Title

BEVATRON OPERATION AND DEVELOPMENT. 49

Authors

Crebbin, Kenneth C
Lothrop, Fred H.G.
Fries, Robert.

Publication Date

1966-05-24

UCRL-16809

University of California

Ernest O. Lawrence Radiation Laboratory

BEVATRON OPERATION AND DEVELOPMENT. 49

DISCLAIMER

UCRL-16809
UC-28 Particle Accel.
and High Volt. Mach.
TID-4500 (48th Ed.)

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

BEVATRON OPERATION AND DEVELOPMENT. 49

Kenneth C. Crebbin, Fred H. G. Lothrop, and Robert Frias

May 24, 1966

BEVATRON OPERATION AND DEVELOPMENT. 49

January through March 1966

Contents

Abstract v

I. Machine Operation and Experimental Program 1

II. Shutdown 4

III. Bevatron Development and Studies: Radius Freedback System . . 4

IV. Magnet Power Supply: Bevatron Mezzanine Pulsing 7

Staff 15

References 16

*Preceding Quarterly Reports: UCRL-16741, UCRL-16554

BEVATRON OPERATION AND DEVELOPMENT. 49

January through March 1966

Kenneth C. Crebbin, Fred H. G. Lothrop, and Robert Frias

Lawrence Radiation Laboratory
University of California
Berkeley, California

May 24, 1966

ABSTRACT

The beam was on for experimenters 87.1% of the scheduled operating time. During the second half of 1965 a beam loss at 40 to 50 msec after injection had sporadically appeared and disappeared, causing a number of hours of lost operating time. It was determined this quarter that the new values of pole-face-winding currents set in July 1965 were in part responsible for this loss. By changing to a previous set of operating values, we were able to eliminate this sporadic loss, and have had no further outages due to early beam-loss problems. Damage was discovered in the epoxy coil potting on the septum of the first magnet in the external proton beam extraction system. It was not clear whether it was a radiation, thermal, or potting problem. A noise pickup problem that existed for some months was eliminated in the Bevatron beam induction-electrode system by the installation of a new cathode-follower circuit. This permitted us again to use the radius feedback system (Autotrack) to control the radial position of the beam during acceleration. The Autotrack system is necessary for beam tracking through a new mode of magnet pulsing known as "mezzanine." Final tests of this mode of pulsing were made and mezzanine is about to become an operating mode at the Bevatron.

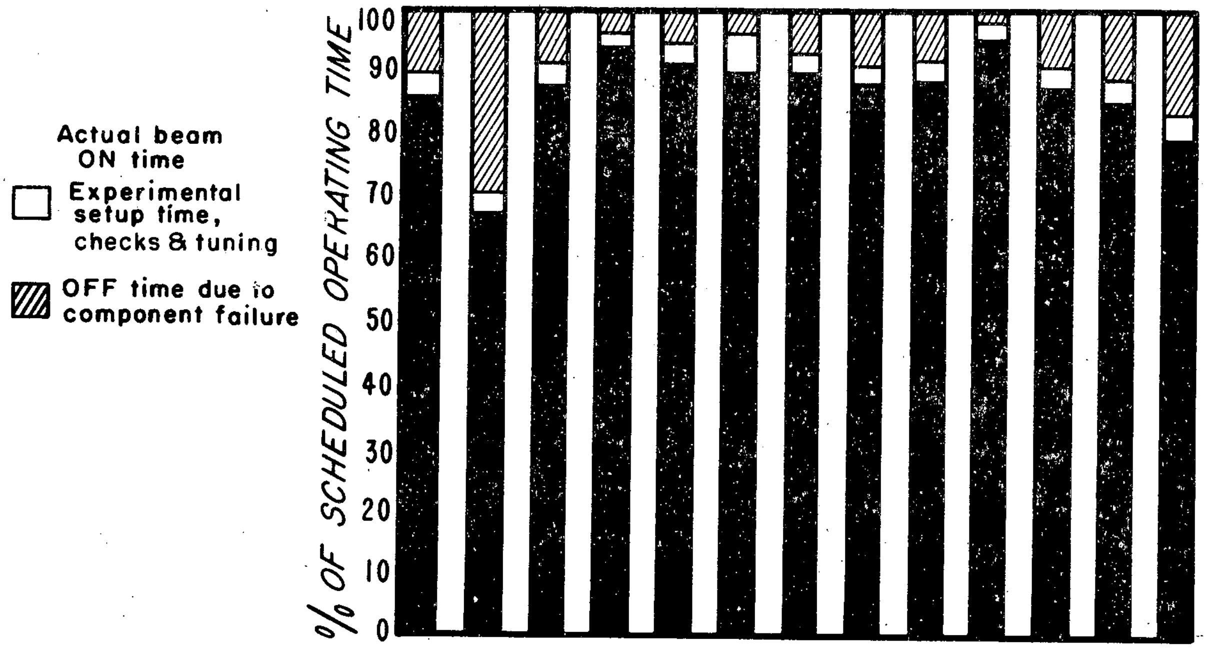
I. MACHINE OPERATION AND EXPERIMENTAL PROGRAM

