NALREP

MONTHLY REPORT OF THE NATIONAL ACCELERATOR LABORATORY
OCTOBER 1973

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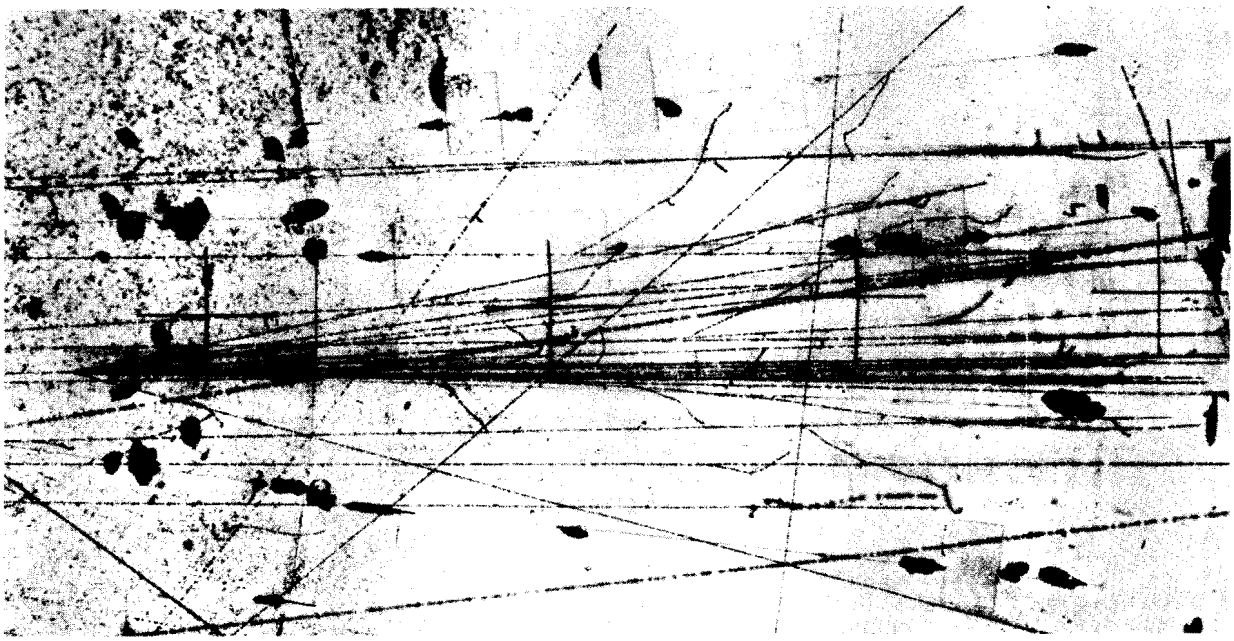

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission

National Accelerator Laboratory

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THE COVER: Interaction by a 300-GeV proton in the 15-ft bubble chamber making 14 secondaries. No magnetic field was on when this photograph was taken on October 15, 1973. Frame from which this portion was selected is shown on page 11.

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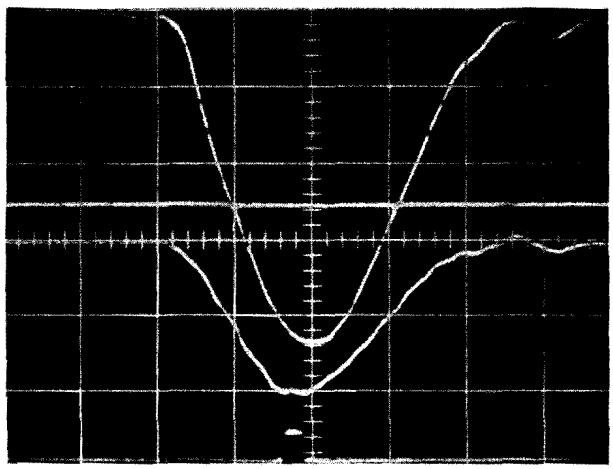
THE 15-FT BUBBLE CHAMBER

Reported by W. Fowler

On September 29, 1973, at 5:15 p.m., NAL's 15-ft bubble chamber was operated successfully for the first time. The NAL team had worked round-the-clock for several days, filling the chamber with liquid hydrogen. At last, expansions of the piston were begun very carefully on Saturday morning. At first, only very small piston motions were used. The system was watched closely for any signs indicating a misalignment. Gradually, as the confidence of the operators grew, the stroke was increased. When it reached 3.7 in., particle tracks became visible in the hydrogen, signalling the successful operation of the chamber.



20 msec/cm

An oscilloscope photograph showing data from the expansion trials on September 29. The top trace is the piston motion, showing a 3.7-in. stroke. Before expansion the chamber pressure was 60 psia; the vapor pressure of the liquid hydrogen was at a uniform temperature (50 psia). The pressure drop shown on the middle sweep is 50 psi, giving track sensitivity in the chamber.

The recording of tracks in NAL's 15-ft bubble chamber, the world's largest liquid hydrogen chamber, was the culmination of an intense three-year effort by a highly skilled and dedicated staff. The first experiment scheduled for the chamber is an engineering run by the Bubble-Chamber Group to fully test the entire system and its ability to produce significant physics results. Following successful completion of these studies, the series of approved neutrino experiments planned for the chamber will get under way.

The use of the high-energy, high-intensity proton beam of the NAL accelerator as a source of high-energy neutrinos has, from the very beginning, been a prime justification for NAL. Experiments in which neutrino interactions are studied, in many instances, require a simple target such as hydrogen. Therein lies the main impetus to construct a large-volume hydrogen bubble chamber at the Laboratory.

Initially, it had been hoped to build a 25-ft (100 m^3) chamber. A proposal was prepared in association with R. Shutt's Brookhaven National Laboratory Group, and the justification for this size chamber was the subject of two Aspen Summer Studies (1969 and 1970). Unfortunately, there were no funds to construct a chamber this large, and in the spring of 1970 it was decided to trim down the project to a 15-ft (30,000 liter) version.

When it was decided to construct the chamber at the Laboratory, an NAL Bubble-Chamber Group was formed by W. B. Fowler. In July 1970, R. Huson, who assumed the responsibility for the design and assembly, took up residence in Batavia, and serious design efforts began. Huson was joined in November by G. Mulholland, who, in addition to helping with design, was

placed in charge of testing and operations. Major aid was obtained on the optics system when W. Smart joined the team in May 1971. H. Kautzky arrived at NAL the following September and began working on the camera design. Later he was responsible for the design and construction of the metal piston. Other engineering support came from M. Morgan, H. Feng, R. Niemann (now in the Meson Section), L. Kula, and C. Pallaver. A. Skraboly, L. Mapalo, G. Nosal (now with Borg, Inc.), and H. Stapay provided design and drafting support. Many of the Operations crew members who are mentioned later also contributed to the design effort.

