NPA/Int. 64-14
Meyrin, 25th May 1964

NOTES ON A TRIP TO U.S. LABORATORIES (APRIL 1964)

This is an abbreviated version of notes from brief visits to the following laboratories :

Lawrence Radiation Laboratory Berkeley	(30/3 - 2/4)
" " " Livermore	(8/4)
Stanford Linear Accelerator Centre	(3/4 - 9/4)
Oak Ridge National laboratory	(13/4 - 14/4)
Argonne " "	(15/4 - 17/4)
Brookhaven " "	(20/4 - 23/4)
Princeton - Pennsylvania Accelerator	(24/4)
R.C.A. Sarnoff Research Laboratory, Princeton	(24/4)
Cambridge Electron Accelerator	(27/4 - 28/4)
National Magnet Laboratory, Cambridge / Mass.	(28/4)
A.V.C.O. - Everett Laboratory, Everett / Mass.	(29/4)

More elaborate handwritten notes (or photocopies of these) which sometimes contain more details are available for the case that somebody is interested. Some of the items reported on have been described in more detail last year by C. Germain [1], K.H. Reich [2] and F. Rohrbach [3].

Perhaps the most interesting impressions from this trip were :

- the widespread interest in higher intensities and
- the number of "medium" and large size bubble chamber projects,

which illustrate the importance attributed to weak interaction physics and

- the rapid advances towards the utilisation of large superconducting solenoïds.

PS/4386

1. Accelerators

Intensity

All finished machines I saw are working well at specified or higher intensities apart from the ZGS where initial troubles have not yet been overcome. However, up to 2×10^{12} have been accelerated there in a test on April 15. An increase in intensity is to be expected during this year (see table) with some accelerators. It may be achieved after elimination of hot spots in the shielding of the Bevatron, and by multiturn injection into the AGS.

Present intensities

	per pulse	per second	aimed at in 1964
Bevatron	5×10^{12} ppp (6 GeV)	10^{12} pps	2×10^{12} pps
Z.G.S.	2×10^{12} ppp (12 GeV)	5×10^{11} pps	2×10^{12} pps
A.G.S.	$3\text{-}4 \times 10^{11}$ ppp (30 GeV)	1.5×10^{11} pps	5×10^{11} pps
Cosmotron	5×10^{11} ppp (3 GeV)	10^{11} pps	const.
Princeton-Penn.	5×10^{10} ppp (3 GeV)	1×10^{12} pps	const.
C.E.A.	5×10^{10} epp (6 GeV)	2×10^{12} eps	const.
[C.P.S.	$7\text{-}8 \times 10^{11}$ ppp (24 GeV)	2.5×10^{11} pps	?]

There is a general interest in still higher intensities; the state of affairs ranging from preliminary thinking to established study groups. The only exception is L.R.L. where the Bevatron improvement is just being completed and the 200 GeV study is under way.

2×10^{13} ppp at 1 s^{-1} rep. rate are aimed at by the <u>A.G.S.</u> improvement study group : 500 MeV linac, new R.F. system, improved vacuum, remote handling from overhead tunnel, new magnet supply (new magnet coils ?), new experimental areas (up to 2500 feet length reserved). A study report is to be submitted in June;

remote handling design and model work is under way; civil engineering studies (trial section ?) are envisaged for this year. Cost probably $>$ 50 Mill. $. An A.G.S. users committee has given this programme preference to the construction of storage rings (considering also CERN's possible intention to build storage rings). The justifications are weak interaction physics and also strong interaction physics where this machine could compete with the 70 GeV machine in π, k, $\bar{p}$ intensity up to 25 GeV.

Studies are being made to overcome the space charge limit at the Princeton-Penn. Acc. and to achieve 10^{12} ppp. - The installation of a 70 - 80 MeV linac is planned at C.E.A. for the near future to bring intensity up to 1 - 2 x 10^{12} epp. - Thoughts are given to a possible rise of intensity up to $\sim 10^{14}$ ppp at Z.G.S. (200 MeV linac, remote handling, new (titanium ?) vacuum chamber, etc).

Stanford 2 - mile linac status

At present approx. 800 people of which a large part works already on the new SLAC site. Of the linac, perhaps half of the tunnel length is cast, part of which is already covered with earth, and approx. 300 m of the overground building are ready. Services installation is about to begin. The switchyard is being started and experimental areas ("endstations") are being designed. It is tried to transfer people from machine design to design of experimental apparatus.

