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January 31, 1968

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ABSTRACT

A shutdown for repairs of the motor generator sets started on December 19, 1966, and ended this quarter. Operation for experimental physics was resumed on June 4, 1967.

Construction work continued for the new two-channel external proton beam facility.

A new magnet was installed in the Bevatron to study resonant extraction of the proton beam. Preliminary measurements started on the dynamics of the internal proton beam orbit shape, beam size, and ν values in preparation for resonant-extraction tests.

I. SHUTDOWN

A shutdown for repair of the Bevatron motor generator sets started on December 19, 1966, and continued into this quarter. The major job during this shutdown was to replace all the rotor poles of the motor generator sets. This is discussed in Section IV of this report.

Advantage was taken of this shutdown to continue and, in some cases, to accelerate construction work on the new dual-channel external proton beam (EPB) system. The Bubble Chamber Building (Bldg. 59) was demolished. Foundation piles and heavy-duty floor for the EPB shielding were poured (see Fig. 1). Steering magnets, beam vacuum pipe, and beam plugs for the EPB were installed in the Bevatron shielding wall. The EPB shielding was installed adjacent to the Bevatron shielding wall and a beam backstop was installed to allow initial beam-extraction studies. This permitted testing the EPB system up to the first focus; F1 is inside the main Bevatron shielding and the EPB shielding.

Work is well advanced for the installation of overhead sprinkler systems to protect the ceilings and roof structures of the Bevatron main ring building and the motor generator building in case of fire. This system is divided into three zones: two in the main ring building and the third in the MG Room. When installation is completed the system will be automatic. The pipes are filled with air and the pressure is monitored to detect any leaks in the pipes. Heat detectors are mounted on the ceiling. If one of the heat detectors is triggered, a valve will open automatically and fill the pipes in the appropriate zone with water. Water will spray out of only those sprinkler heads where heat has melted the fusible links. This prevents unnecessary water from being sprayed on the Bevatron and associated equipment. At present, the delivery of the automatic valves is delayed and manual valves have been installed.

A new M1 magnet for the EPB extraction system was built and installed. This magnet was built to study resonant extraction. The magnet was also designed to be compatible with normal energy-loss extraction to permit operating the EPB for experiments during normal running periods. However, because the resonant-extraction magnet required more electrical feed circuits than the magnet it replaced, there were not enough electrical feed-throughs to provide power for the quadrupole magnet that was part of the original M1-Q1 system. Therefore, both the septum magnet and the quadrupole were removed to make room for the resonant-extraction magnet. This reduced the quality of the extracted beam slightly, but it was still quite usable.

II. MACHINE OPERATION AND EXPERIMENTAL PROGRAM

During the shutdown the Bevatron operations crew had worked on a two-shift (day and swing) five-day-a-week schedule. On May 14 the operations crew went on to a three-shift seven-day-a-week schedule in preparation for normal Bevatron operation.

Overhaul and studies of the injection system continued this period. On May 11 the linear accelerator was turned on and a series of adjustments and measurements started. These adjustments and measurements were