Both design and construction proceeded rapidly, in large part because of the readiness of the NAL group to seek ideas and assistance from others with experience in bubble-chamber work. Thus the NAL 15-ft chamber contains contributions from Argonne (the superconducting magnet), SLAC (expansion system actuator), Brookhaven (vacuum vessel design), and CERN (optics, piston, and seal).

The design of the chamber is shown on the following page. The volume of liquid, 32,000 liters, is contained in a spherical stainless-steel vessel 12.5 ft in diameter, with a hemispherical head for the optics ports 9 ft in diameter. In addition, a large beam window protrudes 2-1/2 ft between the magnet coils, giving a total track length of 15 ft for charged particles. The chamber is designed to operate with hydrogen, neon-hydrogen mixtures, and deuterium.

There is also provision for the installation of track-sensitive targets, and for internal metal plates to help make gamma rays "materialize." The

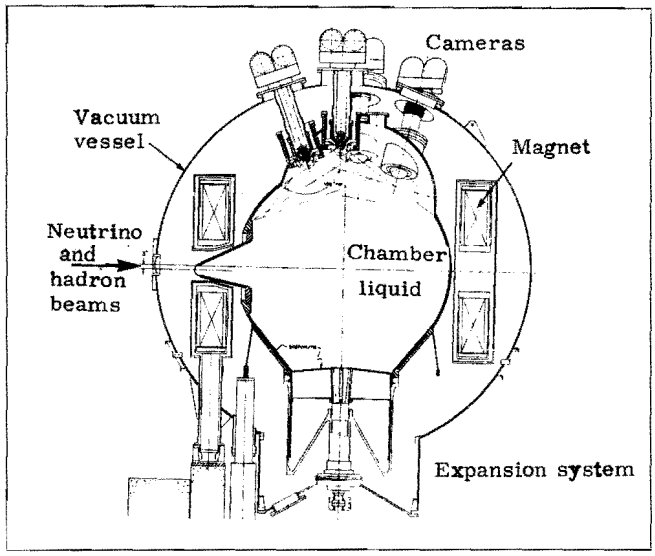
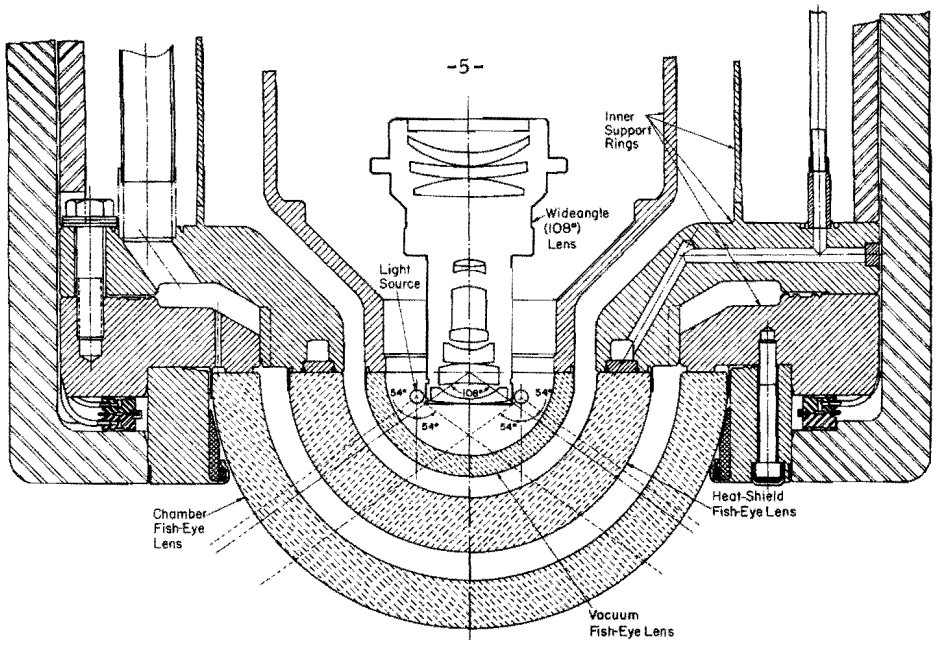


Diagram showing major components in NAL's 15-ft liquid hydrogen bubble chamber.

integration of the chamber in hybrid setups with, for example, arrays of multiwire proportional chambers, has been undertaken by the LBL-University of Hawaii collaboration of L. Stevenson and V. Peterson.

The outer vacuum chamber is a stainless-steel sphere 22 ft in diameter, capable of withstanding a test pressure of 60 psi. Under emergency conditions it will withstand up to 150 psi. It is evacuated to 10^{-6} torr by a 20-in. oil diffusion pump.

The optical system used for photographing bubbles in the 15-ft chamber consists of six 26-in. diameter ports. Each contains three hemispherical windows and a lens and film transport system. The inner camera window projects into the chamber far enough to view almost all of the liquid hydrogen. The 108° wide-angle lens produces a demagnification of the middle of the

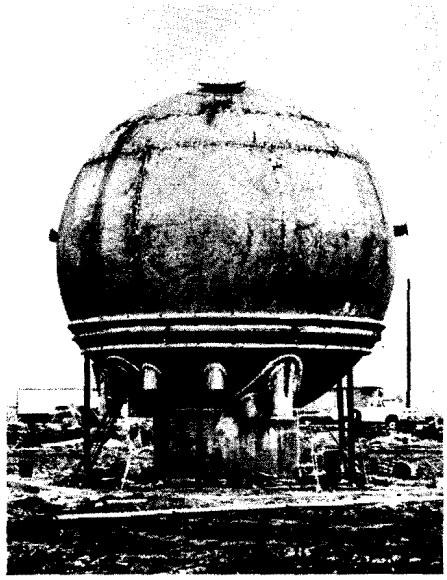


Detail of a camera port of the 15-ft bubble chamber, showing the fish-eye lenses. There are six such ports, arranged in two triangular arrays.

chamber onto the 70-mm film of 65. The chamber is illuminated by flash tubes which are concentric with the lens; the light is retrodirected by 3M Scotch-lite consisting of small glass beads applied to the chamber wall. The film is stored on 2000-ft rolls, so that it need be replaced only every eight hours.