The Bevatron operation record is shown in Fig. 1. The beam was on 87.1% of the scheduled operating time. The beam was off 9.4% of the time because of equipment failure and 3.5% of the time for experimental setups, tuning, and routine checks.

Two new experiments were set up using secondary-particle beams from targets inside the Bevatron. The Moyer Group experiment, number 47A, was set up at the north straight section area, and the University of Washington experiment, number 50, was set up in the west straight section area. The Segrè-Chamberlain experiment, number 37, at the external proton beam (EPB) third focus ended this quarter. A summary of the experiment program for this quarter is shown in Table I.

The operating modes of the Bevatron this quarter were essentially the same as described in the preceding quarterly report.[1]

Pole face windings (pfw) are used in the Bevatron to control the spatial shape of the magnetic field at and shortly after injection; the pfw power supply was modified in July 1965.[2] This modification permitted ramping of the pfw currents after injection and provided better control mode of individual windings. Experience to date has not shown any advantage in ramping of currents. However, some minor changes were made in the distribution of currents in the windings. These changes occurred during the month of July and August 1965, and were believed to have improved the capture efficiency. Subsequent to these changes we started to have unexplained beam losses at about 40 to 50 msec after injection. The rf system and auxiliary tracking equipment were all checked for spurious operation or noise. Changes that were made never seemed to correlate with either the beam loss or the return to normal conditions. Early this quarter the operation crew found that the beam-loss effect was changed by changing the pfw current level. Retracking of the beam also tended to reduce the loss. Once the crew started using the pfw current level as a tuning control, the situation became greatly aggravated. A search through the operating record on outages yielded the following information about time lost searching for unexplained causes of beam loss. During the first quarter of 1965 we lost 0.75 hour searching for rf noise and 0.25 hour looking for a ground loop. There were no outages during the second quarter of 1965 from unexplained beam loss. The readjustment of pfw currents was finished in August 1965. From that time on up to our Christmas shutdown we had 11 outages for a total of 21.5 hours of lost experimental time searching for unexplained beam loss. During the first three weeks of January we lost another 5.25 hours of experimental operation time for the same unexplained beam loss. These periods are only the periods experimenters were actually shut down and we took controlling time to study the problem. There were many more prime hours lost due to intensity variations that were not sufficiently bad to suspend operation but which certainly reduced the level of taking good data. It was still not clear what was changing and causing the early beam loss, but it was quite apparent that it was aggravated by the distribution of pfw currents. The changes in the pfw power supply the previous July made it impossible to return to exactly the same conditions under which we had previously operated. The new supply caused the currents to vary in time, during the magnet pulse, in a different manner than previously.