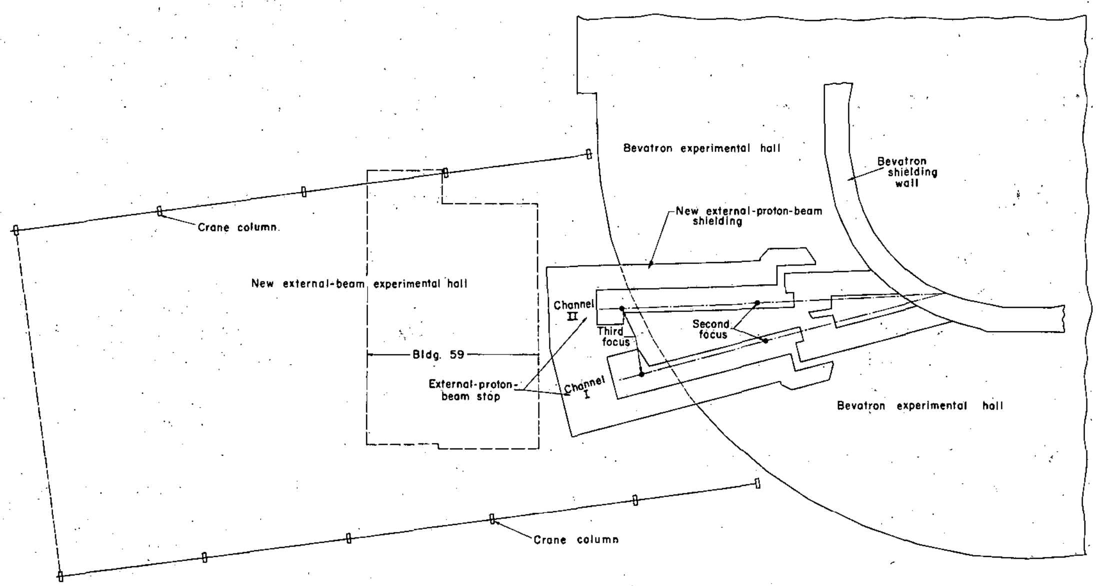

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Fig. 1. Layout of new external-beam experimental hall.

designed to return the linac to a suitable operating mode for injection into the Bevatron. These tests continued until the end of May.

On May 28 final adjustments and tests were started on the main motor generator sets in preparation for normal operation. On June 3 the Bevatron was turned on and protons were accelerated to full energy. On June 4 beam control was turned over to the Moyer Group to continue their study of K_2^0 decay modes (Expt. 47A).

There were two major modes of operation this quarter. The first mode was a 900-msec flat-top at 5.3 BeV. The beam was spilled on an internal target during a 700- to 800-msec period for the Moyer Group. The target for this experiment was near the exit of Quadrant III.

The second mode of operation was a 300-msec flat-top at 6.1 BeV. Two experiments were run on this mode, receiving their respective beam spills on alternate Bevatron magnet pulses. On the first magnet pulse the beam was spilled during a 150-msec period for the Washington–U. C. San Diego Group (Expt. 50). The Washington (Davis) Group (Expt. 54) ran as a secondary experiment at the end of the beam channel of Expt. 50. On the alternate Bevatron magnet pulse, the beam was spilled in two 300-μsec periods for the 25-Inch Bubble Chamber Group Expt. 39. The first period was just after the start of flat-top and the second period just before the end of flat-top.

A summary of the experimental program for this quarter is shown in Table I.

The Bevatron operation record is shown in Fig. 2. The beam was off 6.5% of the scheduled operating time because of equipment failure and 10.8% of the time for experimental setup, tuning, and routine checks. The beam was on 82.7% of the scheduled operating time.