The six camera ports are arranged in two triangular arrays. Thus hadron pictures can be taken using one set of cameras while data are being recorded for neutrino experiments using the other set. The neutrino beam to the 15-ft chamber might, for example, absorb 70 per cent of the beam early in the accelerator flat-top, still leaving the opportunity for a burst of charged particles to the chamber at the end of the flat-top.

At the opposite end of the chamber, extending into a pit far below the chamber building, is the expansion actuator system. Designed by R. Watt of SLAC and built there as a collaborative project, it consists of an ensemble of devices including drive piston, expansion valves, and recompression system. The expansion system is controlled by the movement of high-pressure nitrogen and oil. For a typical hydrogen chamber expansion of 0.7 per cent, the piston stroke is 3.7 in. An acceleration of more than 60 g's subjects various parts to high dynamic loads.



A milestone in the construction of NAL's 15-ft chamber. (Left) The inner vessel is lowered into position on November 29, 1971. (Right) The outer vacuum tank, constructed in the field because of its size, ready for installation. It was the first component of the chamber to be completed.

The superconducting magnet lies between the chamber body and the vacuum vessel. It was designed at Argonne by J. Purcell and built there as a collaborative project. It consists of a large cryostat system containing two major coils. The inner diameter of the winding is 14 ft; the outer diameter is nearly 17 ft. The magnet is comprised of approximately 3000 turns of conductor (superconducting filaments of niobium titanium embedded in copper), totaling 134,000 ft. The central magnetic field is 30 kG, created by a 5000-A operating current with a stored energy of nearly 400 MJ. In order to keep the magnet superconducting, the helium refrigerator must be able to supply 50 liters per hour.

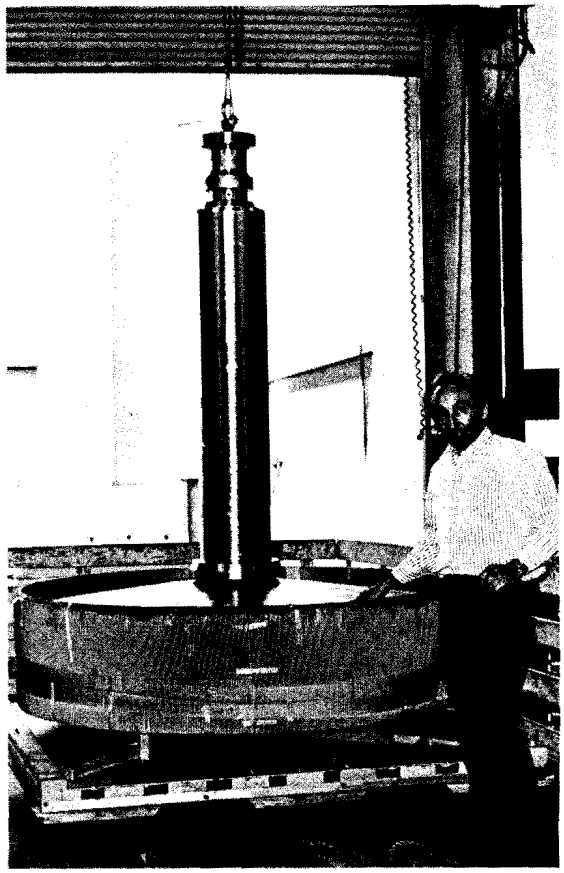
The hydrogen vessel is cooled down by circulating liquid hydrogen through cooling loops. This liquid, as well as that for filling the chamber, is provided by a hydrogen liquefier which provides an equivalent refrigerator capacity of nearly 7000 W at 23° K.

The approximately 1 per cent volumetric change which occurs during expansion of the 15-ft bubble chamber is accomplished by moving the piston--6 ft in diamter--approximately 4 in. in about 60 msec. It is not easy to build a piston strong enough, yet light and dimensionally stable to insure good seal performance with minimal heat leakage across the piston head. Also, low electrical conductivity is needed to minimize eddy-current heating.

During an expansion the forces come from the dynamic pressure difference and inertia. The piston is the only moving link between the outer "environment" around the chamber and the 32,000 liters of liquid hydrogen.

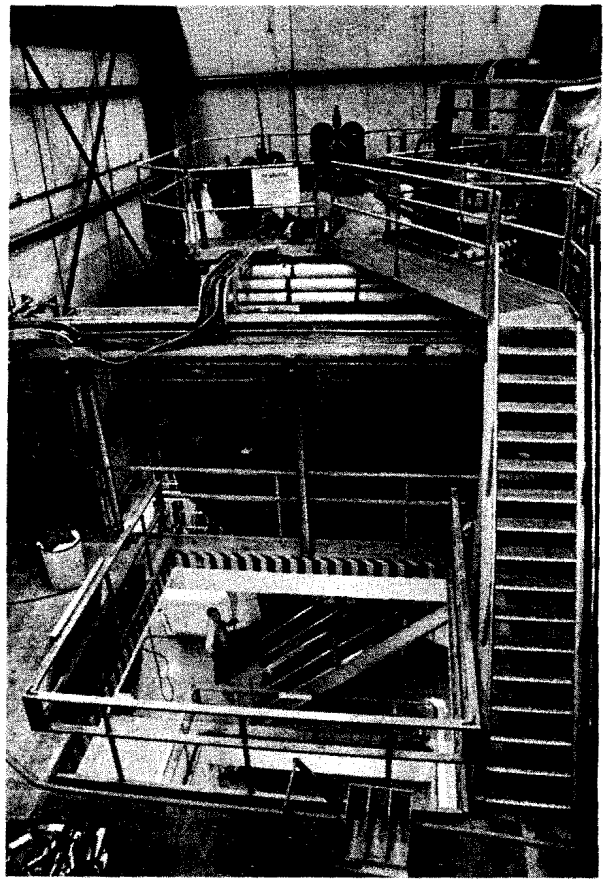
The dimensional tolerances are as small as ±0.001 in. in some instances. The structure is loaded to approximately one-half million pounds, and the accelerations which have to be allowed for are up to 100 G. In addition, the temperatures range from room to that of liquid hydrogen.

By the end of 1972 the repaired wood-fiberglass piston had failed during a test stage. A crash program to build a back-up all-metal piston was therefore begun, using a CERN piston design as a guide. This metal piston



H. Kautzky stands beside the all-metal piston installed in the 15-ft chamber. It differs from the CERN design in many ways. The ribs have stiffeners instead of holes; a new stem with full-penetration welds was developed; and the skin and joints were modified. Fabrication work was done in NAL shops in about nine weeks. This piston has been used for thousands of pulses thus far. It will be replaced by a fiberglass epoxy model now being tested.

consists of a tubular stem with a 1-in. wall, 12 in. in diameter, and 8-ft long, extending into 36 ribs at one end. This internal rib structure, made of 304 stainless steel, is covered by a skin of two cone-shaped parts and an outer cylindrical shell, all welded together. Hundreds of hours of welding were required to finish the job. Each step was inspected for quality of the weld and any unwanted distortion buildup.