Acceptance testing of apparatus (modulator, klystrons) is under way and the klystrons manufacturer is about to be selected. A hall of 50 x 50 m^2 or more is completely installed for waveguide and accelerator structure manufacture (cleaning, bracing, testing). Mark IV linear accelerator essentially consists of two sections of SLAC on test (approx. 80 MeV). Mark III has been equipped with SLAC structure last winter (energy has been increased to 1.2 GeV).

Alignment will be done with targets with etched linear patterns, of which the Fresnel diffraction pattern will be observed at the end of the linac. Light source is a 100 Watt Laser.

Though magnetic shielding is provided for the whole structure, degaussing wires will be stretched along the whole length, and steering coils have been developed.

The Pierce-type electron-gun will be provided with features for wide versatility, single bunches, limited pulse trains, etc. There will be one or two more sources installed further downstream the accelerator in order to allow to a certain extent for repairs of the main source. (Inflection by D.C. magnets). There are also two outlets provided for work at lower energy (e.g. the 3 BeV storage rings). The layout provides for three main experimental areas : one for electron and photon experiments, one for experiments with secondary beams and the "direct beam" for e.g. neutrino experiments. Only two of these areas will be finished at the outset, that for electron experiments and that for secondary beams.

Large synchrotrons

At Berkeley the 200 to 300 GeV A.G.S. study group is well under way. There are approx. 70 persons involved, part of which work only part-time on the study. Parameters are not yet fixed. A booster appears to be favoured for financial reasons and equal acceleration frequencies for linac, booster and main ring are considered. A preliminary report is due for end 1964 and a detailed report for mid 1965.

At Brookhaven the 600 to 1000 GeV study has been temporarily interrupted because of the urgency of the A.G.S. improvement programme.

High current linac

A "magnetic induction type" linac has been built for the Astron experiment at Livermore that provides 160 amp electron pulses of 0.25 μs duration at 4 MeV, with 10^{-4} rad. m emittance.

Operation

List of principal operational troubles I have seen or been told of :

Bevatron : New shielding is too weak at certain points for the possible peak intensity ($\sim 10^{13}$ ppp). Continuous running therefore at 5×10^{12} or less.

Z.G.S. : Mechanical trouble with the vacuum chamber and more eddy currents than anticipated. Unbalance in magnet octants due to leakage currents through cooling water hoses.

A.G.S. : During my presence, unstable operation was due to R.F. trouble (new cooling water hoses) and vacuum troubles.

C.E.A. : Mechanical structure of ring choke (replacement of coils), radiation damage to epoxy coated vacuum chamber.

Beam extraction

Extracted beams are operated at almost all working accelerators; they are particularly widely used with the weak focusing machines (Piccioni scheme).

Bevatron : Separated beam and p-p scattering experiment are run off external targets. (Efficiency 50 o/o. Extension of use is envisaged (several experiments in cascade, new experimental area ?).

Z.G.S. : All slow (Piccioni) and fast ($\sim$ 20 μs sweep across Piccioni target) ejection equipment is installed. The first user will be the neutrino experiment, but two more outlets for extracted beams are provided in the shielding. Efficiencies of 40 o/o for the slow and of 20 o/o for the fast ejection are expected. The computed beam sizes are 2" near the synchrotron and 0.3 " at the target.

A.G.S. : Fast ejection is working for the neutrino experiment. Different conception : three-stage-system, different kicker circuit efficiency near 100 o/o. Beam size similar to CERN near the synchrotron, but larger spot at the target, since no high gradient lenses are available.

Cosmotron : Almost all experiments are being run from external targets (Piccioni scheme).

P.P.A. : Resonant extraction is being prepared, all material on order. New experimental hall is being built for external beams (up to ten experiments in parallel and cascade).

C.E.A. Resonant extraction (resonance established by current strip) is working and has been tested in the last machine period. Efficiency up to 70 o/o, energy spread 0.1 o/o. Two or three experiments in parallel are envisaged.

Beam observation is done with scintillators (Bevatron, oversaturated at full intensity) or Zns screens, and by observation of the darkening of glass, (CEA) which appears to have a convenient sensitivity (visible darkening by a few times 10^{12} electrons) and can easily be calibrated. Cerenkov light is envisaged to be used for beam observation at Stanford. R.F. cavities are used for monitoring where longer pulse-trains are ejected (CEA, Stanford).

Radiation problems

Remote handling equipment is under development at Brookhaven : a working prototype of an automatic target changing mechanism exists and hot laboratory remote handling arms are being tested with the aim of finding improved designs, better suited for mechanical work. If the A.G.S. programme for improving the intensity is approved, the design of remote handling apparatus will be an important part of the programme : operator in lead box suspended from crane, equipped with remote handling arms. A recent survey of tunnel air and cooling water activitiy indicates that with 10^{13} pps activity problems will be serious.