III. BEVATRON DEVELOPMENT AND STUDIES

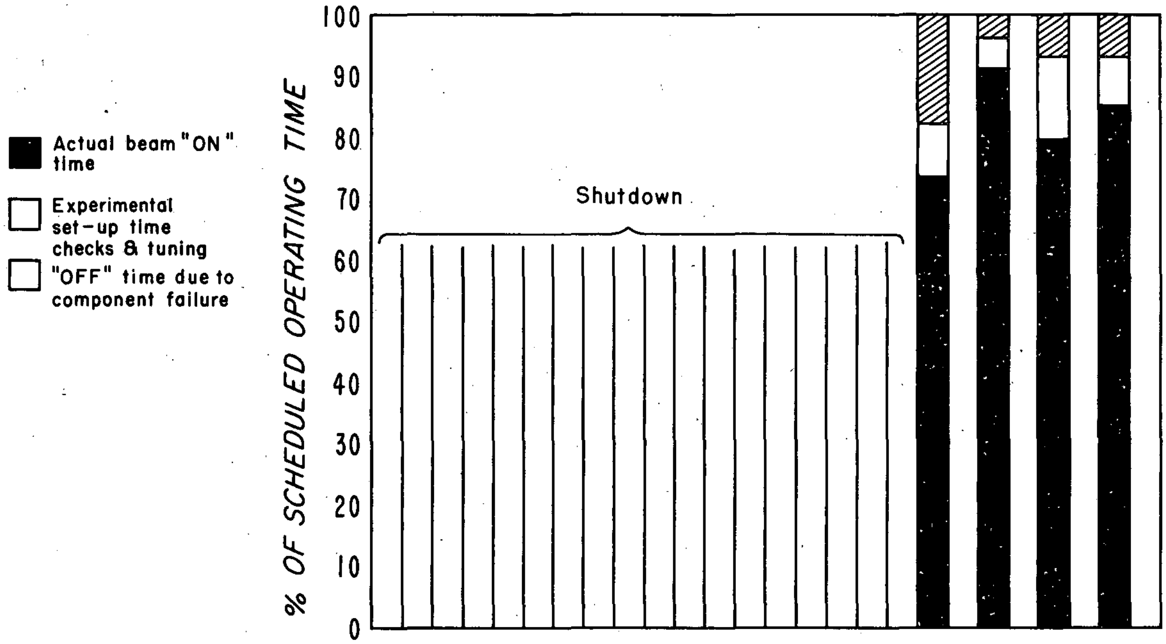
The first periods of development time were devoted to checking the beam quality and extraction efficiency of the EPB with use of the new resonant-extraction magnet. These extraction studies used the normal energy-loss target and the new septum magnet. The extraction efficiency was about the same as we had previously run (about 35%). The beam spot at the first focus was slightly larger than we had previously achieved, but looked usable. This is probably due to the absence of the first quadrupole (Q1).

The remaining periods of development time this quarter were devoted to studying the beam size and closed orbits of the beam in the Bevatron. This was in preparation for the resonant-extraction tests.

For some time we have known that the radial closed orbit in the Bevatron was about 2 in. farther outward radially in the north and west straight sections than in the east and south straight sections. More complete measurements, using the travel target in Quadrants II and III, showed a peak-to-peak amplitude of about 4.5 in. for the closed orbit. The perturbation appeared to be in the middle of Quadrant III. This was considered excessive for

Table I. Summary of Bevatron experimental research program, April through June 1967.

Groups	Dates: Run	Dates: Start	Dates: End	Experiment	Beam time: This quarter (April-June): 12-Hour periods	Beam time: This quarter (April-June): Hours	Beam time: From start of run through June 1967: 12-hour periods	Beam time: From start of run through June 1967: Hours	Pulse schedule	Primary or secondary experiment
Internal Groups										
Alvarez (Murray)	39	8/5/65	In progress	K^0-K_2^0 interference using 25-in. bubble chamber	0	2	217	2304	1:1	P
Moyer-Helmholz (Parker)	47A	5/19/66	In progress	Neutral decay rate	28	284	91	967	1:1	P
				$K_L^0 \rightarrow 2\pi^0$	0	0	66	827	1:1	S
Lofgren	67	8/28/67	In progress	Ke_2 branching ratio	0	0	0	0	1:1	P
		6/7/67		0.5-BeV/c separated K^+ beam	4	62	4	62	1:1	S
External Groups										
U. of Washington	50	3/16/66	In progress	Magnetic moment of	16	128	114	1276	1:1	S
U. C. San Diego		5/20/66	In progress	Ξ^- cascade	6	72	35	381	1:1	P
		9/10/66	In progress		0	0	39	428	1:2	P
U. of Washington (Davis)	P-12	7/21/66	In progress	Spark chamber tests	2	36	20	245	1:1	S
				for Run No. 54	0	0	38	426	1:2	S



