per station (4 girders):

a. A special test has been set up at Station 26-7 at twice peak power and 1/2 repetition rate. Two klystrons are installed, at 26-7B and 26-7C respectively, and their output combined in a hybrid coupler prior to the existing waveguide system. The relative phase of the 2 klystrons can be adjusted manually. The beam voltages are obtained from two pulse forming networks which are charged by the existing dc modulator supply.

To date peak power in excess of 50 MW has been supplied at that station and relatively few difficulties have been encountered in adjusting the station. However, additional tests are needed to verify the potential operation at 60 MW input to the accelerator section.

b. A tube was run up in the test laboratory to approximately 320 kV at 180 pps. Operation appears satisfactory with an arcing rate which was not substantially different from that obtained at 270 kV, 360 pps. The peak output power was approximately 45 MW.

During these tests we attempted to use a CH 1222 thyratron which had been operated on life tests for over 9000 hours in Heavy Electronics area. Unfortunately the reservoir range was extremely narrow. As a result we were unable to obtain operation over a wide range of voltage, nor could we reach the peak power which we had anticipated with that thyratron.

B. Operation and Maintenance

With a low number of operating hours during the quarter the number of failures was also one of the lowest ever experienced during any previous quarter. The MTBF was 20,000 hours.

One subbooster failed during the quarter.

1. High Power Klystron Operation

Usage and failure records of our klystrons are summarized in Table 2 which shows a continuing mean age at failure and a substantially constant cumulative MTBF. The information is also shown in Fig. 4.

Figures 5 and 6 gives the tube age distribution of all living and failed klystrons respectively in 500 hour increments.

TABLE 2

KLYSTRON MTBF

Dates	PER QUARTER				CUMULATIVE			
	Operating Hours	Failures Number	Failures Mean Age	MTBF	Operating Hours	Failures Number	Failures Mean Age	MTBF
To 6/30/66					129,400	19	260	7,200
To 9/30/66	111,000	8	610	14,000	240,400	27	360	9,000
To 12/31/66	154,000	11	1,100	14,000	394,400	38	575	10,300
To 3/31/67	207,000	13	1,490	15,900	601,400	51	810	11,800
To 6/30/67	287,000	9	2,490	32,000	888,400	60	1,060	14,800
To 9/30/67	330,500	25	2,860	13,300	1,218,900	85	1,590	14,500
To 12/31/67	263,000	21	3,520	12,500	1,481,900	106	1,980	14,100
To 3/31/68	309,500	17	4,800	18,200	1,791,400	123	2,360	14,700
To 6/30/68	306,000	15	3,820	20,400	2,097,400	138	2,520	15,200
To 9/30/68	314,200	24	5,500	13,100	2,411,600	162	2,960	14,900
To 12/31/68	349,800	23	8,350	15,200	2,761,400	185	3,630	15,000
To 3/31/69	328,600	20	6,610	16,400	3,090,000	205	3,930	15,100
To 6/30/69	335,000	16	7,280	19,700	3,425,000	221	4,190	15,400
To 9/30/69	179,800	8	11,670	22,500	3,608,100	229	4,450	15,750
To 12/31/69	303,600	10	10,230	30,400	3,911,700	239	4,690	16,300
To 3/31/70	358,700	32	9,950	11,200	4,270,400	271	5,270	15,800
To 6/30/70	257,200	18	11,350	14,300	4,527,600	289	5,650	15,700
To 9/30/70	259,600	13	9,600	20,000	4,787,100	302	5,810	15,800
To 12/31/70	365,800	31	10,800	11,800	5,152,900	333	6,280	15,500
To 3/31/71	220,200	11	9,600	20,000	5,373,100	344	6,400	15,600

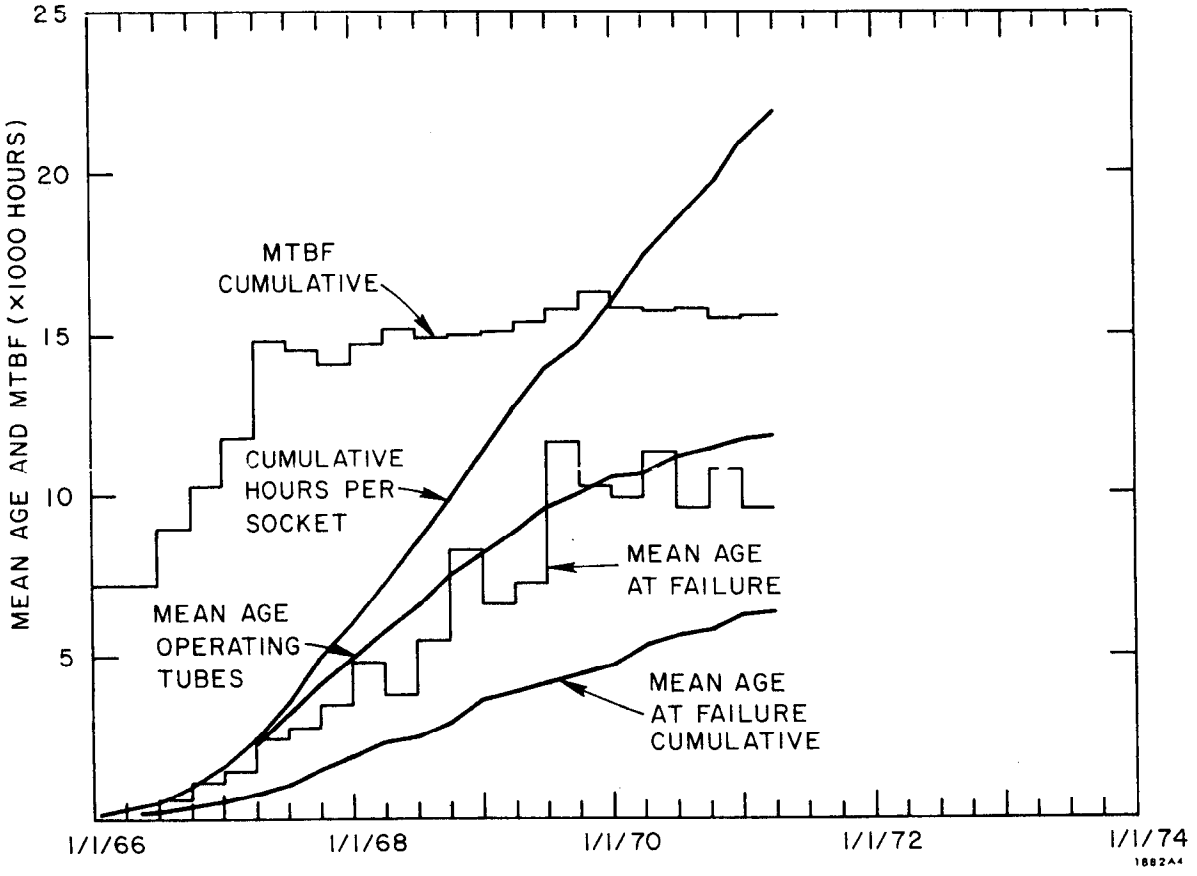

FIG. 4--High power klystrons: cumulative MTBF, mean age, mean age at failure, cumulative age at failure, and cumulative hours per socket, March 31, 1971.

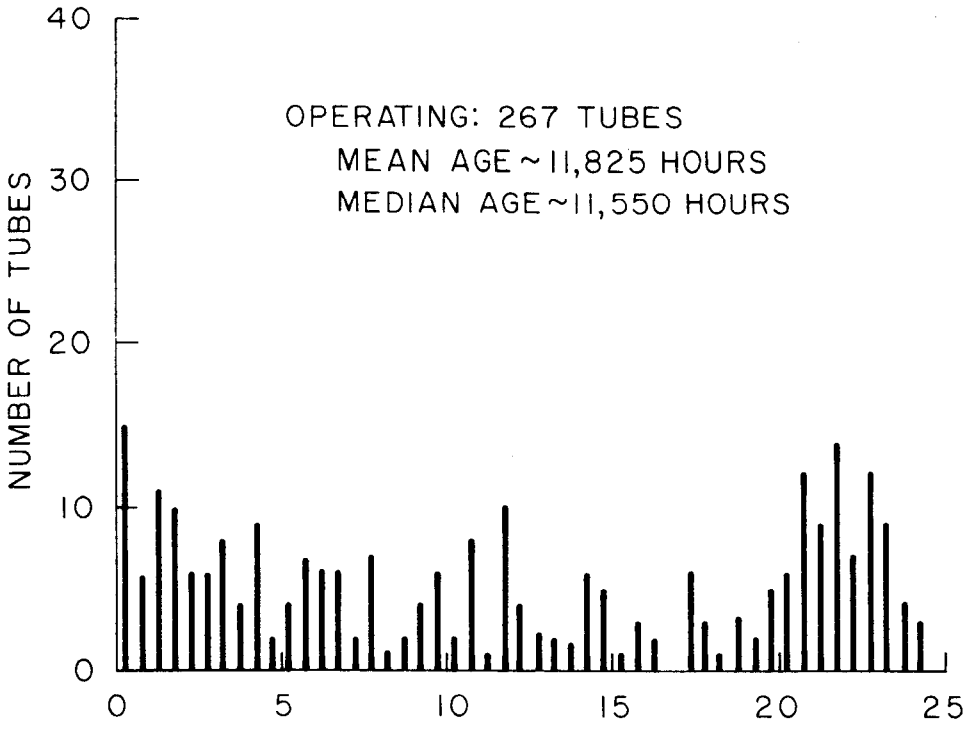

FIG. 5--High power klystrons: age distribution of operating tubes, March 31, 1971.