Stanford problems are still more serious : only anorganic material will be admitted into the accelerator tunnel or the switchyard : e.g. coax. "cables" (better : tubes) with $Mg\ O_2$ insulation will be used (also multicore); only welded vacuum joints, no O-rings all along the linac.

Material samples have been exposed to up to 10^{11} roentgen total dose at the Mark IV linac with e.g. the following results

- Quartz windows (Corning fused silica code 7540) are very safe (no deterioration after days of full beam, where glass becomes brown after minutes).
- Ferrite is much safer than magnetic alloys like Permalloy or Mumetal.
- Araldite with anorganic filler ($Mg\ O_2$) appears to be safe.

A "radiation proof" T.V. camera is sold by KINTEL for 7000 $ (with lens). 5 o/o light loss after 10^6 r.

2. Experimental apparatus

Separators

R.F. separators are being developed at Stanford and Brookhaven. The Stanford beam bunch structure is convenient for R.F. separation ($\sim 3 \times 10^{-12}$ s bunch length expected). No working set of cavities is expected to be ready before next year at Brookhaven.

Development work on electrostatic separators does not appear to be strongly pushed at any of the visited laboratories. At Berkeley, glass electrodes are regularly used with 500 kV over 5 cm. At Argonne some work on screens and successful tests with SF_6 filled bushings are being done. Experiments on charging the electrodes by an electron beam are continuing, but have not yet yielded new results (max. voltage 450 kV). At Brookhaven tests with glass electrodes are being prepared but the separator group is mainly involved in running beams.

Nowhere are SAMES generators used in routine operation; the main troubles might well result from the large distance to the manufacturer and the lack of local expert device.

Bubble chambers

Despite the number of chambers already in operation, many new ones, particularly large ones, are being built or planned. The impression is conveyed in discussions, that even with the very large chamber projects, the technical problems are believed to be in hand, the decision on the construction solely depending on the financial authorities.

Stanford — A 1.3 m diameter 0.5 m long H_2 chamber for photon experiments is being designed (target date early 1967), a pulsed H_2 chamber with cryogenic coils, 2 m Ø at 40 kG, with polyesterbody is being studied.

Argonne : The 10" H_2 or He chamber is assembled for expansion tests. The superconducting magnet has arrived at Argonne after testing at 32.5 kG peak field, and it is expected to still improve its performance. The 30" H_2 chamber from MURA has had its first expansions at mid April. It is installed in a separated beam, ready for use. A 40" approx. 1 to heavy liquid chamber is under construction at Michigan for use at Argonne. A 7.5 m^3 heavy liquid chamber has been proposed by Camerini et al. (Wisconsin). 68" diameter, 148" long, 20 kG with 11 MW supply, 90^o stereo photography (6 to 10 cameras), 1.3 Mill $; expansion tests are envisaged for early 1967 (if the project is authorized). A proposal for a 12' diameter, 6' high H_2 chamber is being prepared at Argonne. (Two almost complete pole-pieces, 4 cameras around the upper edge of the pot, metal membrane). A scaled down magnet model with superconducting wire is being built.

Brookhaven : A proposal for a large heavy liquid chamber for the A.G.S. is being prepared at MIT (Pless). A report proposing a H_2 chamber 16' diameter 12' high, principally for experiments on neutrino interactions and leptonic decays, has been written at Brookhaven. 20 kG with 16 MW, 1c/s (or faster) repetition rate, piston expansion with hydraulic actuation, 16 Mill. $ total (site etc. included), 4 years construction schedule.

C.E.A. All parts of the 1.2 m H_2 chamber appear to be available. Assembly is said to be retarded by simultaneous running of experiments with a smaller chamber.

Spark chamber magnets

A D.C. magnet with 50" x 60" x 30" volume is under construction at Argonne. 70 to Fe, 10 to Cu, 5 kA/cm^2, 11 MW supply. Up to 15 kA/cm^2 have been achieved on a model test of the particular cooling technique applied. A still larger magnet has been proposed by Roberts : 4 m x 2.5 m x 2 m useful volume. With the above 11 MW supply and without iron, 14 kG are expected. 1.7 Mill $ estimated.

Storage rings

The 500 MeV - electron storage rings at the Stanford Mark III linac are operating and detectors are installed in the interaction region. Up to 250 mA have been injected, decaying within minutes down to 50 - 100 mA. Then the current remains stable long enough to try observation of e - e scattering. Statistics are still too poor for a clear interpretation of the obtained events as e - e interactions. The main trouble is due to a pressure rise during injection which is due to gas being freed from the vacuum chamber wall by synchrotron radiation. There was an improvement after several amp. hours of running.