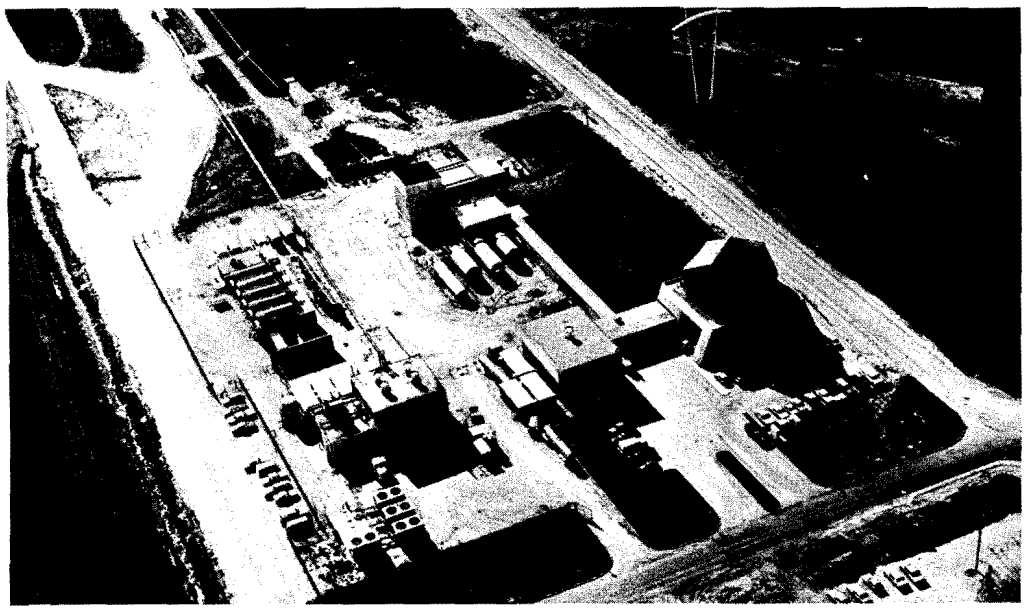


The NAL 15-ft chamber, with all sections in place, occupies 60 ft, about three floors of space. It sits on a foundation anchored in bedrock, at the end of the neutrino beam line. Steps lead to the camera magazines.

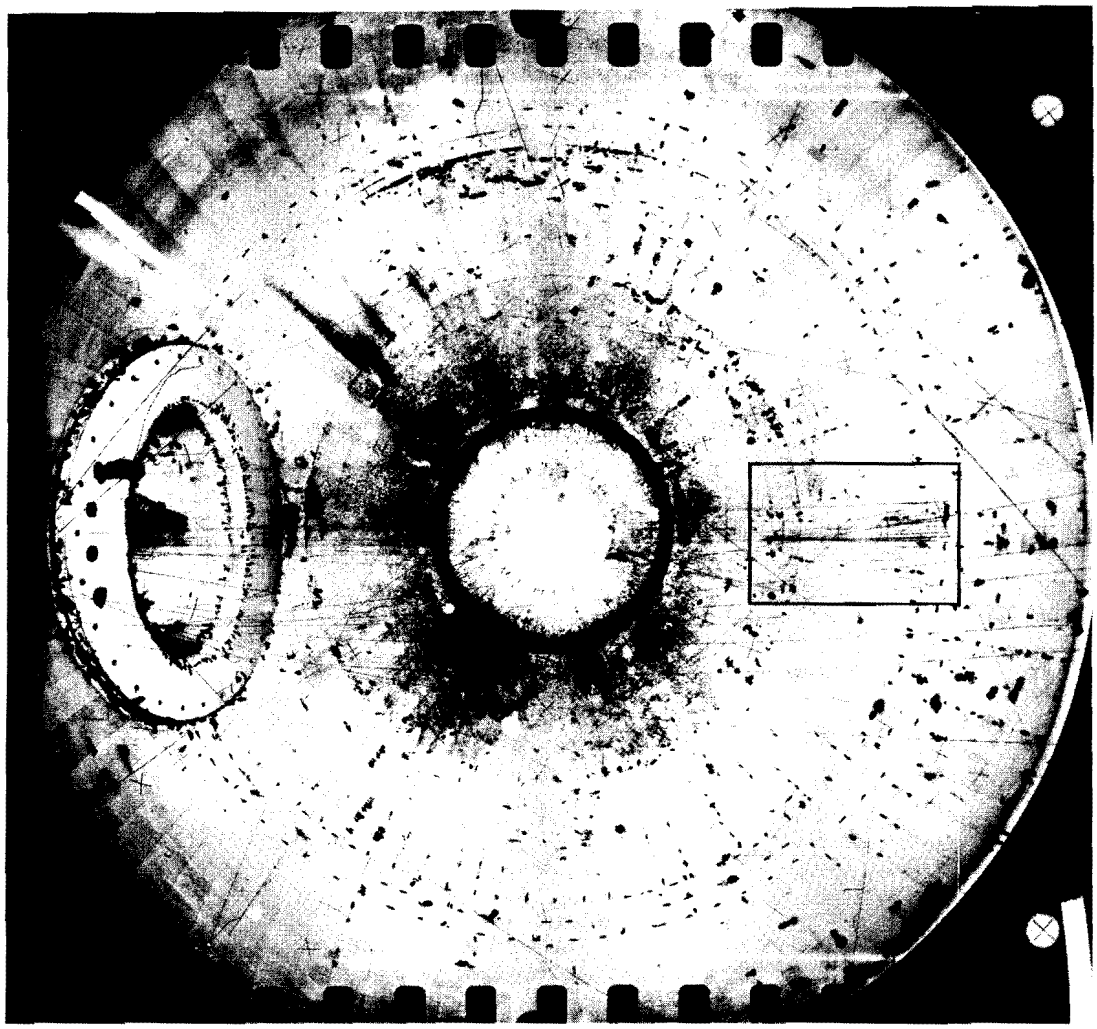
In addition to the series of pressure tests for all individual components of the 15-ft bubble chamber, a series of important system tests were carried out to assure the workability of each subsystem. These included:

1. Expansion system actuator pulsing
2. Optics cartridge cooldown
3. Hydrogen refrigerator performance test
4. Helium refrigerator performance test
5. Magnet cooldown, fill with liquid He, excite to 5000 A (30,000 G)
6. First chamber cooldown and fill without pulsing
7. Second chamber cooldown and fill including pulsing
8. Magnet and chamber operation together

These tests were begun in the spring of 1972. They have all been successfully completed. The first tracks in the chamber with the magnet functioning are being analyzed now.