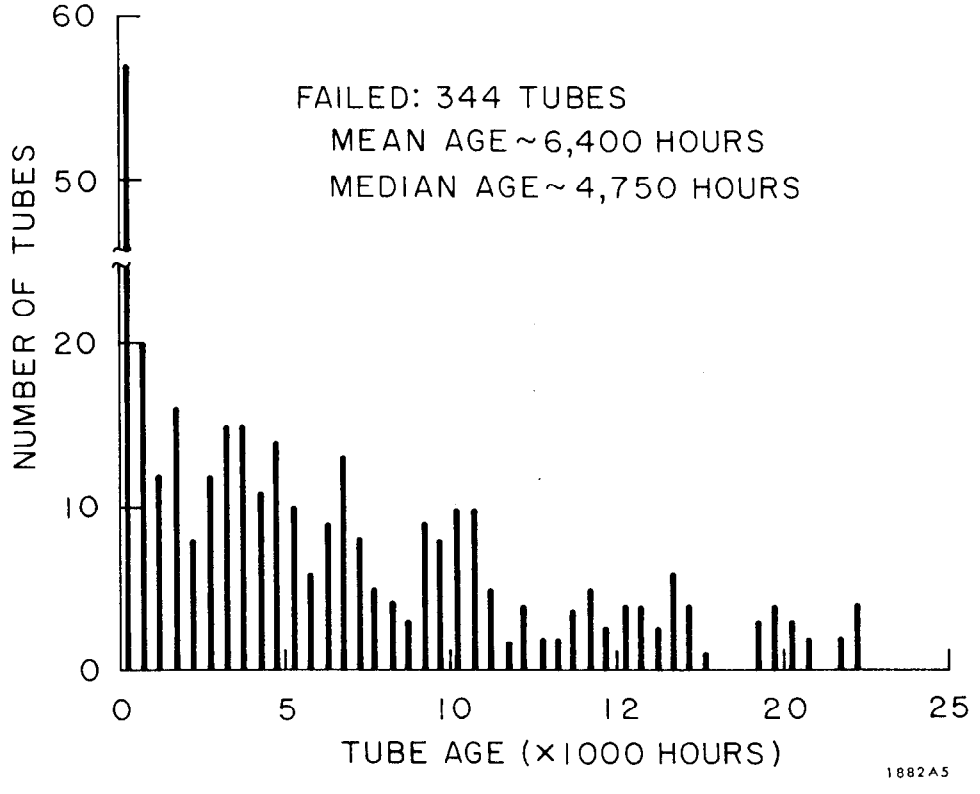

FIG. 6--High power klystrons: age distribution of failed tubes, March 31, 1971.

The analysis of the data shown on these figures is plotted in Fig. 7 and gives the failure and survival probability for all vendor tubes.

Operation at 265 kV still results in a large difference in MTBF. However, the samples are very small (4 and 7 failures respectively at 265 and 245 kV). If one considers instead the trouble report and replacements, the overall rate is 1-1/2 times at 265 kV that at 245 kV.

2. High Power Klystron Maintenance

Thirty-five tubes were replaced in the gallery; approximately 1/3 because of suspected tube failure, 1/3 because of suspected pulse transformer tank failure, 1/4 for oil leaks and the remainder for miscellaneous reasons.

The causes for tube failures continued basically unchanged with the one exception of the large number of Litton failures due to poor emission (temperature limited cathodes) after between 5000 and 7000 hours of operation. Figure 8 shows the operating experience of all high power klystrons since the beginning of operation.

3. Subbooster Klystrons

Three tubes were replaced during the quarter with one SLAC tube failure at the very tender age of 353 hours. The tube age distribution of all subboosters living and dead is given in Figs. 9 and 10 respectively. Note the 30,000 hours median age of the 8 remaining Eimac tubes.

4. Main Booster Klystrons

Attempts are being made to improve the performance of Station No. 1 where noise and diurnal drifts in power output have been more evident than in Station No. 2. Water cooling was installed in the cavities of the klystron in this station to reduce the effect of ambient temperature on cavity tuning, and a replacement was made at that station in an attempt to reduce the spurious signal output.

Improvements following these changes have been observed but are not as much as anticipated. Additional measurements are being taken including records of air, water, and cavity temperatures.

Station No. 2 continues to operate satisfactorily but also exhibits diurnal power output drifts.

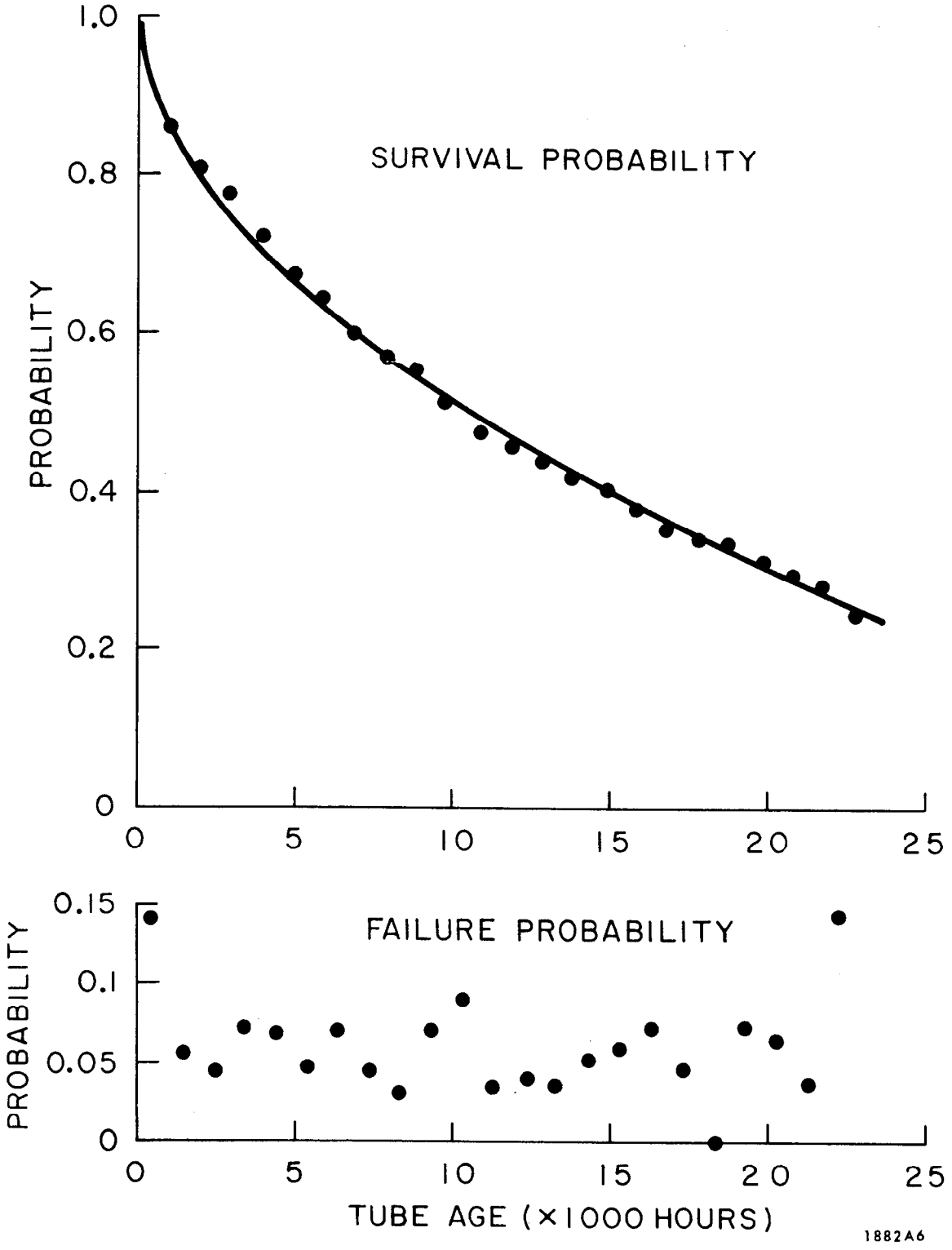

FIG. 7--High power klystrons: survival and failure probabilities, March 31, 1971.