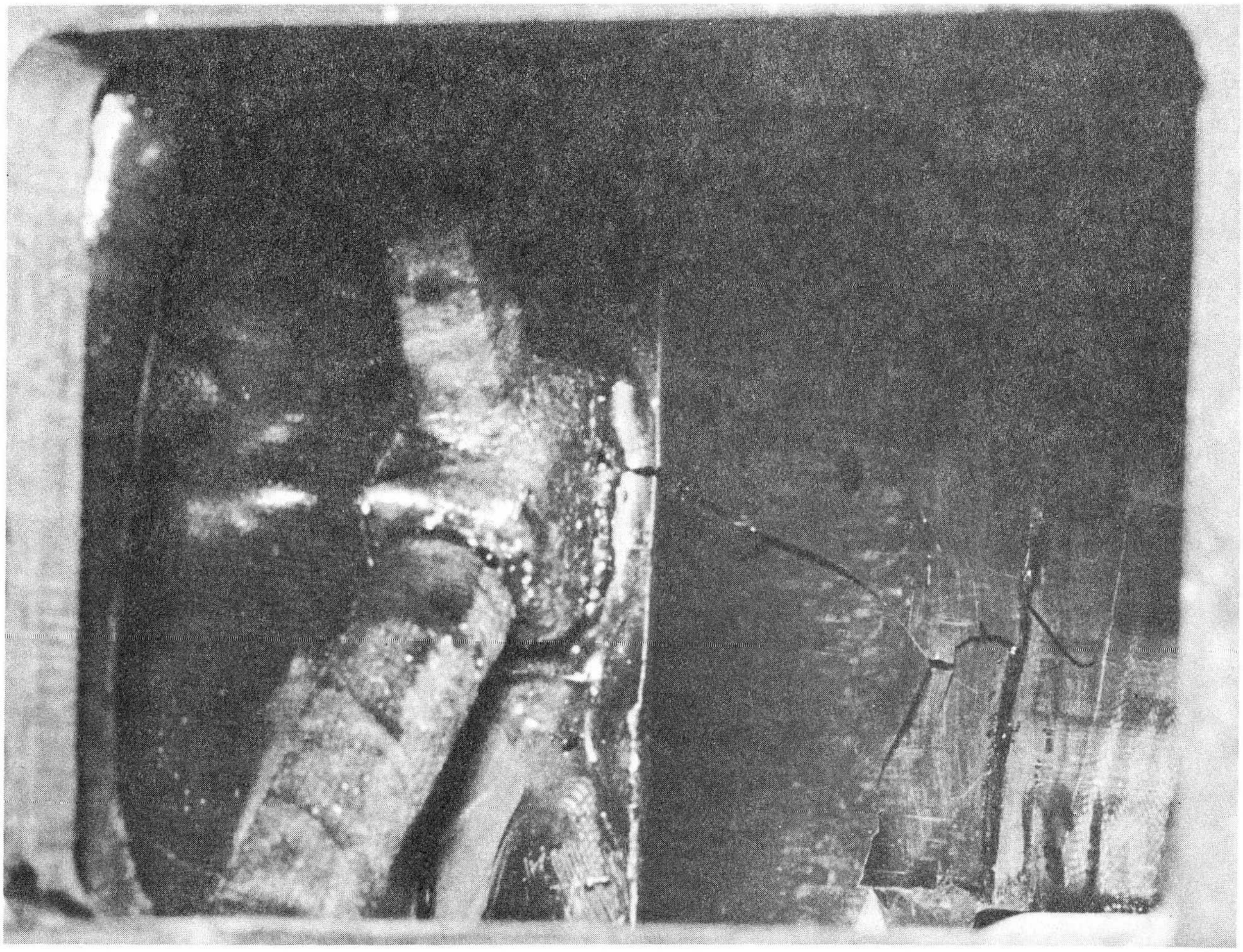
Week of	1/2	1/9	1/16	1/23	1/30	2/6	2/13	2/20	2/27	3/6	3/13	3/20	3/27
Crew hours	144	168	168	168	168	168	168	144	168	168	168	168	168
Turnon & maintenance time (h)	60	6	9	10	10	9	11	10	9	10	8	10	6
Scheduled operating time (h)	79.5	133	151	149	151	150	146	136	131	152	145	152	90
Scheduled Bevatron test time (h)	4.5	9	8	9	7	9	11	6	28	6	15	6	0
Scheduled shutdown time (h)	0	20	0	0	0	0	0	0	0	0	0	0	72
Holiday (h)	24	0	0	0	0	0	0	24	0	0	0	0	0