A single 3 GeV storage ring for $e^+ - e^-$ experiments has been proposed, to be built at Stanford or at Cambridge. A committee has been appointed by AEC to decide upon the location.

3. Neutrino experiments

At Argonne the ejection system is installed and also in place is the beam transport equipment up to a Be target (1" diameter, 60 cm long). The neutrino horn is being assembled in the hall. An inner conductor is ready, all sections of the primary winding and outer conductor are in the assembly baseplate, it is expected to be ready for test in the beginning of May. Capacitor bank and switches are being assembled on their final platform in the proton hall. All shielding and the observation equipment is ready, waiting for the beam. Very thin Al - plate spark chambers ($\sim$ 1.5 mm) of 2 x 2 m^2 cross section are alternated with 1/2" steel plates which are circularly magnetized, approx. 30 to Fe. Also ready is the equipment for the measurement of the π and K spectrum under the actual conditions of the experiment. The measurement is rather simpler than it would be at CERN due to the use of slow extraction : one standard bending magnet, a telescope of 4 small scintillators and Cerenkov detectors. No attempt to make μ flux measurement. The philosophy is, that a good spectrum measurement is one of the few chances that are left for them in view of the advance CERN has otherwise.

At Brookhaven, approx. 200 events have been obtained without focusing, and runs with the plasma lens are about to start, at 29 - 30 GeV. The lens has been tested for a few thermal time constants and appears to be all right, but nothing is known about the effect of electrode evaporation during longer periods. With the help of a (equally pulsed) solenoïd field a discharge with more or less homogeneous current distribution can be stabilized for several microseconds. However, due to a dL/dt term introduced by the variation of the effective discharge radius, only 400 kA instead the planned 550 kA peak current are expected now.

A horn is under construction at Columbia University. It is expected to be ready for tests in approx. 1 month. There exists a proposal for a ν exp. with the 80" chamber in the present location which should yield $\lesssim 1$ event per day at 10^{12} ppp with two plasma lenses in cascade, 75 m decay path, 25 m Fe shielding.

At Stanford the work towards preparing neutrino experiments has been interrupted. The layout provides for three experimental areas - one for electron and photon experiments, one with secondary beams, and the "direct beam" for e.g. neutrino experiments - but only the first two will be finished and the direct beam will be blocked off "until one thinks of some clever way of making neutrino experiments". Basically the π (and k ?) flux per second will be higher, and this specially at higher momenta ($\sim$15 GeV) than at CERN or A.G.S. It also will be better collimated; since a "Drill type" process is involved most of the flux is contained within an angle $\propto \sim \frac{m}{E}$. (This process has been confirmed for π - production at CEA, not yet for K's). Due to the low duty cycle it is difficult to make use of this flux, e.g. a bubble chamber could at best use a few out of the 360 pulses per second, a spark chamber might be a better proposition. The basic philosophy however appears to be that one should first concentrate on topics where SLAC is unique; for example electron scattering, γ - experiments, μ - experiments, and positron - experiments at high energies.

4. High current pulse techniques

Capacitors : Electrolytic capacitors are used at Berkeley in installations where lower repetition rate and discharge frequency ($<$ 1 ks/s) are required. Their lifetime has not yet been reached (experience up to 3×10^4 shots). They can stand reverse voltage and be used in series. Electrolytic capacitor banks are rather cheap : SPRAGUE computer type capacitors, 0.25 sfr/J; australian DUCON capacitors offered for 0.13 sfr/J. A 15 MJ bank is in use by University of Washington, and banks between 0.1 and 1 MJ are used in plasma research.

At Stanford low loss SANGAMO paper capacitors are used in the klystron modulators (high repetition rate and discharge frequency). The horn capacitor bank at Argonne is also made with SANGAMO paper capacitors (1 sfr/J) and similar capacitors are used at Brookhaven.

Switching devices

Ignitrons and hydrogen filled thyratrons are the most widely used switches for capacitor discharges. Hydrogen thyratrons are applied where lower currents ($\leqslant$ 5000 amps) and very small time jitters ($\lesssim$ 10 μs) are required, and ignitrons for higher currents ($\lesssim$ 50 kamp) and less stringent requirements on jitter ($>$ 100 ns).

At Stanford a large scale investigation of thyratrons for the SLAC modulators has been carried out (42 kV, 2000 amp) and up to 2000 hours lifetime at 360 pps (total 2.5 x 10^9 pulses) have been obtained (Kuthe KU 275 A). The ejection kicker magnet at Brookhaven is switched with GL 7890 H_2 thyratrons (40 kV, 5000 amp). In the storage bank for the 160 amp. electron linac for the Astron experiment at Livermore the KU 5949 A H_2 thyratrons are gradually being exchanged against D_2 - filled tubes, to obtain higher voltage capabilities, or lower prefire rate respectively. (Price increase 2 to 3 times).