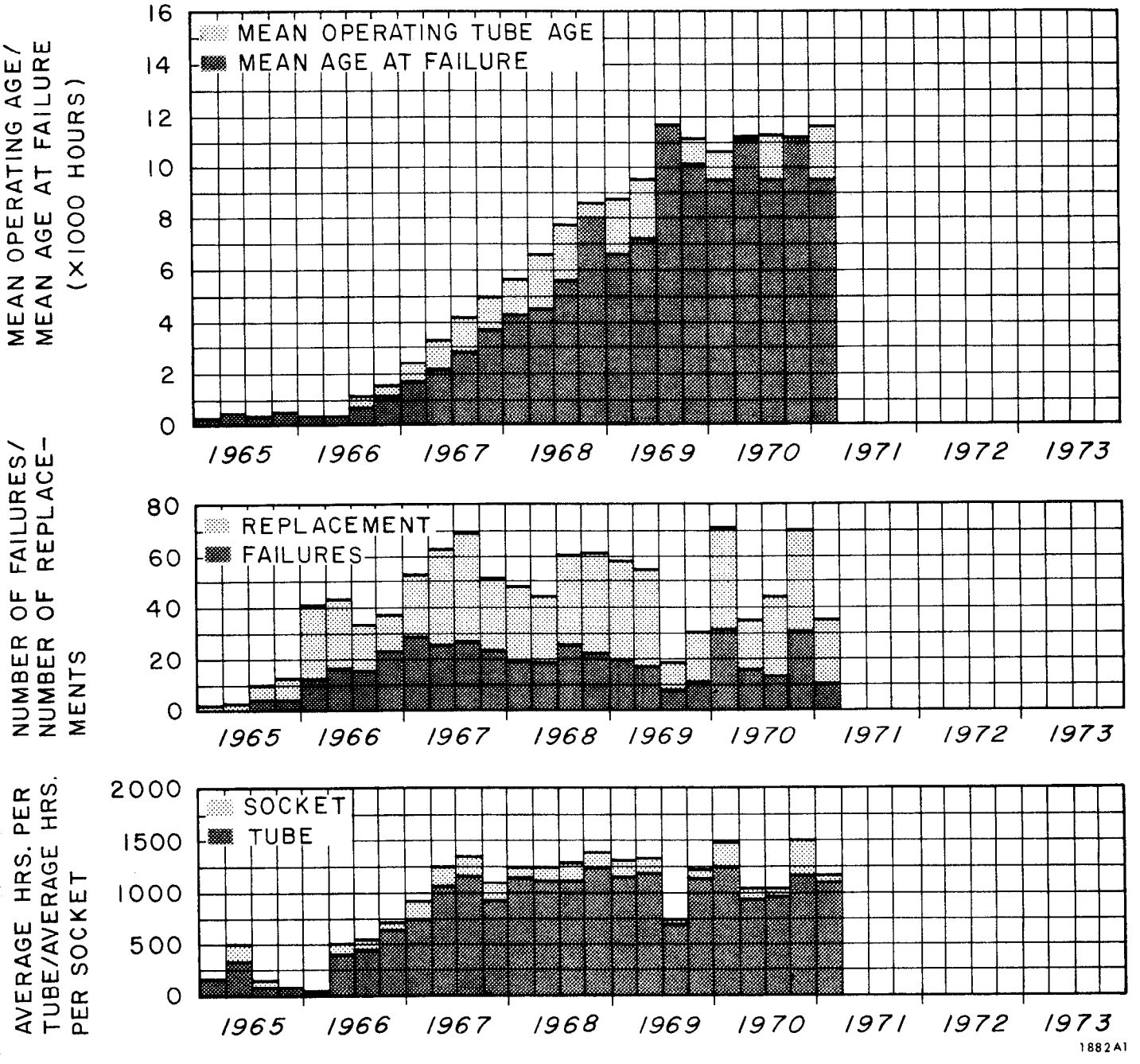

FIG. 8--High power klystrons: operating experience through March 31, 1971.

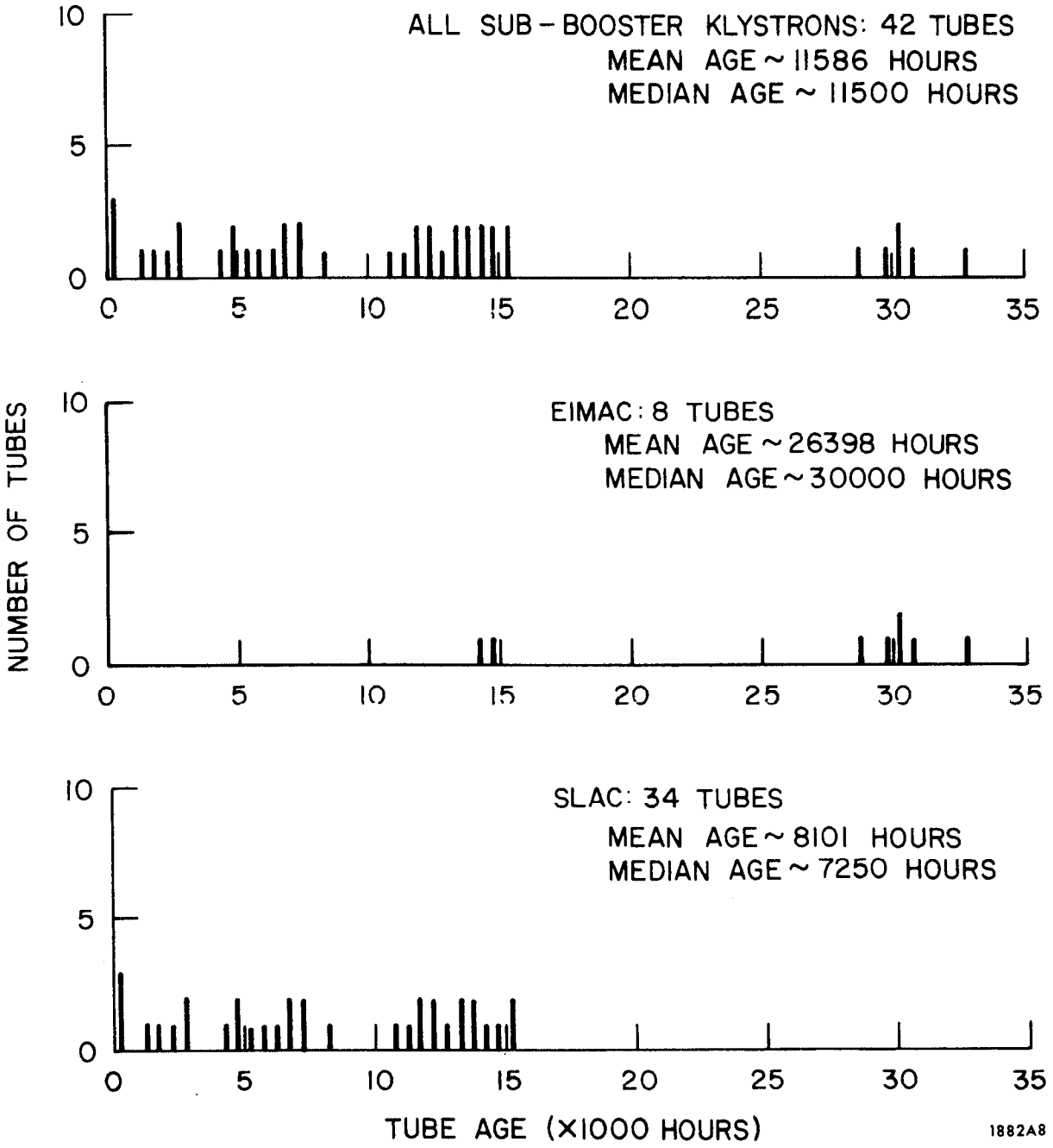

FIG. 9--Subbooster klystrons: age distribution of operating tubes, March 31, 1971.

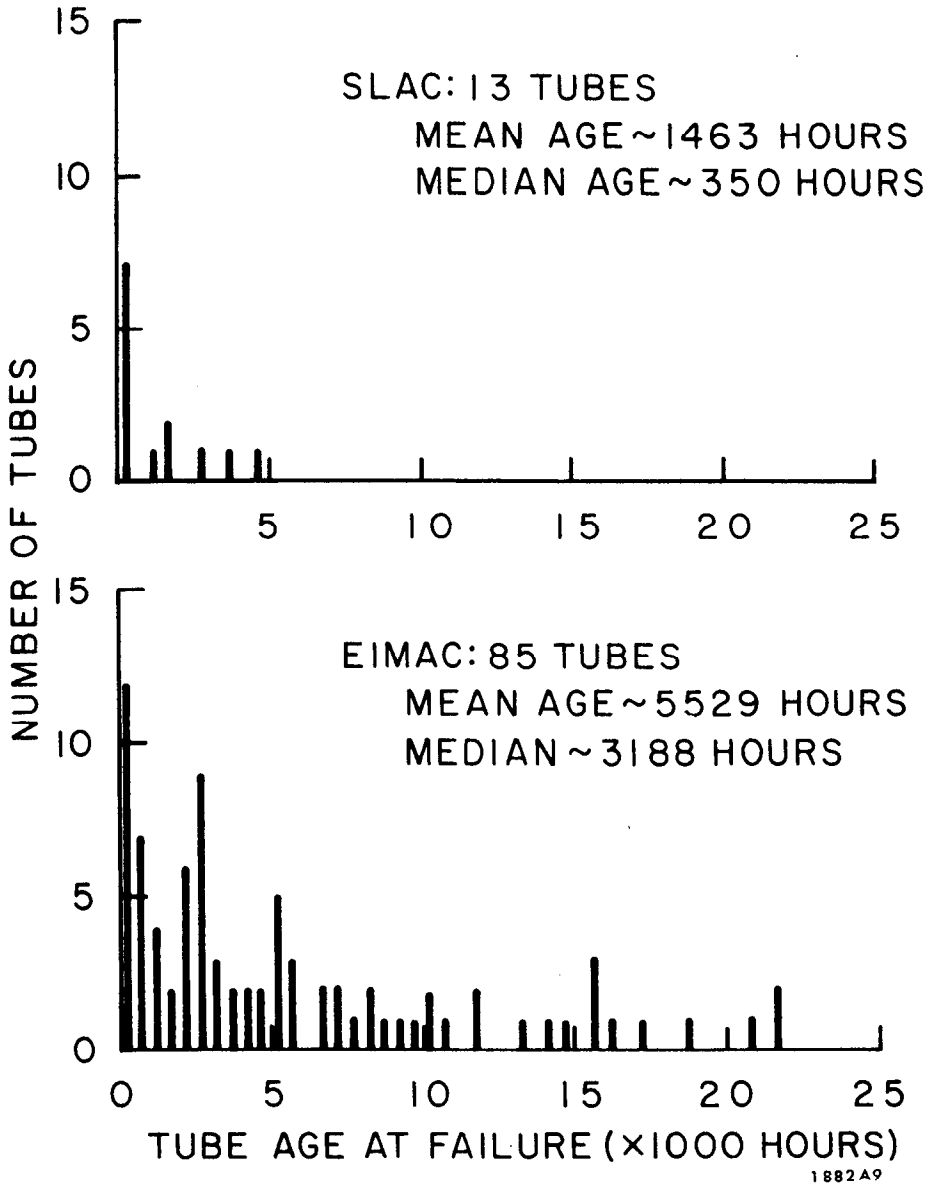

FIG. 10--Subbooster klystrons: age distribution of failed tubes, March 31, 1971.