MUB-11176

Fig. 1. Bevatron operating schedule.

Table I. Summary of Bevatron experimental research program, January through March 1966.

Group	Run No	Start of exp.	End of experiment	Experiment	Beam time: This quarter (Jan-Mar) 12-Hour periods	Beam time: This quarter (Jan-Mar) Hours	Beam time: Start of run through March 1966 12-Hour periods	Beam time: Start of run through March 1966 Hours	Pulse schedule	Primary or secondary exp.
Internal Groups										
Alvarez - LRL	45	5/2/65	In progress In progress	Studies of p-p and π^+-p and π^--p interactions, using 72-in. bubble chamber	44	49	91 21	 233	1:1 1:1	P S
Moyer-Kenny	47A	1/28/66	In progress	Investigation of neutral particles using a π^- beam	12	139	12	139	1:1	P S
Alvarez-Murray	39	8/5/65	In progress	Study of K^0-K_2^0 interference using 25-in. bubble chamber	52	441	127	1125	1:1	P S
Segrè-Chamberlain-Stiening	40	9/2/65	In progress	Polarization of K-3 decays in spark chambers	83	928	88	994	1:1	P S
Lofgren-Cork-Wenzel	48	9/16/65	In progress	Diboson test	8	77	10	107	1:1	S
Segrè-Chamberlain-Steiner	37	8/21/65	3/14/66	Elastic scattering of pion S and K^+ in polarized proton target	95	749	180 43	1195 436	1:1 1:1	P S
Powell-Birge	55	1/18/66	2/22/66	Study of π^+ and P^+ interactions at bubble chamber and 4.1 BeV/c.	39	420	39	420	1:1	P
Powell-Birge	56	1/5/66	1/12/66	Investigation of C invariance in decay of n^0	4	51	4	51	1:1	S
External Groups										
Alvarez-UCLA-Ticho	45	5/7/66	In progress	72-in. H_2 bubble chamber	0	0	47 21	 233	1:1	P
Masek-U. of Wash.	50	3/18/66	In progress	Studies of magnetic moment of the cascade particles (Ξ) using spark chamber	1	31	1	31	1:1	S
Alvarez-Tautfest-Kruse Purdue-Illinois	45	5/7/65	In progress	Studies of p-p and π^+-p interactions using 72-in. bubble chamber	21	212	31		1:1	P
*Alvarez-UCLA-Ticho LRL-Purdue-Illinois Tautfest-Kruse	45	5/7/65	In progress	Total time shown for this run No. 45	65	261	169 21	1382 233	1:1 1:1	P S



ZN-5539

Fig. 3. Damage to EPB magnet M1.

longer confused by the spurious noise, and there are no restrictions on the use of Autotrack for programming.

A basic reason for making Autotrack operational is the advent of "mezzanine" in the magnet current waveform. Proper tracking of the proton beam through this region of the magnet pulse is facilitated by Autotrack. In fact, at this time, Autotrack is essential to the success of this mode of operation, since no special open-loop programming devices have yet been built, and most of the existing program devices must be called into operation merely for beam survival in the mezzanine region.

IV. MAGNET POWER SUPPLY: BEVATRON MEZZANINE PULSING

Robert Frias

1. History

The shape of the Bevatron magnet current has been limited to two basic configurations. Figures 4 and 5 show these two operating modes. Figure 4 is a normal pulse which allows current to rise to a peak and then return to zero. Figure 5 shows the flat-top mode, in which the peak current time is extended to allow an increased beam-spill period.