Looking southwest over NAL's Bubble Chamber Area. The 15-ft chamber is located at the end of the berm (back center); its controls are in the geodesic-dome roofed structure (right). (Aerial photo taken October 18, 1973, by T. Frelo, NAL.)



The enlarged segment of tracks displayed on the cover were taken from this frame, photographed in the 15-ft bubble chamber on October 15, 1973. Black specks represent unwanted boiling from Scotch-lite edges, which will be corrected in future runs.

Preparation for and carrying out of the commissioning of NAL's 15-ft bubble chamber would not have been possible without the dedicated efforts of the entire Bubble-Chamber Group. Design work has already been mentioned. G. Mulholland, assisted by H. Kautzky, has been responsible for operations. Four crews, working on rotating shifts since June 1973, have carried out the cooldown work in the chamber, with assistance from a Laboratory A support team. These crews consisted of:

Crew A: J. Stoffel (Operations Chief), G. Athanasiou, J. Foglesong, C. McNeal, A. Newman, and R. Stoever.

Crew B: D. Curtice (Operations Chief), R. Ahlman, A. Coleman, J. Kilmer, W. Noe, and G. Simon.

Crew C: F. Bellinger (Operations Chief), J. Colvin, R. Davis, S. Johnston, C. Pitts, and J. Woodworth.

Crew D: W. Smart (Operations Chief), R. Ferry, G. Gadow, R. E. Thompson, S. Tonkin, and J. White.

Lab. A: S. Alexander, E. Beck, M. Diveley, N. Johnson, C. Mangene, C. Pallaver, J. Ramus, L. Robinson, J. W. Thompson, and P. Thorkelson.

Recognition is due also to the secretarial staff, E. Renaud, D. Augustine, and M. Richardson, for keeping all the records straight.

ELIMINATION OF SEXTUPOLE RESONANCES IN THE MAIN ACCELERATOR

Reported by L. Teng

A major part of the beam loss in the Main Accelerator has always occurred at injection when the Main Accelerator is functioning as a storage ring for 0.8 sec while 12 booster pulses are being injected. The injected beam showed typical decay patterns leading to a 30- to 40-per cent loss at the end of this storage period, just prior to the start of acceleration. A major step has been taken toward the understanding, and hence, the reduction, of this beam loss by the efforts of R. Stiening and E. J. N. Wilson, with the assistance of S. Ohnuma.

At the injection energy of 8 GeV, the main-accelerator guide field is relatively low, about 400 G. Small differences in the remanent fields of the main-ring magnets are important. These field imperfections have all multipole components and act periodically on the circulating protons at all harmonics of the revolution frequency. They cause the transverse oscillations (horizontal and vertical) of the protons to be unstable if the tunes (i. e., number of oscillations per revolution) are near certain resonant values.

The tunes are controlled by the strength of the quadrupole magnets in the Main Ring. The beam is unstable at all tune values that fall on the solid lines shown in Fig. 1. As the current in the focusing quadrupoles in the accelerator is varied, the tunes move along the dashed line in the figure crossing resonant values at points A through F. In Fig. 2 the beam intensity remaining at 0.4 sec after injection is shown as a function of quadrupole current. Each of the resonances destroys the beam.

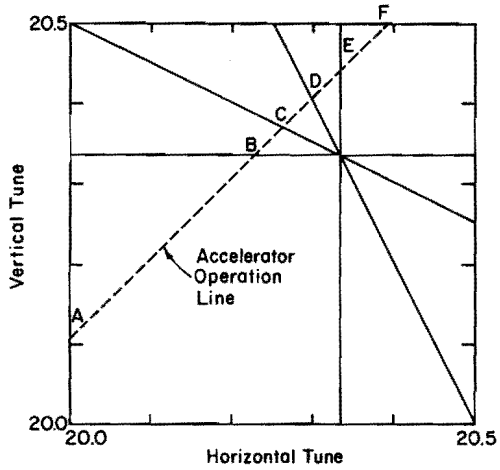


Fig. 1. Tune-plot showing resonance lines and the trajectory of the accelerator tunes.

The field imperfections which cause the beam instability at points B through E have been compensated for by a set of 48 correction sextupole and skew sextupole magnets. The small size of the corrections required is

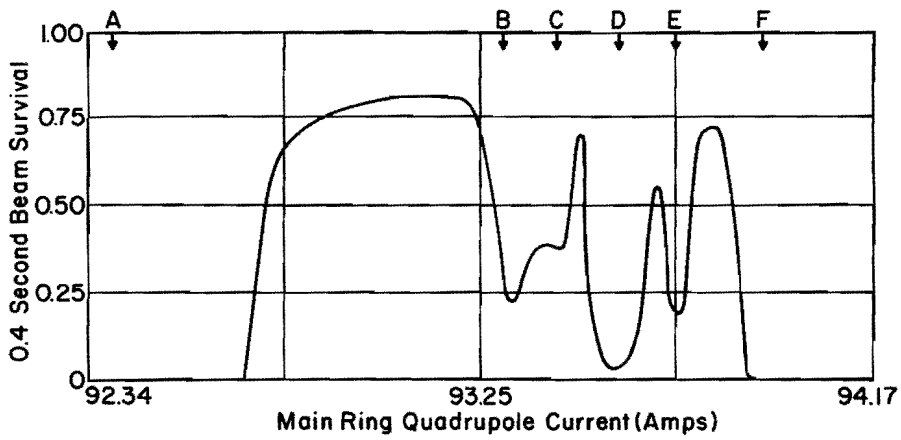


Fig. 2. Before correction, the amount of beam surviving 0.4 sec after injection as a function of the current in the main-ring quadrupole magnets.