5. Vacuum System

The only serious problem observed within the vacuum system has been the need for replacement of an O-ring in a 3" valve. It appears that in some stations rf power can leak directly from the station into the vacuum system and can create a resonance between the valve discs and the valve bonnet. The result is hardening of the viton O-ring either by direct rf or by heat generated by the resonance. If the hardening is excessive the valve can no longer close with a satisfactorily small leak rate to change the klystrons during operation.

This same problem has been observed only a few times since the beginning of operation, hence does not appear to be an immediate crucial operational problem, but it does mean that some times the stations have to be left off until a down period when the tube can be removed after the whole sector is let up to nitrogen.

VI. ACCELERATOR ELECTRONICS

(April 1, 1970 to March 31, 1971)

A. Main Modulators

These units continued to operate satisfactorily with an average of 22,000 hours recorded running time. We continued to improve them in various areas to increase their reliability and reduce maintenance time.

We continued to watch closely our large, expensive components for indications that they might be reaching end-of-life but have not noticed anything serious other than the usual problems, as follows.

1. Pulse Capacitors

These units continued to be our most troublesome problem, although we are gradually working out of it with new, improved capacitors. The original capacitors, which at the end of the period comprised 39% of the total units, had the most failures with 657 failed during the past year. There were an additional 80 failures among the remainder, which are improved types. One year ago we had 50% original capacitors and 50% improved types.

During the past year we made a contract for 2500 improved type capacitors, the result of an evaluation program conducted over the past several years. We have received nearly 700 of them. Three hundred and twenty were installed in Sectors 1 and 2 in February and have been operating satisfactorily with no failures.

2. Rectifier Transformers and Charging Chokes

We continued to have problems with some of our rectifier transformers. Most of them were oil leaks around the high voltage bushings and cracked ceramic insulators around the low voltage studs. During the past 12 months we repaired 38. This compares favorably with 50 the previous 12 months and 60 the 12 months before that.

During the past 12 months we experienced 20 charging choke failures. This compares with 21 the previous 12 months. These units had internal problems necessitating complete rebuilding at an outside shop.

3. Pulse Transformer Tank Assembly

During the past 12 months we processed 300 of these assemblies. Whenever the klystron is taken off them for repair or replacement, the tank assembly

must be reprocessed. In the case of units that have been on klystrons a year or more, the reprocessing is more thorough, including complete disassembly, cleaning, and recalibration of the capacitive voltage divider. It is interesting to note that four of the original 245 tanks are still operating with over 20,000 hours on them over the five years the machine has been in use.

During this operation the pulse transformers are checked and minor problems corrected. Major problems are corrected by sending the transformers out to the original vendor. During the past year we sent 20 transformers out for such work. In most of them the cores had to be replaced.

4. Main Rectifiers

Only eight failed during the past 12 months as compared with 13 the previous 12 months and 24 the 12 months previous to that. Our operating time has only decreased a little during that period so it appears we have been weeding out the weak units during the past several years.

In each case of a failure, a single diode appears to open internally causing arcing which works outside the diode, eventually causing a small fire in that area. The fire protection wires mounted above these rectifier assemblies actuate an alarm and turn off high voltage and fans. In all cases the fire extinguishes itself and only three out of a total of 60 cards are damaged. The damaged cards are replaced and the rectifier restored to service.

Over three years ago we obtained 29 backup source rectifiers from several manufacturers for evaluation on the accelerator. They are still operating satisfactorily and since we have been able to repair the old units no further purchasing of these units has been necessary.

5. De-Q'ing SCR Assemblies

During the past 12 months we had 84 SCR assembly failures compared with 51 the previous 12 months and 40 the 12 months before that. Thirty-two (38%) of these failures were in high power sectors (21, 22, 23, and 24). Since the high power sectors comprise only 13% of the whole accelerator, it appears that we are experiencing about three times higher failure rate in those sectors than on the rest of the machine.

We are continuing our efforts to improve these units. At the close of the quarter we were investigating self-contained spark gaps to provide additional fault protection.

6. Pulse Cable Assemblies

These units, which transfer pulse power from the modulator cabinet to the pulse transformer tank, had 19 failures the past 12 months compared with 43 the previous 12 months.

The failure rate is decreasing because we replace many of the original units with new improved ones before failure.

We have been constantly seeking better, longer-lived units. In this effort we contracted for a run of solid silicone rubber cable with terminations. At the end of the quarter about 75% of this work was complete.

7. Hydrogen Thyratrons

The average life of all failed tubes from the start of accelerator operations to date is still increasing with 5340 hours as compared with 5150 hours 12 months ago. The quarterly average age at failure is holding fairly constant at 6000 hours. Cumulative MTBF has been fairly constant around 6700 hours for a year and a half. Figure 11 shows these trends.

CH1191. The Wagner CH1191's life appears to be levelling off around 6500 hours, as can be seen in Fig. 12. Included are failures in 265 kV sectors (21, 22, 23, and 24) which are shorter lived on the average than on other sectors. As we add more sectors to such operation the average life of these tubes should decrease somewhat.

The high power sectors have had a total of 25 failures with an overall average of 3389 hours. This number is still increasing but what it will ultimately be is difficult to predict at this time.

CH1222. As mentioned in our last report, we started life testing in December, 1969, a very large hydrogen thyratron, the Wagner Electric Company CH1222. It has 2000 sq cm cathode area compared with 800 for the CH1191 and a 15 ampere average current rating compared with 8. We life tested it on a water load in the Test Laboratory over a year. In March, 1971, we terminated our test because the modulator it was in was needed in other tests. It was subsequently loaned to the Klystron Department for use on their 300 kV modulator. After only 50 additional hours, it ran into troubles and never recovered. Its total life was 9666 hours.

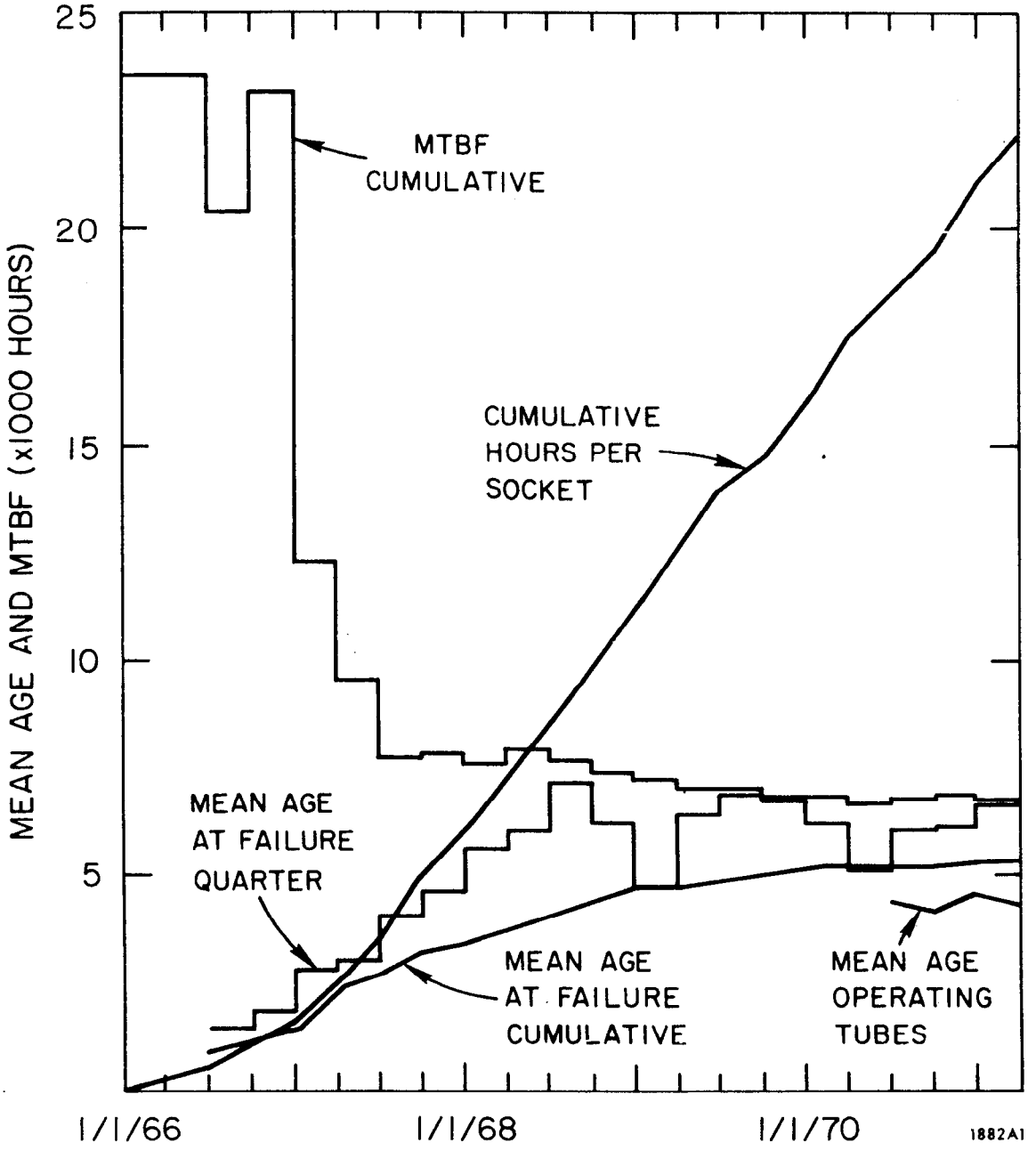

FIG. 11--Hydrogen thyratrons: cumulative MTBF, mean age, mean age at failure, cumulative age at failure, and cumulative hours per socket, March 31, 1971.

KU275C. We continued to evaluate this tube as rapidly as possible by running as many as we could on the accelerator. At the end of the period we had 84 of them on the accelerator with an average age of 2902 hours.