Peak current, flat-top length, and pulsing rate are limited by the power capability of the two Bevatron 3600-hp motors. An example of the full-load operational flat top is a 6200-A peak extended for 900 msec, at 10 pulses per minute.

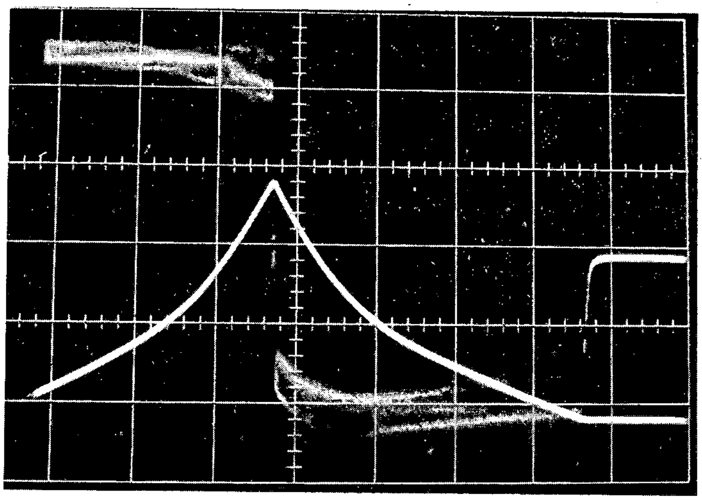
In January of 1964 an additional pulsing mode, the mezzanine, was first tested.[3] The mezzanine current waveform is shown in Fig. 6. In this mode, current rises to a plateau as in flat-top operation, but instead of decreasing at the end of the flat period, it is again allowed to increase.

The mezzanine mode makes an extended beam spill available at two different energy levels during a single pulse. Pulsing combinations of mezzanine rising to a normal peak current or mezzanine rising to a flat top can be programmed as long as the power capability of the motors is not exceeded.

2. Mezzanine Operations

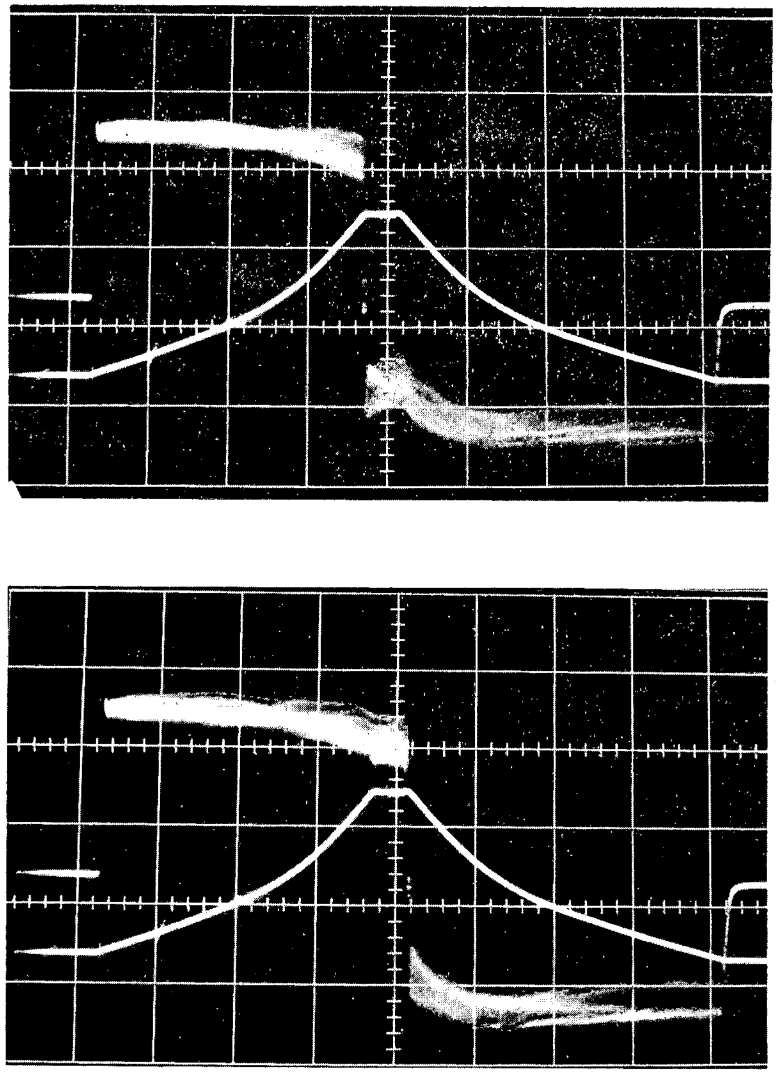
The Bevatron power supply is shown in Fig. 7. The two separate and independent units of this system are controlled by gate information from the Bevatron magnet pulser. Rectification and inversion of the units are programmed to give the desired current configuration. A mezzanine or flat-top period is obtained by delaying the start of inversion of one power supply with respect to the second.