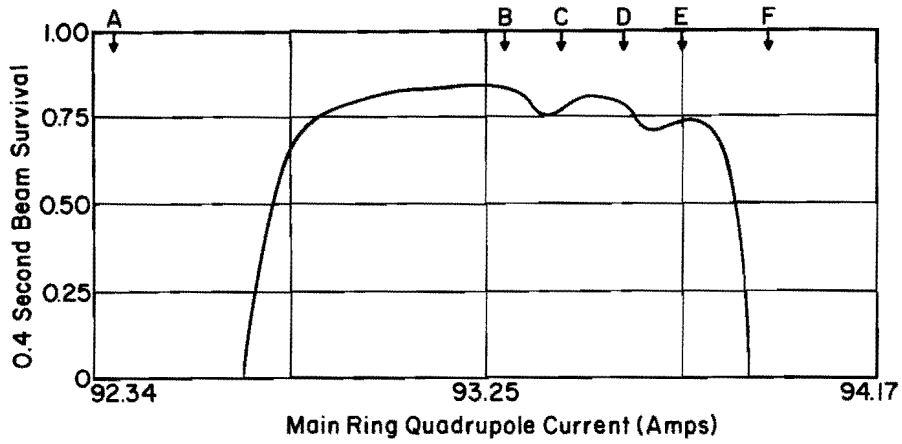


Fig. 3. After correction, the amount of beam surviving 0.4 sec as a function of the current in main-ring quadrupole magnets.

indicated by the fact that the correction magnets are 30-cm long coils mounted on wooden forms. In Fig. 3 the beam survival after correction is shown. The resonances at points B through E have been eliminated.

With these corrections, the decay lifetime of the injected beam has been increased to 3 to 5 sec, corresponding to a reduction of beam loss to about 20 per cent at the start of acceleration. The remaining beam loss is due to some stochastic process unrelated to resonances which has yet to be investigated. This reduction of beam loss during injection is reflected in an improvement of the total transmission through the Main Accelerator--from injection to top energy--of up to about 80 per cent. In addition, the increased tolerance to variations in tunes so achieved have contributed to the stability of the operation of the Main Accelerator. It will give a greater freedom from shifts in tunes that will be caused by space charge fields when a higher intensity beam is available from the Booster.

NOTES AND ANNOUNCEMENTS

CHANGES . . .

R. F. Bacher has been elected President of Universities Research Association, Inc. He replaces N. F. Ramsey, who has resigned to take a sabbatical leave at Oxford University, England. Ramsey had been President since 1966. He is Higgins Professor of Physics at Harvard University.

Bacher, who assumed his new responsibilities on October 16, is Professor of Physics and Provost of California Institute of Technology. He has served as a member of the Board of Trustees of URA for over eight years and as Chairman since 1970.

Replacing Bacher as Chairman of the Board of Trustees is the former Vice Chairman, A. G. Norman, Professor of Physics at the University of Michigan. A new Vice Chairman will be elected by the Trustees at their next meeting in December.

NEXT MEETING OF THE PROGRAM ADVISORY COMMITTEE . . .

The next meeting of the Program Advisory Committee will be held at NAL on Tuesday and Wednesday, November 6 and 7, 1973. Members of the Committee and invited spokesmen for selected experiments on the Agenda will attend.

In addition to examining specific proposals, the Committee will consider the general recommendations which have resulted from the Hadron Jet Workshop and panel discussion and the Backward Scattering Workshop.

TRAILER SITE PREPARED AT NAL . . .

A location for residential trailers is being prepared at the Laboratory. It will be west of the Machine Shop, next to the Saw Shop in NAL Village. Gravel pads to accommodate trailers 12 × 50 ft will be available, with hook-ups for gas, electricity, sewer, and water. Two spaces should be ready for rental by about November 1; more can be readied later if there is a demand for them.

Experimenters interested in bringing residential trailers temporarily to the Laboratory should contact D. Getz in the Director's Office.

CORRECTION . . .

As mentioned in the September issue of NALREP, W. Baker has resigned as Research Services Section Head so that he may devote full time to his research activities. These include both Total Cross Section Experiment #104 and Elastic Scattering Experiment #7, which are now running in the Meson Area.

EXPERIMENTAL PROGRAM SITUATION REPORT

The experimental program situation at NAL is summarized below. The experiments are listed separated by experimental area under categories that best describe their circumstance as of September 12, 1973. The experimental area names are abbreviated as follows: Internal Target Area (ITA), Meson Area (MA), Neutrino Area (NA), Proton Area (PA). Publications are available or talks have been given about the experiments marked *.

Total Number of Experiments - 99

		Spokesman	Extent of Run to Date	Date Completed
A. 23 EXPERIMENTS THAT HAVE COMPLETED DATA TAKING:				
ITA	*Proton-proton Elastic #36A	Cool	700 hours	June 24, 1973
	*Proton-proton Missing Mass #67A	Sannes	600 hours	Aug. 8, 1973
	*Photon Search #120	Cline	1,200 hours	May 29, 1973
	*Proton-Nucleon Inclusive #188	Sannes	1,050 hours	May 9, 1973
MA	*Quark #72	Leipuner	500 hours	June 11, 1973
	Quark #75	Yamanouchi	900 hours	Sept. 8, 1973
	Super-Heavy Elements #147	Debeauvais	3 exposures	Aug. 29, 1973
	*Emulsion exposures to protons @ 200 GeV for experiments 90, 103, 105, 114, 116, 117A, 156, 171, 183		48 stacks	Sept. 20, 1972
NA	*Proton-proton Inelastic #14A	Franzini	140 hours	June 21, 1973
	*30-Inch p-p @ 300 #37A	Malamud	51,000 pix	June 1, 1973
	30-Inch π^--p @ 100 #125	Morrison	54,000 pix	Aug. 28, 1973
	*30-Inch π^--p @ 200 #137	Huson	48,000 pix	March 10, 1973
	*30-Inch p-p @ 100 #138I	Ferbel	33,000 pix	Dec. 6, 1972
	*30-Inch p-p @ 200 #141A	Fields	67,000 pix	Nov. 27, 1972
	*Massive Particle Search #199	Frankel	2 targets exposed	Aug. 22, 1973
B. 14 EXPERIMENTS THAT ARE IN PROGRESS:				
ITA	*Particle Production #63A	Walker	1,800 hours	
MA	*Neutron Cross Section #4I	Longo	1,000 hours	
	*Nuclear Chemistry #81A	Weisfield	27 bombardments	
NA	*Neutrino #1A	Cline	350 hours	
	*30-Inch Hybrid #2B	Smith	60,000 pix of p-p @ 200 - Sept. 7,1973	
	*Neutrino #21A	Barish	650 hours	
	*Muon #26	Hand	600 hours	
	*Monopole #76	Carrigan	4 targets exposed	
	*30-Inch π^+-p @ 100 #121A	Lander	58,000 pix - Aug. 10, 1973	
	*30-Inch p-p @ 400 #138II	VanderVelde	12,200 pix - May 9, 1973	
PA	Monopole #3	Ross	Exposure of 2 targets in progress	
	Lepton #70	Lederman	450 hours	
	*Particle Search #100A	Piroue	500 hours	
	Particle Search #187	Lederman	100 hours	
C. 6 EXPERIMENTS THAT ARE IN TEST STAGE:				
ITA	Particle Search #184	Mann	Early equipment tests	
	Proton-proton Inelastic #221	Franzini	Early equipment tests	
MA	Elastic Scattering #96	Ritson	Beam tests & particle yield measurement	
	Total Cross Section #104	Kycia	Beam tests & particle yield measurement	
NA	Muon #98	Mo	Parasitic tests in progress	
	30-Inch Hybrid #154	Pless	5,000 test pix - Sept. 8, 1973	