We have had a total of 35 failures to date since it was first introduced in 1969. The average life is 3421 hours and increasing. A chart showing each failure is shown in Fig. 13. It has a great deal more variation from point-to-point than the Wagner chart in Fig. 12, mainly because each failure is plotted in Fig. 13, while each point in Fig. 12 is the average of 10 tubes.

Trigger thyratrons. The small trigger thyratrons (HY-61, KU71) are running well with an average life around 7000-8000 hours. We would like to replace them with a semiconductor trigger system which should be less expensive to run. Work toward this end proceeded throughout this period.

B. Subbooster Modulators

We continued the modifications mentioned in our last report, namely: fast recycling, holding circuits on the fault lights, and other improvements to reduce maintenance time. By the end of the period four subboosters were modified (Sectors 9, 10, 11, and 12).

C. Two Modulators on One Power Supply

In connection with our studies to upgrade the energy of the accelerator, we took part in an experiment to determine if two 30 MW klystrons could be run on two modulators fed from the same power supply but at 180 pps instead of 360 pps. The rf outputs from the two klystrons were combined in one waveguide and fed to the accelerator below.

We used two modulators in the Test Laboratory for this test. We fed both modulators from the same power supply using charging diodes to isolate them from one another pulsewise. Repetition rate, of course, was limited to 180 pps in order to stay within the power ratings of the power supply.

This test proved the feasibility of this type of operation. There were no unusual problems. We could de-Q both pulse forming networks with good pulse height stability (0.1%).

Upon completion of this test, we moved one of the modulators (prototype No. 1) out to the accelerator and hooked it into 26-7 modulator for further tests on the machine. That experiment was also successful.

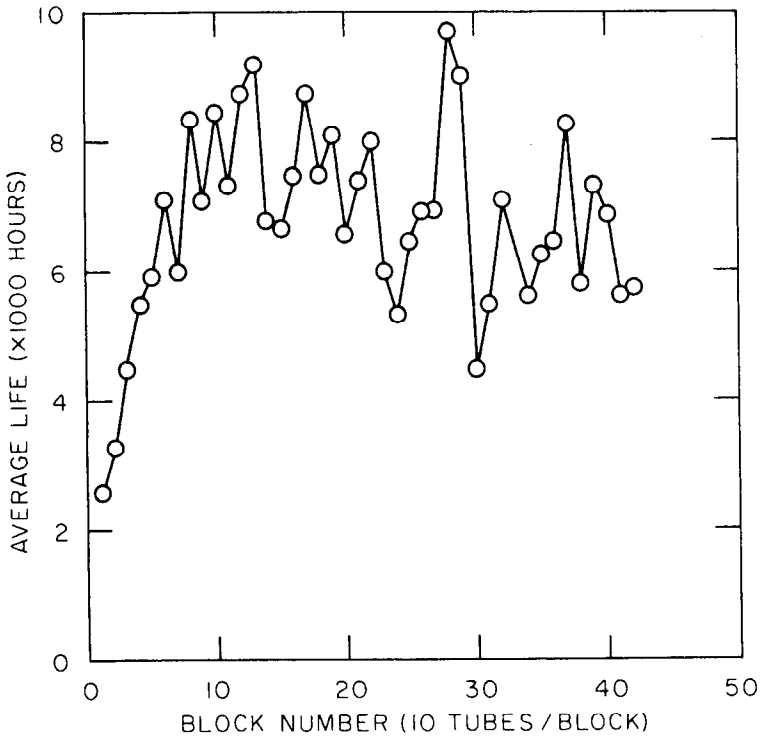

FIG. 12--Hydrogen thyratrons: age at failure of 420 CH1191 tubes, means of 10-tube groups.

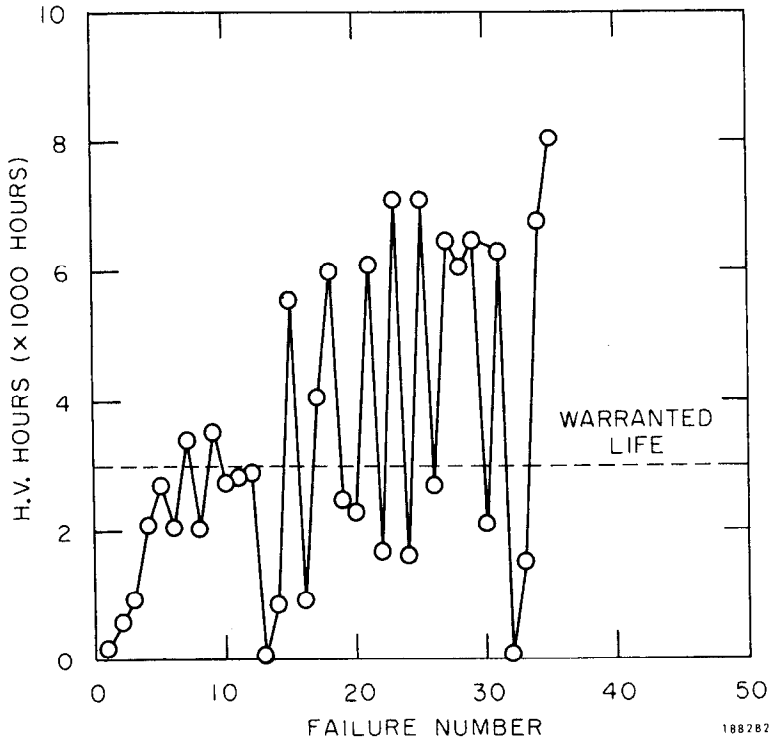

FIG. 13--Hydrogen thyratrons: age at failure of 35 KU275C tubes.

D. Double Pulse Modulator

Another experiment we participated in for upgrading the energy of the accelerator called for two pulses from our main modulators separated by 20 microseconds with 360 of these pulse pairs per second. In order not to exceed the average power capability of the power supply, output pulses were limited to 200 kV. The idea behind this scheme was to provide two 10 MW rf pulses from our klystrons separated by 20 microseconds for recirculation of the beam. The first pulse would accelerate the electron beam through the accelerator whereupon it would be fed back to the front of the machine and during the second pulse it would be accelerated again.

We performed this work on a standard modulator in the Test Laboratory. The present pulse forming network was divided into two halves and each half discharged through the common pulse transformer by its own thyratron. This is shown schematically in Fig. 14.

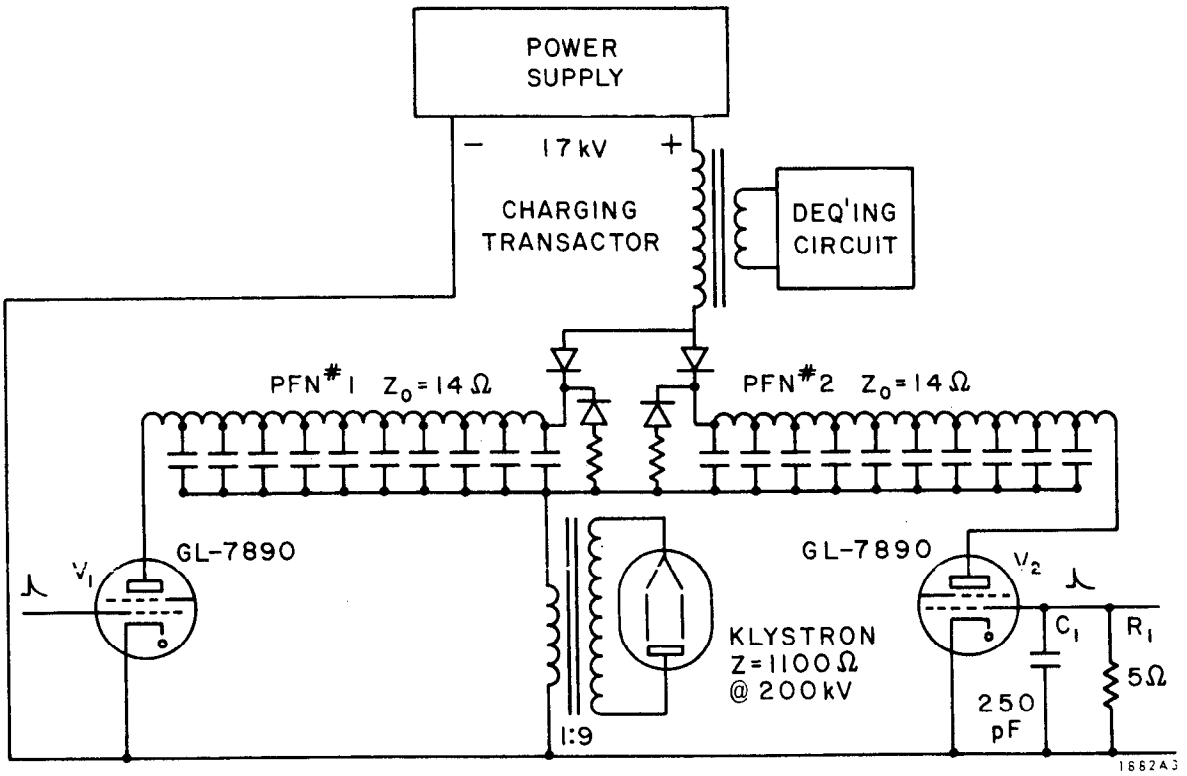

FIG. 14--Divided pulse-forming network for double-pulse modulator.

We produced two 180 kV 2.5 microsecond pulses separated by the required 20 microseconds. In fact other separations may be had between 2 microseconds and 250 microseconds merely by varying the time delay between the two trigger pulses.

In addition to the above changes, we added an additional charging diode and an end-of-line clipper diode circuit, and changed the pulse transformer from the standard 12:1 ratio to 9:1. The extra charging diode was necessary to isolate the two pulse forming networks electrically. The extra end-of-line clipper circuit was necessary to protect the second pulse-forming network from over voltages due to klystron arcs. The change in pulse transformer ratio was necessary to match the impedance of the existing pulse-forming networks to the klystron load which at 200 kV is 1100 ohms.