In order to provide the proper programming for mezzanine operation, as well as all previously required timing functions, a new magnet pulser was designed, built, and installed in the motor generator room. Figure 8 shows the power supply switching necessary to develop a mezzanine followed by a flat top during the same pulse. In conjunction with these basic switching parameters, the pulser includes the following features.



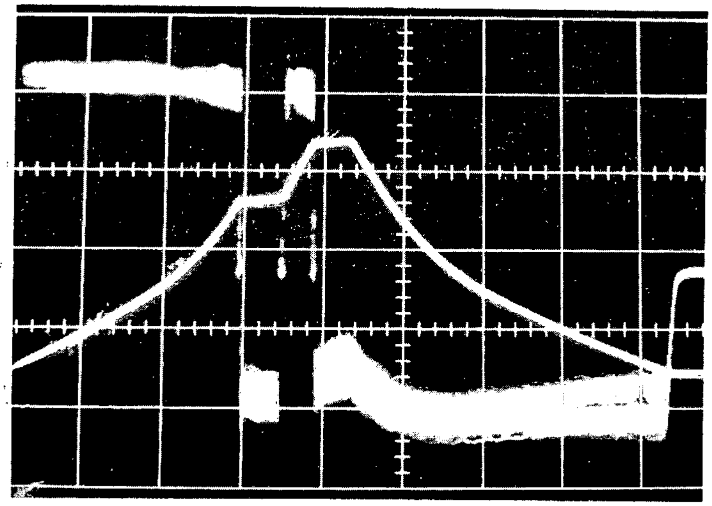
ZN-5558

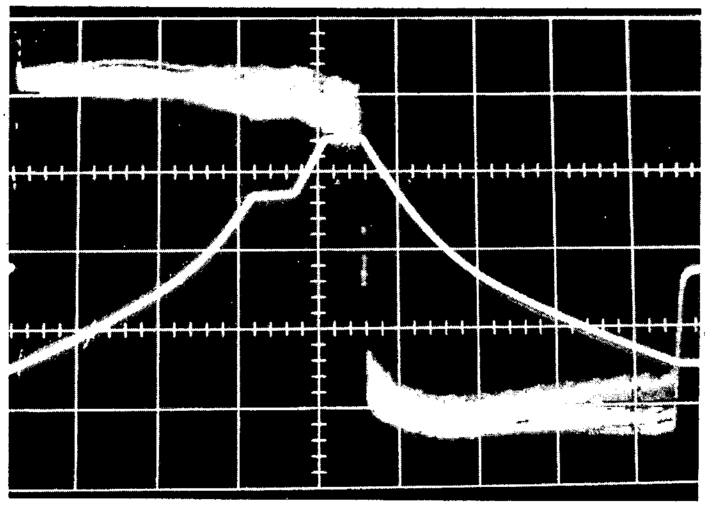
Fig. 4. A Bevatron normal pulse. Both machines begin inversion at the same time. (Only one photo is used to describe the normal pulse.)
Total magnet current: the peak is at 8333 A.
Each machine voltage: rectification = 8000 V;
inversion = - 6500 V.