Week of	4/2	4/9	4/16	4/23	4/30	5/7	5/14	5/21	5/28	6/4	6/11	6/18	6/25
Crew hours	80	80	80	80	80	80	80	80	64	168	168	168	168
Turn on & maintenance time (h)	0	0	0	0	0	0	0	0	0	19	9	14	11
Scheduled operating time (h)	0	0	0	0	0	0	0	0	0	131	130	100	135
Scheduled Bevatron test time (h)	0	0	0	0	0	0	0	0	0	18	29	54	22
Scheduled shutdown time	80	80	80	80	80	80	80	80	64	0	0	0	0
Holiday	0	0	0	0	0	0	0	0	16	0	0	0	0

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Fig. 2. Bevatron operating schedule.

the resonant-extraction system to work well. Magnetic field measurements were made in each of the 144 sectors by integrating the B signals from the pole base windings. The results of these measurements could account for only about half of observed closed-orbit amplitude. A compensation was computed from the closed-orbit measurements. The air gaps in six sectors in Quadrant III were increased by 112 mils. This modified the field by about 2% in each of those sectors. This modification changed the peak-to-peak amplitude of the closed orbit to less than 2 in.

A series of measurements was made to determine the radial and vertical size of the beam and the ν values as a function of radial position. This information is necessary to set the operating radius of the septum magnet and the central orbit of the proton beam. The beam dimensions turned out to be dependent on the tracking of the beam during the acceleration cycle. Optimum tracking curves were determined to give minimum radial size to the beam at the time of resonant extraction. The measured radial ν values were very close to the values calculated from the magnetic field shape curves that were measured when the Bevatron magnet was first tested.

IV. MAGNET POWER SUPPLY

Robert Frias

During this period the installation of the 16 new field poles in the two 46-MW Bevatron generators was completed. Installation had started on March 7. The poles and associated damper rings were in place by April 14. Figure 3 shows one generator rotor during the installation of the "V" block coil supports.

The Westinghouse Electric Corporation provided supervision and labor for the pole replacement as well as all jobs required to put the machines back in operation. Their crews worked two shifts a day in this effort.

The V block installation required 3 weeks for completion of both machines. Figure 4 shows the generator with V blocks installed. By May 5, the motor-generators were in the final phase of the shutdown. This phase included

shaft alignment,
stator connection,
dynamic balance,
overspeed run to insure pole seating,
final pole wedge tightening,
installing 32 lower-coil supports,
bevatron operation.

These jobs and the numerous associated jobs were complete by June 3. Bevatron operation resumed at that time, marking the conclusion of the 5-month pole-replacement shutdown.

A study to determine the cause of the pole cracks is still in progress. Initial studies have shown that fatigue damage may be caused by the cyclic change in rpm during a Bevatron pulse.