The pulse transformer proved to be the weak part of the circuit because it exhibited saturation effects above 180 kV. We used one of our standard 12:1 transformers and merely rewound the primary for a 9:1 ratio. If the transformer were properly designed for this application, we feel that 200 kV operation without saturation would be possible. In addition, if the transformer were further modified to have an appropriate tap which would give us a 12:1 ratio, we could have two sockets on the pulse transformer tank, one for the 9:1 ratio for double pulse type operation and the other for normal 12:1 ratio 250 kV operation and by plugging the cable between the modulator and the pulse transformer tank into the appropriate socket and firing the thyratrons separately or in unison one could utilize the modulators for either type of operation.

In passing, it is well to mention the interaction problem one can expect with this type of modulator and the method we used to solve it. As expected when one encloses two modulators in the same cabinet with no shielding between them the thyratron that is supposed to fire later, V_2 in Fig. 4, will fire at the same time as V_1 because of stray coupling between the circuits. This was a formidable problem which was finally solved by loading the grid circuit of V_2 heavily. It was necessary to go as low as 5 ohms on R_1 and as high as 250 pf on C_1 to eliminate such sympathetic firing.

E. Pulse Magnet Power Supplies

During the past 12 months we continued our efforts to improve these units. We widened the SCR gate pulses to make them fire more reliably, built new

pulse transformers to feed the wider pulses to the SCR gates, and designed and built a new regulator for regulating the voltage on the energy storage capacitor. The old regulator used a triode vacuum tube (which was sensitive to anode voltage) to feed current to the energy storage capacitor. The new circuit uses a tetrode which makes charge current independent of anode voltage, and other things being equal, improved stability.

F. Alpha Magnet Pulser

During this report period we designed and built a pulser to feed pulse power to a new electron gun setup in the injector.

G. Modifications for Computer Operation of the Accelerator

In keeping with our efforts to computerize operation of the accelerator, we modified the steering magnet controllers for use with the computer.

Engineering work was also done on the pattern generator to make it controllable by the computer.

H. Pulsed Quad, Steering, and Beam Loading Delay Drivers

Over the past several years we have been adding additional beam handling equipment to the accelerator, in particular, pulse steering quadrupole and beam loading delay units. The existing line driver system in Central Control Room was not able to handle the extra signals so we modified the system in such a way that about 100 miles of twisted pair transmission lines were saved. Instead of adding additional drivers in CCR, we added five repeaters along the accelerator, each feeding six sectors.

I. Modification of Battery Chargers

This project, mentioned in our last report (April 1, 1969 - March 31, 1970) was finished during this period. The modification operates very well; it has virtually eliminated troubles from the chargers, and has speeded maintenance of them.

J. Beam Guidance Multiplexers

We designed and built 10 of these units, of which four are installed in Sectors 11, 25, 28, and 29; three others are installed in Sectors 4, 5, and 6. Their purpose is to feed output current information from pulsed quadrupole, pulsed steering, and dc steering to CCR for operating such supplies from CCR.

VII. PLANT ENGINEERING

Project work in support of the colliding beam storage ring in the north target yard continued throughout the quarter. Construction of the two interaction pits was started and completed. Erection of the power supply and control buildings is essentially complete. Installation of above-ground electrical utilities is approximately 25% done. Construction of the storage ring housing will commence next month and is scheduled to be finished in October, 1971. Design is well along on the balance of the facilities and a number of bid invitations for this work will be issued in the next quarter. Included are: paving, bridge trestle, water utilities, and erection of the two interaction pit buildings. This overall effort is the major item in the current plant engineering field program.

Eleven individual projects, programmatically approved by the Atomic Energy Commission for FY-71 funding, relate to the Fire, Safety, and Adequacy of Operation program. Two of these (Service for Remote Radiation Monitors, and Standby Computer Power) are complete. The remaining nine are in various stages of scoping, design, or construction. All are scheduled for completion by July, 1971.

Field work is in progress on several other capital projects, the principal ones being as follows:

1. Film Procesing Facility — a second processing unit was added and is in operation. Bids for installation of air conditioning are being solicited.
2. B-Beam Equipment Shelter (Bldg. 413) — this new building is in place in the research yard and construction is complete.
3. End Station B Utility Extension — installation of the mechanical and electrical components in support of new beam line experiments is well along.
4. Installation of 5-kV contactors — installation of four of the contactors in Bldg. 108 has been made. The remaining two will be installed later in the year as the operational schedule permits.
5. Cooling Tower Cell — this project increases the capacity of the BSY cooling water tower by adding a cell to the three already in service. A contract has been awarded and field work will commence in May, 1971.

6. Two-MVA Unit Substation — installation of this electrical facility in the research yard is 50% complete.
7. Relocation of Bldg. 403 — this research yard building will be enlarged and relocated to a position adjacent to Bldg. 413 in support of new beam line experiments. A concrete pad has already been placed and the move is scheduled for April, 1971.

Preliminary work on various other items, as stated below, is under way.

1. Electrical Utilities — procurement has been initiated for a transformer to replace the unit damaged in service in the BSY substation. Engineering is progressing for the installation of a ground current relay system in the research yard.
2. Engineering Studies — an engineering study for the conversion of the SLAC two-mile machine to a superconducting accelerator was continued. A cost estimate for the conventional facilities associated with a recirculating accelerator beam (SUPERSLOOP) was made for SLAC management. Various electric power service and load studies were conducted in connection with optimizing the SLAC buildings and the establishment of an off-site facility for power factor correction.

The department's ongoing program of plant utilities operation and minor modifications to buildings and site structures was continued. Modifications are being made in Bldg. 214 to accommodate the installation of the Standard Computer in April, 1971. Extensive remodeling of several buildings in the research yard for new beam experiments has been necessary during the quarter. An addition to the north boundary fence was made and the security fence along Klystron Gallery Sectors 28, 29, and 30 was relocated so as to include the Central Control Building in the site radiation area.

VIII. RESEARCH DIVISION DEVELOPMENT

A. Data Analysis

1. Hardware

Hummingbirds. A new calibration pattern, suitable for the forthcoming e-ρ experiment (E-65), was made and installed. Preliminary runs indicate a residual error after calibration of approximately 4 microns. This is better than it used to be, presumably because the raster (and hence distortions) are smaller.

Due in part to hardware improvements (increased beam current and better track detection circuitry) the overall "pass" rate on HB3 improved from 50% to 86% on streamer chamber film, which is the level for conventional hand measurements. As a result it was decided to push into production, so a few minor hardware items were cleaned up in preparation for this.

Scan Tables. New lenses have been received, and platens and lens adapter hardware fabricated, to accommodate the new single strip 35 mm film format for the 82" chamber camera. A trial assembly will be made in April.

The 40" bubble chamber IMP is being modified to allow better image quality monitoring. It will be available at the start of the April 15 accelerator cycle.

SPVB. The Kennedy tape drive has been reworked at the factory and has been returned in good condition. It is now installed on Group G's SPVB.

2. Software

NRI System. Release 5 of BUCAPS is now in production. This contains requested operating changes for E-40 and E-48. The tape error recovery and repositioning routines have been modified to make the Datamec and A-11 drives compatible.

A high-priority effort has started on Release 6, which is to contain the software necessary for quickly and routinely measuring the constancy of fiducial separation. The film to be checked is the 3-strip 35 mm format from the 82" chamber, which has exhibited problems in the past. It is expected that this release will be ready in April to test film from BC-33, -38, and -43.

Hummingbird. Individual software packages for recognizing spark images, three-dimensional sparks, and tracks, for the e-ρ experiment (E-65) have been completed and checked out using simulated data.

As noted above, Hummingbird 3 now works satisfactorily on streamer chamber film as far as accuracy and pass rate are concerned. Therefore a high priority effort is being given to just those programming changes necessary for a production system. Operator training is currently under way, and first attempts at production should take place early in April.

3. Operations

During January an estimated 250,000 frames were scanned and 35,000 events were measured. Of this total events measured, approximately 16,000 were done on the NRI system and about 14,000 on the Spiral Reader. In addition a small amount of work was done on Hummingbird 2 in decoding Experiment 22 data boxes; about 37 rolls were completed before work was interrupted to permit maintenance personnel to make some changes in the machine. Work on Hummingbird 2 has since resumed.

During February 246,000 frames were scanned in 1885 hours, and 36,000 events were measured in 2700 hours (15,600 on the NRI system, 14,800 on the Spiral Reader, and 5600 on other conventional machines). In addition 40 rolls (about 140,000 frames) of data box decoding for the π-ρ experiment were done on Hummingbird 2.

During March 300,000 frames were scanned in 1750 hours; over 38,000 events were measured in 2900 hours. Of these events measured, 12,200 were done on the Spiral Reader in 330 hours, 19,400 on the NRI system, and the remainder on the Vanguards and the SPVB. In addition about 60 rolls (210,000 frames) of the π-ρ data box decoding were done on Hummingbird 2.

B. SPEAR Activities

1. Main Magnet System

Out of 36 bending magnet cores required for the project, we have 11 on site. The initial data indicates that it may be desirable for us selectively to place the bending magnets within the ring so as to optimize their performance. It is probably possible to carry out this procedure on small groups of magnets, so that the installation can begin before delivery of all 36 magnets is completed.

Of the required 18 concrete girders, 14 are now poured and curing. All the support footings are in place in the north research yard.

Sextupole magnet assembly on a production basis has now started in Building 101 and we hope to obtain an output of about 2 magnets per day. Magnetic measurements will then be performed upon them.

2. Vacuum System

Eight complete distributed-ion pump assemblies have been finished. It is expected that, by the end of April, all pump assemblies will have been fabricated.