D. 9 EXPERIMENTS BEING INSTALLED:

ITA	Proton-deuteron Scattering #186	Melissinos
MA	Elastic Scattering #7	Meyer
	Neutron Dissociation #27A	Rosen
	Pion Charge Exchange #111	Tollestrup
	Multigamma #230	Longo
NA	15-Foot Neutrino/H_2 #45A	Nezrick
	15-Foot EMI Test #155	Peterson
PA	Photoproduction #87A	Lee
	Photon Search #95	Cox

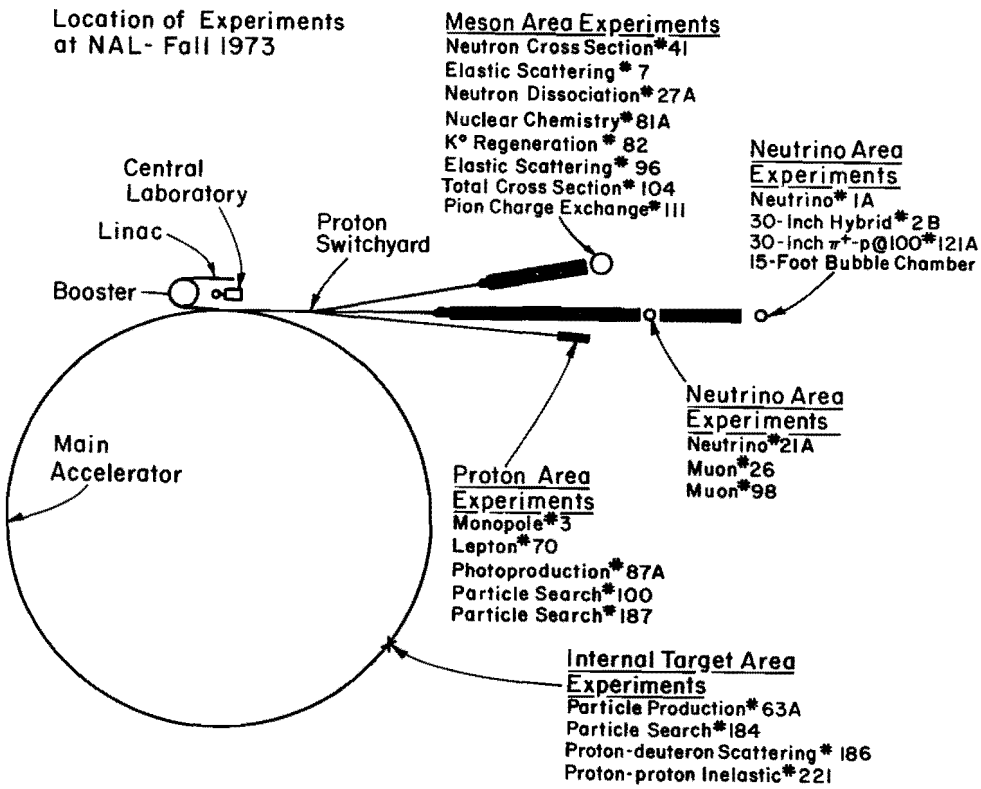
E. 23 EXPERIMENTS TO BE SET UP WITHIN A YEAR:

MA	Neutral Hyperon #8	Pondrom
	Missing Mass #51A	von Goeler
	Elastic Scattering #69A	Sandweiss
	K^o Regeneration #82	Telegdi
	Beam Dump #108	Awschalom
	Multiparticle #110A	Pine
	Multiplicities #178	Busza
NA	15-Foot Anti-Neutrino/H_2 #31A	Derrick
	Super-Heavy Elements #142	Stoughton
	30-Inch p-p & Ne @ 300 #161	Fry
	30-Inch π^--p & Ne @100 or 200 #163A	Walker
	Emulsion/Protons @ 300 #181	Cary
	Emulsion/Protons @ <400 #189	Ritson
	Emulsion/Protons @ 300 #195	Lim
	Emulsion/Muons @ 150 #205A	Kusumoto
	30-Inch π^+-p @ 200 #217	Lander
	30-Inch p-p @ 50 or 60 #228	Ferbel
	Emulsion/Protons @ 300 or 400 #232	King
	Emulsion/Protons @ 300 & 400 #233	Hebert
	15-Foot Engineering Run #234	Fowler
	Emulsion/Protons @ 300 #237	Lord
PA	Proton-proton Elastic #177A	Orear
	Beam Dump #211	Goebel

F. 24 OTHER EXPERIMENTS

MA	Neutron Elastic Scattering #4II	Longo
	Neutron Backward Scattering #12	Reay
	Monopole #22	Collins
	Inclusive Scattering #23A	Rothberg
	Polarized Scattering #61	Chamberlain
	Diffractive Dissociation #86A	Lubatti
	Charged Hyperon #97	Lach
	Form Factor #216	Drickey

NA	15-Foot Neutrino/H_2 & Ne #28A	Fry
	Detector Development #32	Hofstadter
	Detector Development #34	Huggett
	15-Foot Neutrino/H_2 or Ne #53A	Baltay
	30-Inch π^--p @ 300 #143	Kalbfleisch
	15-Foot Anti-Neutrino/H_2 & Ne #172	Bingham
	15-Foot Anti-Neutrino/H_2 & Ne #180	Nezrick
	Tachyon Monopole #202	Bartlett
	Detector Development #206	Peterson
	30-Inch p-p @ 500 #207	Engelmann
	30-Inch π^--p @ 400 #215	Goldhaber
	Detector Development #229	Yuan
PA	Photon Total Cross Section #25A	Caldwell
	Muon Search #48	Adair
	Monopole #74	Fleischer
	Long-Lived Particles #115	Stevenson



ACCELERATOR UTILIZATION SUMMARY - SEPTEMBER 1973

Generally speaking, the month of September was a period of transition for accelerator operations. At the beginning of the month there was approximately a week of operation at 200 GeV. By the end of the month, following a week-long shutdown for maintenance and development work, the accelerator was operating fairly well at 300 GeV. Many phases of experimental work were completed during the 200-GeV run; several new experiments were then started up in the Meson and Internal Target Areas.