ZN-5557

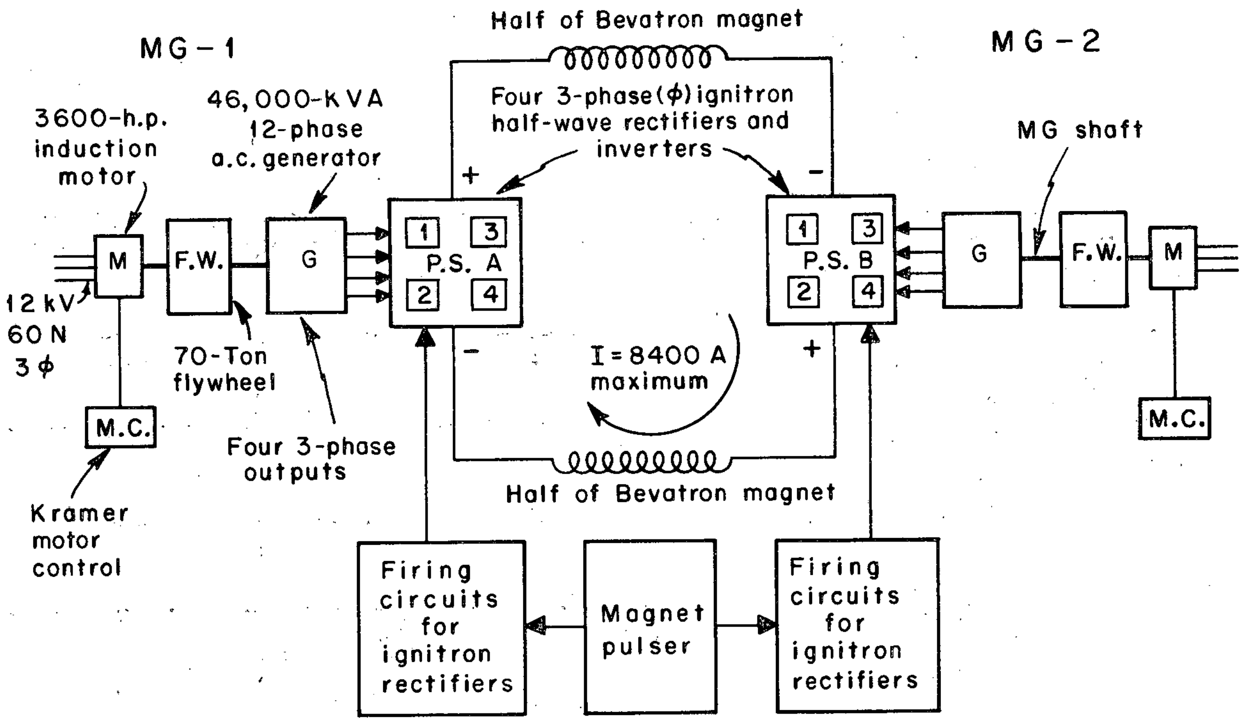
Fig. 5. A Bevatron flat-top pulse. Machine A (upper) inverts first. Machine B (lower) shows delayed inversion.
Total magnet current: 300-msec flat top at 8000 A.
Machine voltage: rectification = 8000 V;
inversion = - 6500 V.





ZN-5559

Fig. 6. A Bevatron mezzanine and flat-top pulse. Machine A (upper) inverts at the start of both modes. Machine B (lower) does not invert until the end of flat top. This indicates it was the faster machine at both modes. On the next pulse Machine A will probably be the rectifier during both modes.
Total magnet current: mezzanine -- 250 msec at 6200 A,
flat top -- 205 msec at 8200 A.
Machine voltage: rectification = 8000 V;
inversion = - 6500 V.