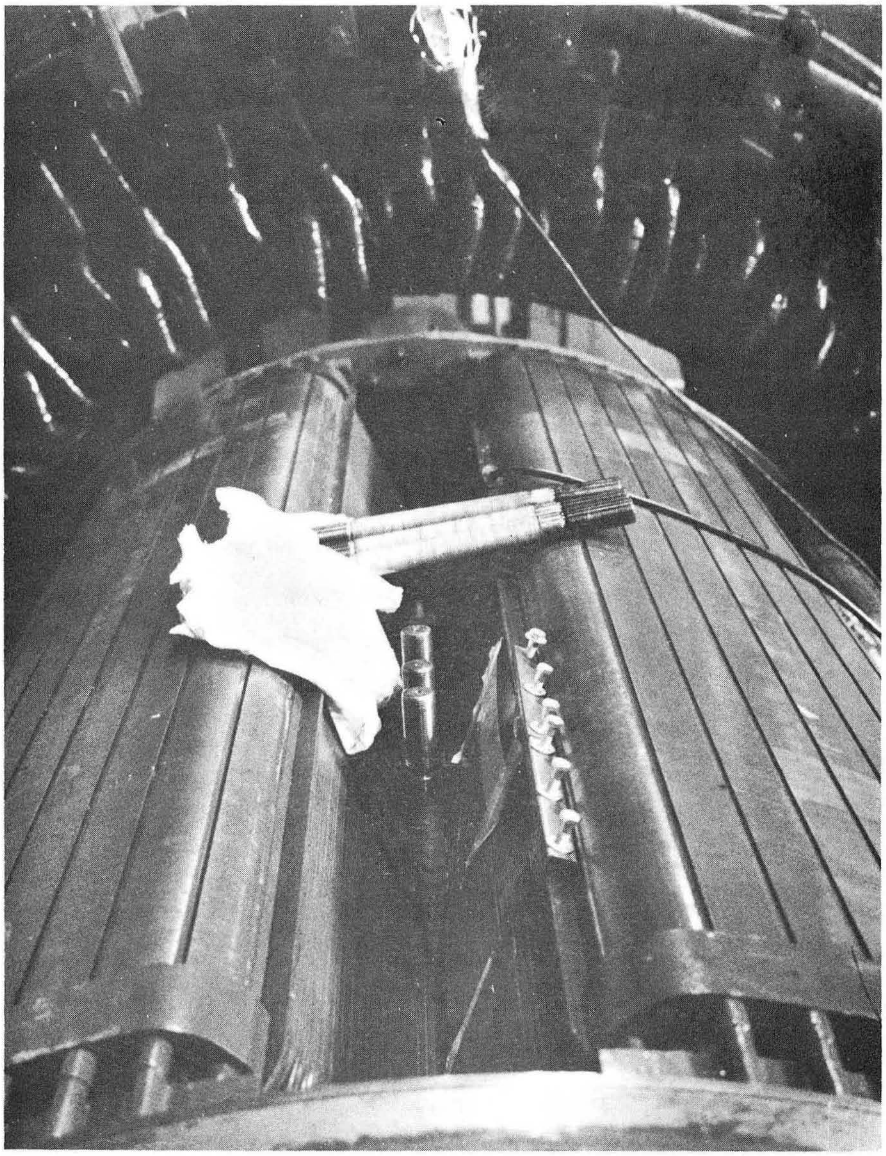

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Fig. 3. Generator rotor during installation of the V-block coil supports.