During the 200-GeV operating period, the Neutrino Area program was directed toward taking exposures in the 30-in. bubble chamber. About 50,000 pictures were taken of 200-GeV protons on hydrogen for Hybrid Experiment #2B, and about 5000 test pictures were taken by Hybrid Experiment #154. Because of the failure of some of the components on the trainload in late August, it was not possible to continue narrow-band neutrino and muon running. However, Neutrino Experiments #1A and #21A did make tests using a bare target. Considerable work has been done to repair the trainload and prepare it for operation in October. A new splitting station was installed upstream of the Neutrino Hall to allow for flexible splitting of most types of beam spill between the proton beam line to the neutrino target and that to the hadron target for the bubble chambers. At the end of the month a single neutrino horn was successfully given a complete electrical test in the target tube. It will be used for experiments late in October.

In the Proton Area, Particle Search Experiment #100A completed data taking at 200 GeV, and Lepton Experiment #70 began measurements of

electrons produced at 50 mrad. The zero-degree neutral (photon) beam was tested and a probe of the beam line to the Proton West Area was started.

In the Meson Area, the data taking for Quark Experiment #75 was completed during the 200-GeV run.

A summary of the accelerator operating time for the month of September is as follows:

I. Summary of Accelerator Operations

A. Accelerator hours for physics research		
Accelerator physics research		80
High energy physics research		238
	Subtotal:	318
B. Nonphysics hours		
Accelerator setup and tuning to experimental areas		61
Scheduled interruption		104
Unscheduled interruption		237
	Subtotal:	402
C. Unmanned hours		0
	Total:	720

II. Summaries of Experimental Use

A. Integrated number of hours in external beams:		
For approved experiments		1097
Other (for beam tuning and studies)		190
	Total:	1287
B. Total hours charged to approved experiments		1062
C. Total bubble-chamber pictures for approved experiments		55,000
D. Total number of experiments to which time or pictures were charged		15

MANUSCRIPTS SUBMITTED FOR PUBLICATION DURING SEPTEMBER AND OCTOBER 1973

Experimental Physics

P. Limon et al. NAL-Pub-73/66-EXP	A Sign-Selected Dichromatic Neutrino Beam (Submitted to Nucl. Instr. and Methods)
J. K. Walker NAL-Pub-73/67-THY/EXP	Review of Large Transverse Momentum Phenomena in Hadron Collisions (Submitted to the Vth International Conference on High Energy Collisions, Stony Brook, New York)
J. Whitmore NAL-Conf-73/68-EXP	Diffraction Dissociation in pp Interactions at NAL (Presented at the APS Division of Particles and Fields Meeting, Berkeley, Calif., August 13-17, 1973)
D. Carey et al. NAL-Pub-73/72-EXP (Experiment 63)	Production of Large Transverse Momentum Gamma Rays in pp Collisions from 50 to 400 GeV (Submitted to Phys. Rev. Letters)
R. Stefanski et al. (Experiment 1A)	Observation of Muonless Neutrino-Induced Inelastic Interactions (Submitted to Phys. Rev. Letters)
F. A. Nezrick (Experiments 1A and 21)	Neutrino Program at NAL (Given at the Vth Hawaii Topical Conference, August, 1973)
G. Krafczyk et al. (Experiment 21)	A Lower Bound on the Intermediate Boson Mass [Phys. Rev. Letters 31, 180 (1973)]
D. Bogert et al. (Experiment 137)	Inclusive γ, K_S^o, Λ^o, and $\overline{\Lambda^o}$ Production by 205 GeV/c $\pi^- p$ Interactions (Submitted to the APS Division of Particles and Fields Meeting, Berkeley, Calif., August 13-17, 1973)
K. Abe et al. (Experiment 188)	Determination of Triple Regge Couplings from a Study of Reaction $p + p \rightarrow p + X$ Between 50 and 400 GeV/c (Submitted to the 2nd Aix-en-Provence International Conference on Elementary Particles, France, Sept. 6-12, 1973)

F. T. Dao and J. Lach	Study of Charged Multiplicity and Neutral Decay Particles from 14.75 GeV/c $\bar{p}p$ Interactions (Submitted to the 2nd Aix-en-Provence International Conference on Elementary Particles, France, Sept. 6-12, 1973)
M. Atac et al.	Y^* and Ω^- Production by Negative Hyperons on Nuclei (Submitted to the 2nd Aix-en-Provence International Conference on Elementary Particles, France, Sept. 6-12, 1973)
M. Atac et al.	The Elastic Scattering of π^- and Σ^- on Protons at 23.3 GeV/c for $0.04 < t < 0.25$ $(GeV/c)^2$ (Submitted to the 2nd Aix-en-Provence International Conference on Elementary Particles, France, Sept. 6-12, 1973)

Theoretical Physics

R. J. Crewther et al. NAL-Pub-73/45-THY	Positivity and the Axial-Vector Current in Quantum Electrodynamics (Submitted to Phys. Rev. Letters)
S. Nussinov NAL-Pub-73/55-THY	Asymptotic Behavior of Form Factors Density of States and Total e^+e^- Annihilation Cross Section into Hadrons (Submitted to Phys. Rev.)
B. Margolis and S. Rudaz NAL-Pub-73/58-THY	On the Description of Diffractively Produced Multipion Enhancements (Submitted to Phys. Rev.)
S. L. Adler NAL-THY-59	Theories of the Fine Structure Constant α (Reprinted from Atomic Physics, Vol. 3)
H. J. Lipkin NAL-Conf-73/60-THY	Strangeness Exchange Resonances (Submitted to the BNL Conference on Nuclear and Hypernuclear Physics with Kaon Beams, July, 1973)

H. J. Lipkin NAL-Conf-73/61-THY	Quarks, Partons, Triality, Exotics and Colored Glue (Submitted to the Topical Conference on Deep Inelastic Scattering, SLAC, July 16-18, 1973)
H. J. Lipkin NAL-Pub-73/62-THY	A General Formulation of Pionic Decays in the Quark Model (Submitted to Phys. Rev. Letters)
A. I. Sanda NAL-Pub-73/64-THY	The Hadron Constituents and e^+e^- Colliding Beam Experiments (Submitted to Phys. Letters)