MUB-11178

Fig. 7. Bevatron magnet power supply.

Table II. Bevatron motor generator set monthly fault report.

4 to 6 pulses/min

1966	1.5 to 6.9 kA Pulses	Faults 14	Faults 26	P/F	7.0 to 9 kA Pulses	Faults 14	Faults 26	P/F
Jan.	4,576		1					
Feb.								
Mar.	53							
April								
May								
June								
July								
Aug.								
Sept.								
Oct.								
Nov.								
Dec.								

7 to 9 pulses/min

1966	1.5 to 6.9 kA Pulses	Faults 14	Faults 26	P/F	7.0 to 9 kA Pulses	Faults 14	Faults 26	P/F
Jan.	440				122,184	4	13	
Feb.	2,744				144,584	5	5	
Mar.	61				44,316	6	6	
April								
May								
June								
July								
Aug.								
Sept.								
Oct.								
Nov.								
Dec.								

10 to 17 pulses/min

1966	1.5 to 6.9 kA Pulses	Faults 14	Faults 26	P/F	7.0 to 9 kA Pulses	Faults 14	Faults 26	P/F
Jan.	996				209,883	13	2	
Feb.	177,870	2	1		9,519			
Mar.	178,891	4	10		145,699	7	6	
April								
May								
June								
July								
Aug.								
Sept.								
Oct.								
Nov.								
Dec.								

Total

1966	Total	Arc backs	Arc through	P/F	Ignitrons replaced
Jan.	338,079	17	16 33	10,245	2A1-Ign.Chg. 1/11/66
Feb.	334,717	7	6 13	25,747	
Mar.	369,020	17	22 39	9,462	
April					
May					
June					
July					
Aug.					
Sept.					
Oct.					
Nov.					
Dec.					

STAFF

E. J. Lofgren Walter D. Hartsough	Bevatron Group Leader In charge of Bevatron Operations
Kenneth C. Crebbin Fred H. G. Lothrop Wendell Olson	Operation supervision
William Everette	Radiation control
Duward S. Cagle Frank W. Correll Robert G. Gisser William H. Kendall	Operating crew supervisors
G. Stanley Boyle Robert W. Brokloff Aston H. Brown Gary M. Byer Norris D. Cash Donald N. Cowles James R. Guggemos Charles H. Hitchen Arthur K. Ikuma Robert M. Miller Joseph F. Smith Harvey K. Syversrud Marsh M. Tekawa John E. Tommaney Stanley T. Watts	Bevatron operators
Robert W. Allison, Jr. Trancuilo Canton Warren W. Chupp Bruce Cork Kenneth C. Crebbin Tom Elioff Robert Force Leroy T. Kerth Fred H. G. Lothrop Donald Milberger Robert Richter Glenn White William A. Wenzel Emery Zajec	Development and support
Edward Hartwig Robert Force	In charge of Electrical Engineering group
Marion Jones	In charge of Electrical Coordination group
Harold Vogel	In charge of Motor Generator group

Donald Milberger	In charge of Electrical Maintenance group
Kenow Lou Cedric Larson Abraham Glicksman	In charge of Mechanical Engineering group

REFERENCES

1. Kenneth C. Crebbin, Bevatron Operation and Development. 48, UCRL-16741, May 1966.

2. Kenneth C. Crebbin and Robert Frias, Bevatron Operation and Development. 47, UCRL-16554, March 1966.

3. Kenneth C. Crebbin, Robert Frias, William L. Evertte, and Walter D. Hartsough, Bevatron Operation and Development. 41, UCRL-11560, July 1964.

4. Kenneth C. Crebbin, William A. Wenzel, Harold W. Vogel, Henry D. Lancaster, and Rudin M. Johnson, Bevatron Operation and Development. 34, UCRL-10613, April 1963.