The bellows testing program has been completed. The bellows exceeded the design criteria, including 1/8-inch offset and 290°C, with approximately 1-1/2 in of travel. These bellows are currently in the procurement stage and delivery of the first group is expected in April. Three prototype synchrotron radiation masks have been fabricated. Tests of two are under way.

3. RF System

Complete drawings are being made of the Collins rf power supply as modified at SLAC. The mechanical layout for the coaxial transmission lines and combiners is being planned. Construction work is continuing on the master-oscillator-low-power driver. A tenth Collins rf power supply is being obtained from the Stanford Radio Sciences Laboratory. Most parts of the rf cavity are in the weld shop and on schedule.

4. I/C System

The fabrication of the first engineering prototype of the stripline beam position monitor was interrupted when it was discovered that over a kilowatt would flow out of each monitor at maximum stored beam current. We cannot afford such sensitive monitors. A new design was modeled and has been sent to the shops; it consists of four electrodes, capacitively coupled to the beam, which exhibit a position sensitivity of 30 μV/mA peak/mm. The power output at maximum beam is approximately 3 watts per port. Since the monitor is also sensitive to the polarity of the beam charge, the sum signal will be helpful in identifying the two beams.

The optical test setup for studying mirror deformation in the beam profile monitor is being modified and improved. Metallurgical surveys and some theoretical studies related to mirror deformation have begun.

Design work has begun on the dc current transformer to measure the total stored current. Four toroidal cores have been ordered, enough to make two monitors. Circuit design is now in process for this monitor. Systems design of the communication system for the ring is now complete and detailed design work started. The on/off control chassis for the rf system has been designed and is now in the shop. Cable-tray layout around the ring has been settled. Finally, all parts have been received for the ion-pump current monitors.

5. Injection

The laminated core for the second septum magnet has been stacked and final assembly of detail magnet parts has started. Detail design of the copper portion of the septum straight section is complete and machining will begin about the end of March, when we receive the forged copper billets. The detail design of the aluminum portion of the septum straight section is completed and will be released for fabrication. Integral-copper-gasket/half mil 347 S.S. windows for the beam-transport-to-storage-ring interface have been fabricated and await vacuum testing. Support frame drawings have been released to the shops for all six injection straight sections in addition to six other straight sections.

6. Transport System

Considerable progress was made during the month on installation of the upstream section of the beam equipment inside the BSY housing, although other work within the BSY created priority conflicts which prevented achievement of all the scheduled work.

The following work was completed: 15PM1, the pulse magnet providing the initial deflection to the beam, was installed complete. All equipment stands to the slit 15SL1 were installed. All interferences with housing wall and SL10 piping were removed by cutting and rerouting. Magnets 15D1, 15D2 were installed to check for fit and field measurement of vacuum pipe, then removed for further magnetic measurements. Drift pipe through SL10, SL11 enclosure was installed and field-welded. All cable-trays and trunk control cables inside the housing were installed and are ready for termination.

C. Magnet Research

1. Flux Exclusion Tube

Following the unsuccessful tests with Nb_xTi sheet and tubes plated with Nb_3Sn and Nb_xTi by a plasma arc process, attention was switched to Nb_3Sn ribbon. The low field-shielding capability of helical windings was shown to be due to motion of the ribbon caused by the magnetic forces. This was cured by hot-coating the ribbon with Wood's Alloy, thereby solidly bonding successive layers to each other. As the Nb_3Sn tape is limited in width to 50 mm, edge effects and flux penetration into the tubes made the interpretation of the measurements difficult. However, by constructing the tube out of two half-shells, external fields in excess of 17 kG have been successfully shielded. Each half-shell is prepared separately by pressure-forming a sandwich of long strips of ribbon bonded together with a lead-tin eutectic solder, which proved to be superior in peel strength to Wood's alloy. The characteristics of a number of such tubes are being systematically measured, the parameters of interest being the number of layers of ribbon and the penetration of the field into the tube at the ends, and at the overlaps.

The technique for manufacturing the half-shells in length exceeding 3 m is being refined. The helium supply system and dewar have been designed and parts are currently being made in various shops. The flux exclusion tube itself has been designed, but the final details will be fixed only after the behavior of the tube has been fully understood.

2. Model Wire Chamber Magnet and Superconducting Field Mirrors

This project has been displaced for the time being by the large aperture superconducting solenoid system. However, before the final decision was reached, a pulsed model magnet facility was set up in the Electronics Building, and some peripherals were built, in particular, the field mirror, dewars, and related equipment.

3. Magnets for General Lab Use

Two general-purpose magnets for lab use were built. One is a 4-1/2" bore solenoid, the other a Helmholtz coil supported on an iron yoke, and a gap of 2" between the iron pole-pieces, providing a transverse field, both magnets being primarily intended for studies on flux exclusion tubes.

4. Large Aperture Superconducting Solenoid

A considerable amount of time was devoted to theoretical analysis and design work for this project.

5. Laboratory Maintenance

A program of maintenance and repair of all equipment associated with the production of liquid helium has been completed.

All power supplies and electrical systems were checked and operated under variable load conditions. The data acquisition setup was checked and all instruments calibrated.

6. Computer Programs

All computer programs generated by the Magnet Research Group have been debugged as far as practicable and they are now service-worthy. NUTCRACKER has received much attention and it is now a reasonably fast and very reliable tool for two-dimensional magnetostatic problems. Several versions are available, the differences between them being the problem size capacity and the output format. A small-problem version is permanently available as a load module on disc in the SLAC 360.

If demand warrants it, a version of TRIM, the LRL analog of NUTCRACKER, can be made similarly available.

D. Computation Group Activities

The major recent development is the decision of Standard Computer Corporation not to produce the MLP 900 processor which we had considered receiving for our research purposes. This processor will not be further developed by Standard until they have some assurances in the form of definite orders and/or contracts that they will have sufficient sales. However, they have made an alternate proposal which seems consonant with the Computation Group's research effort. They are proposing a system which is quite similar to the original system except that it has an older version of the main central processor, while it has the same general input/output and peripheral configuration. This system would be quite sufficient to perform the research which currently the Computation Group Systems Lab is focusing upon, although not quite as advanced or as easy to program as the system originally proposed. We are currently negotiating the final disposition of that equipment.

Work on the Graphics System progresses as usual. Of particular interest is the recent publicity given to the work on the detection and visualization of earthquake data relating the Bay Area. This work, in conjunction with the U.S. Geological Survey, has received considerable attention in the local newspapers and is an excellent example of the utility of graphic systems for data visualization and study.

During January a paper was presented at the Fourth Hawaii International Conference on Systems Sciences. This paper was based upon this group's study of text editing and the job-entry systems we may have available in the future. The work described is a very general system wherein one could easily modify the form and details of commands typed by a wide variety of users of the system. Consequently one can imagine systems which permit certain users to use very sophisticated detail command languages, whereas other users (say secretaries) are provided with a much simpler interface. None of the present text-editor systems at SLAC has the ability to provide this variety of interfaces, although we would like them to be used by a wide variety of individuals around the lab. This form of organization may be very useful in the design of future systems of text entry here at SLAC.

E. Physical Electronics

1. Gallium Arsenide Statistics Program

The emission characteristics of glass scintillator samples have been measured for 10 and 15 keV electron beams. A low temperature glass-ceramic-metal seal is being assembled in order to use this glass scintillator as a high vacuum, bakeable window.

2. Kapitza Resistance

Pinhole camera studies of helium sputtering were carried out to determine sputtering uniformity for the Kapitza resistance program.

3. Deposition Rate Monitor

A SLAC deposition rate monitor has been modified by conversion to FET circuitry for increased stability with ambient temperature and load. It is currently stable to within 3 Hz/24 hours, and will be used to measure nitrogen uptake during the formation of niobium nitride.

4. Gas Purification

Preliminary data has been obtained for the design of a recirculating gas purification system, to be used for spark chamber noble gas mixtures.

IX. PUBLICATIONS ISSUED

Journal Articles

SLAC-PUB-738 Rev.
FORWARD COMPTON SCATTERING AMPLITUDE AS A SIMULTANEOUS ANALYTIC FUNCTION OF COMPLEX PHOTON MASS AND ENERGY. Ashok suri (SLAC, and UC Santa Cruz). 104p. Submitted to Phys. Rev.

SLAC-PUB-767
UNITARY PHENOMENOLOGICAL DESCRIPTION OF THREE-PARTICLE SYSTEMS. H. Pierre Noyes. Phys. Rev. Lett. 25, 321-24, Aug 1970.

SLAC-PUB-788
THE REACTION $\pi^- p \rightarrow \pi^+ \Delta^-$ AT CMS ENERGIES 1640-1760 MeV. A. D. Brody, R. J. Cashmore, A. Kernan, D.W.G.S. Leith, B. G. Levi, B. C. Shen (SLAC); D. J. Herndon, L. R. Price, A. H. Rosenfeld, P. Soding (UCRL Berkeley). 13p. Submitted to Phys. Lett. B.

SLAC-PUB-790
PRODUCTION OF B(1235) and $\rho(1710)$ 4π ENHANCEMENTS IN 16 GeV/c $\pi^{\pm}p$ COLLISIONS. J. Ballam, G. B. Chadwick, Z.G.T. Guiragossian, W. B. Johnson, D.W.G.S. Leith, K. Moriyasu. 14p.

SLAC-PUB-806 Rev.
COMMENTS ON "REALIZATION OF AN ARBITRARY SWITCHING FUNCTION WITH A TWO-LEVEL NETWORK OF THRESHOLD AND PARITY ELEMENTS." Keith W. Henderson. 5p. Submitted to IEEE Trans. on Computers.

SLAC-PUB-847
THE DEUTERON ELECTROMAGNETIC FORM FACTOR. R. Blankenbecler, J. F. Gunion. 16p. Submitted to Phys. Rev.