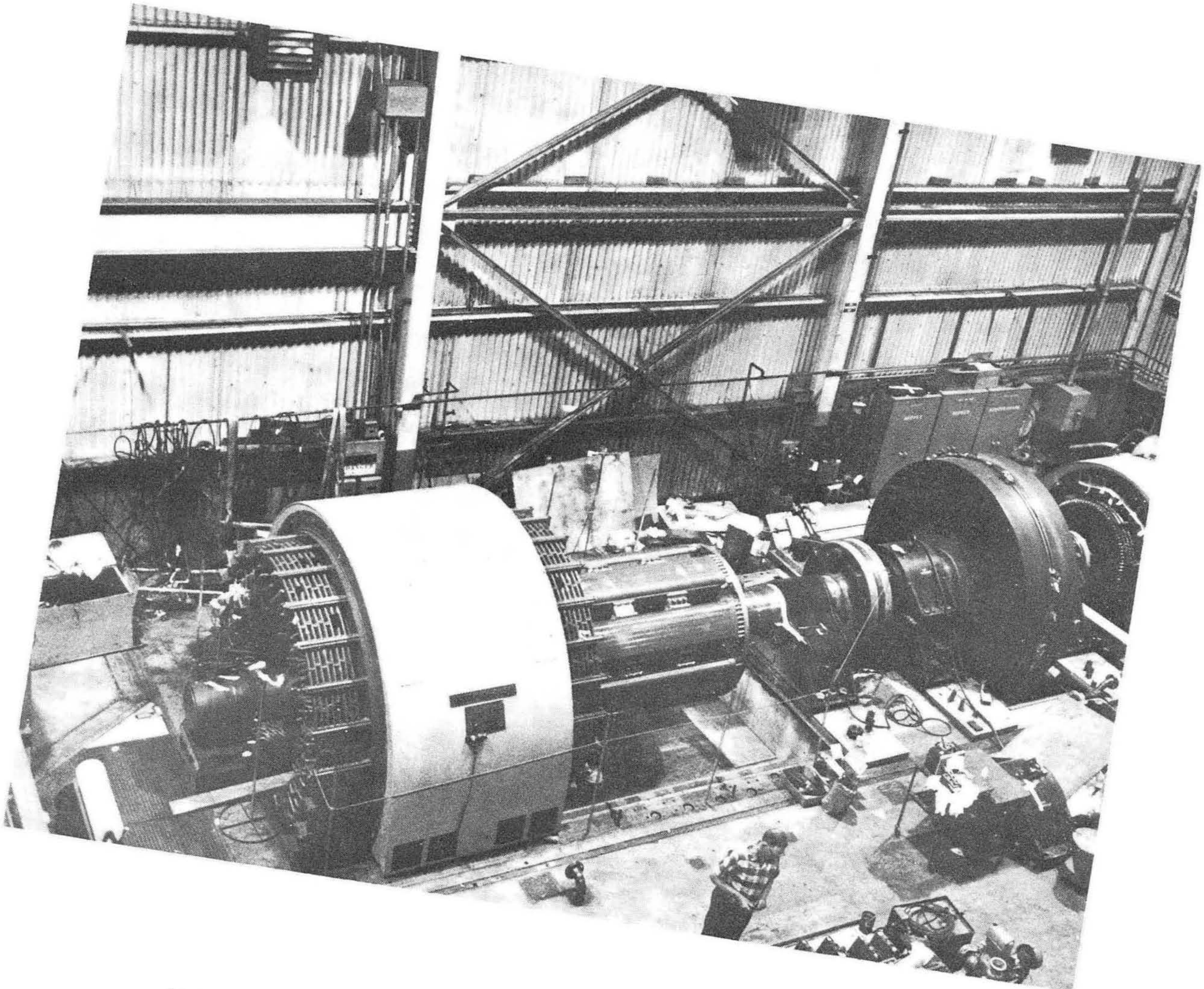

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Fig. 4. Generator with V blocks installed.

A limit of 100 rpm has been set as the maximum change in speed range during any Bevatron pulse mode. This should limit the cyclic stress amplitude to a level that will never intersect the fatigue life curve, and should result in maximum operational life.

A reduction in flat-top length is required in some pulsing modes to maintain the above-mentioned speed change limit. As an example, the limit of the flat-top at 5.3 GeV was 1 sec. It is now reduced to 0.8 sec. However, the pulse repetition rate can be increased to minimize integrated beam loss.

The magnet pulsing record is shown in Table II.

Table II. Bevatron motor generator set monthly fault report.

1967	4 to 6 pulses/min								7 to 8.7 pulses/min								9.3 to 17 pulses/min								Total				
	1.5 to 6.9 kA				7.0 to 9 kA				1.5 to 6.9 kA				7.0 to 9 kA				1.5 to 6.9 kA				7.0 to 9 kA								
	Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F	Pulses	Faults 14	Faults 26	P/F	Total	Arc backs 14	Arc through 26	P/F	Ignitrons replaced
Jan.																													No pulsing, pole replacement
Feb.																													
Mar.																													
April																													
May	1,202	0	7	171																					1,202	0	7	172	Over-speed test
June	1,660	0	0	∞					130,221	1	10	11,838	48,831	3	5	6,104	117,334	1	2	39,111	9,662	1	1	4,831	307,708	6	18	12,821	
July																													
Aug.																													
Sept.																													
Oct.																													
Nov.																													
Dec.																													

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