SLAC-PUB-849
ANOTHER BOUND ON THE ABSORPTIVE PART OF ELASTIC SCATTERING AMPLITUDES. R. Savit, R. Blankenbecler (SLAC); M. B. Einhorn (UCRL Berkeley). 25p. Submitted to J. Math. Phys.

SLAC-PUB-850
FOURIER DESCRIPTORS FOR TWO-DIMENSIONAL SHAPES. Ralph Roskies (Yale U.); Charles Zahn (SLAC). 47p. Submitted to JACM.

SLAC-PUB-851
ENERGY DEPENDENCE OF THE REACTION $\gamma p \rightarrow \rho^- \Delta^{++}$. J. Ballam, G. B. Chadwick, A. Levy, M. M. Menke, P. Seyboth, A. Shapira (SLAC); Y. Eisenberg, B. Haber, E. E. Ronat, Y. Stahl, G. Yekutieli (Weizmann Inst.). 10p. Submitted to Phys. Rev. Lett.

SLAC-PUB-852
PHOTOPRODUCTION OF ω-MESONS FROM 1.2 TO 8.2 GeV. Y. Eisenberg, B. Haber, E. E. Ronat, Y. Stahl, G. Yekutieli (Weizmann Inst.); J. Ballam, G. B. Chadwick, M. M. Menke, P. Seyboth, A. Shapira (SLAC); J. Gandsman, J. Grunhaus, A. Levy (Tel-Aviv U.). 13p. Submitted to Phys. Lett. B.

SLAC-PUB-853
THE EIGENVALUES AND EIGENVECTORS OF THE INTERACTION TERM IN LOCAL QUANTUM FIELD THEORY. David S. Kershaw. 19p. Submitted to Phys. Rev.

SLAC-PUB-854
RELATIVISTIC EXTENSION OF THE ELECTROMAGNETIC CURRENT FOR COMPOSITE SYSTEMS. Francis E. Close (SLAC); Hugh Osborn (Glasgow U.). 9p. Submitted to Phys. Lett. B.

SLAC-PUB-857
OPTICAL TRANSMITTANCE OF COMMON CERENKOV COUNTER GASES. E. L. Garwin, A. Roder. 7p. Submitted to Nucl. Instrum. Methods.

SLAC-PUB-858
MUON-PROTON DEEP INELASTIC SCATTERING. T. J. Braunstein, J. Cox, W. L. Lakin, F. Martin, M. L. Perl, W. T. Toner, T. F. Zipf (SLAC); H. C. Bryant, B. D. Dieterle (New Mexico U.). 11p. Submitted to Phys. Rev. Lett.

SLAC-PUB-864
PHYSICAL BASIS FOR AN EXPANDING HIGH-ENERGY INTERACTION RADIUS. Leo Stodolsky. 12p. Submitted to Phys. Rev. Lett.

SLAC-PUB-865
ACCURACY OF IBM'S SUBROUTINE GAUSS. D. H. Budenaers. 5p. Submitted to Commun. ACM.

SLAC-PUB-867
EIKONAL APPROXIMATION IN PSEUDOSCALAR THEORY. C. E. Carlson (EFI, Chicago U.); T. L. Neff (SLAC). 14p. Submitted to Phys. Rev.

SLAC-PUB-868
COMPARISON OF MUON-PROTON AND ELECTRON-PROTON DEEP INELASTIC SCATTERING. W. T. Toner, T. J. Braunstein, W. L. Lakin, F. Martin, M. L. Perl, T. F. Zipf (SLAC); H. C. Bryant, B. D. Dieterle (New Mexico U.). 12p. Submitted to Phys. Rev. Lett.

SLAC-PUB-887
DOUBLE PARTICLE EXCHANGE IN HADRONIC REACTIONS. Haim Harari. 11p. Submitted to Phys. Rev. Lett.

Conference Papers

1971 PARTICLE ACCELERATOR CONFERENCE, 1-3 MARCH, 1971, CHICAGO, ILLINOIS

SLAC-PUB-862
BEAM - RF CAVITY STABILITY WITH FEEDBACK CONTROL IN A CIRCULAR ACCELERATOR. Martin Lee. 2p. Presented.

SLAC-PUB-863
EFFECTS OF TRANSVERSE COUPLING IN THE SLAC STORAGE RING. P. L. Morton, N. C. Spencer, 2p. Presented.

SLAC-PUB-866
SLAC CONTROL ROOM CONSOLIDATION USING LINKED COMPUTERS. K. Breymayer, T. Constant, K. Crook, J. Hall, T. Huang, D. Reagan, P. Sandland, W. Struven. 4p. Submitted.

SLAC-PUB-869
A SOLID STATE DC POLARITY REVERSING SWITCH. M. M. Berndt, C. Guracar. 2p. Presented.

SLAC-PUB-870
RECENT IDEAS ON UPGRADING THE SLAC ACCELERATOR. R. H. Miller, R. H. Helm, W. B. Herrmannsfeldt, J. V. Lebacqz, G. A. Loew, R. B. Neal, C. W. Olson, J. R. Rees. 5p. Presented.

SLAC-PUB-871
SLAC CONTROL ROOM CONSOLIDATION — SOFTWARE ASPECTS. S. Howry, R. Johnson, J. Piccioni, V. Waithman. 2p. Submitted.

SLAC-PUB-874
FAST BEAM MONITOR USING SYNCHROTRON LIGHT. Andrew P. Sabersky. 4p. Submitted.

SLAC-PUB-875
APPLICATION OF TRAVELLING WAVE RESONATORS TO SUPERCONDUCTING LINEAR ACCELERATORS. W. R. Fowkes, P. B. Wilson. 3p. Submitted.

SLAC-PUB-879
A PRECISION ACTUATOR AND SHAFT ENCODER FOR A HIGH RADIATION ENVIRONMENT AND OTHER BEAM COMPONENT DEVELOPMENTS AT SLAC. L. R. Lucas, D. R. Walz. 4p. Presented.

SLAC-PUB-882
A HIGH-RESOLUTION BEAM INTENSITY PROFILE MONITOR. D. R. Walz, E. J. Seppi, 4p. Presented.

SLAC-PUB-886
COLLIDING BEAMS: PRESENT STATUS; AND THE SLAC PROJECT. B. Richter. 3p. Invited paper presented.

Technical Reports

SLAC-121
THE PHYSICS OF ELECTRON STORAGE RINGS; AN INTRODUCTION. Matthew Sands (UC Santa Cruz). 172 p.

SLAC-127
DIRECT EMULATION OF CONTROL STRUCTURES BY A PARALLEL MICRO-COMPUTER. Victor R. Lesser. 64p.

SLAC-128
TWO-MILE ACCELERATOR PROJECT; Quarterly Status Report July 1 to September 30, 1970. 90p.

SLAC-129
INELASTIC ELECTRON SCATTERING AT LARGE ANGLES. Guthrie Miller. 141p. (Ph.D. thesis.)

Other Publications by SLAC Authors

PARTON MODEL AND INELASTIC PROCESSES WITH TWO PHOTONS. Stanley J. Brodsky (SLAC); Probir Roy (Cornell LNS). Jan 1971. 20p. (CLNS-137) Submitted to Phys. Rev.

NEUTRON-PROTON ELASTIC SCATTERING FROM 5 TO 30 GeV/c. Bruce G. Gibbard, Michael J. Longo, Lawrence W. Jones, John. R. O'Fallon (Univ. of Michigan); Michael N. Kreisler (Princeton); Martin L. Perl (SLAC). n.d. 71p. (UM-HE-71-1)

Other Publications, Based upon Results of Research at Research at SLAC

BRANCHING RATIOS OF THE A_2^+ MESON OBSERVED IN 7 GeV/c π^+p INTERACTIONS. M. Alston-Garnjost, A. Barbaro-Galtieri, W. F. Buhl, S. E. Derenzo, L. D. Epperson, S. M. Flatte, J. H. Friedman, G. R. Lynch, R. L. Ott, S. D. Protopopescu, M. S. Rabin, F. T. Solmitz (UCRL Berkeley). 13p. Phys. Lett. 34B; 152-155 (1971).

STUDY OF K^+ FORWARD SCATTERING FROM THE REACTION $\pi^- p \rightarrow K^+ \Sigma(1385)^-$ AT 4.5 AND 6 GeV/c. David J. Crennell, Howard A. Gordon, Kwan-Wu Lai, James Louie, J. Michael Scarr, W. H. Sims (BNL). Feb 1971. 14p. (BNL 15523)

EVIDENCE FOR AN ADDITIONAL RESONANCE IN THE REGION OF THE K*(1420). A. Firestone, G. Goldhaber, D. Lissauer (Physics Dept. and LRL, UC-Berkeley). Feb 1971. 13p. (UCRL-20261)

OBSERVATION OF THE ANTI-OMEGA. A. Firestone, G. Goldhaber, D. Lissauer, B. M. Sheldon, G. H. Trilling (UC Berkeley and UCRL). Dec 15, 1970. 11p. (UCRL-20235) Phys. Rev. Lett. 26: 410-412 (1971).

f^0 MASS SPECTRUM IN 7-GeV/c $\pi^+ p$ INTERACTIONS. S. M. Flatte, M. Alston-Garnjost, A. Barbaro-Galtieri, S. E. Derenzo, J. H. Friedman, G. R. Lynch, S. D. Protopopescu, M. S. Rabin, F. T. Solmitz (LRL-Berkeley). Jan 1971. 10p. (UCRL-20273) Submitted to Phys. Lett. B.

BUBBLE CHAMBER STUDY OF POLARIZED $\gamma p \rightarrow \pi^+ \pi^- p$ AT 2.8 AND 4.7 GeV. Kenneth Charles Moffeit (UCRL). Nov 1970. 153p. (Ph.D. thesis.) (UCRL-19890)