Ignitrons are used in the neutrino installations. At Argonne, a type similar to ours, Westinghouse WX 4681 or National Electronics NL 1059 is used. At Brookhaven somewhat smaller tubes with ceramic housing 4" diameter with the height of a normal 2" tube, are employed. For the deflection magnets in the beam switchyard at Stanford ignitrons are used at high repetition rate (360 pps) and rather low currents (300 amp., 5 kV) for economical reasons. Grid ignitrons must be used in order to forestall Hg pressure build-up and prefiring at the high repetition rate.

For still higher currents, mechanical switches or the multigap "Megamp switch" are available. At Berkeley, a standard G.E. mechanical switch carries 160 kAmp in the University of Washington experiment, and several low inductance Megamp switches are used in plasma research work. For the latter the minimum current is around 50 kamp, a maximum has not been experienced and is estimated at several Megamps; voltage per gap is 3 to 4 kV, life experience up to several 10^4 shots.

Silicon controlled rectifiers with interesting ratings, units up to 1 kV, 10 kamp (200 $ per unit) are available and units where the current could be interrupted (at low voltage) are expected for the near future.

Pulse transformers

An interesting pulse transformer (20 kV → 250 kV) has been developed for the SLAC modulators (Pearson Electronics, Palo Alto). The ejector magnet at C.E.A. is supplied via a simple home-made pulse transformer that produces a pulse of 6500 A, stable within 0.1 o/o during 1 ms.

Pulsed solenoïds

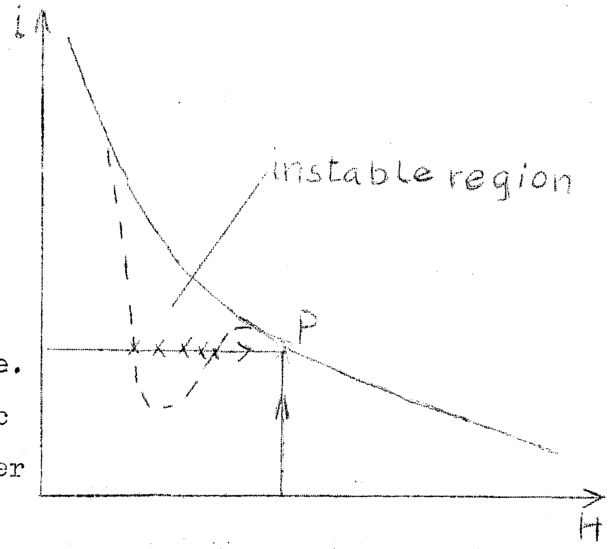
Solenoïds with long life (several 10^4) have been obtained at Berkeley and Livermore by very strong radial and/or axial clamping of the coil, due to the suppression of vibrations, and of diameter increase during pulsing.

5. Superconductivity

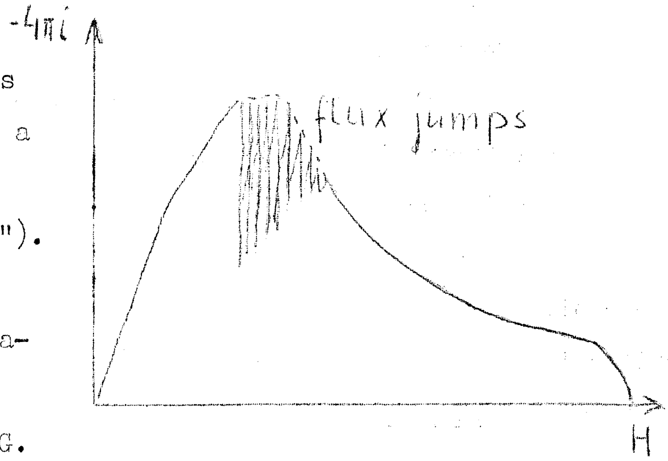
Solenoïds

Several industry laboratories appear to have recently made important advances towards the understanding of the so-called "degradation" effect in superconducting solenoïds and towards conserving the properties of wires when wound into coils. A solenoïd of one foot diameter for the Argonne 10" He chamber has been tested successfully at 32.5 kg. The manufacturer claims that a coil of similar dimensions producing 50 kG could be delivered now on a normal fixed contract basis. One manufacturer is studying the feasibility of a 50 kG coil of more than 1 m diameter and approx. 10 m length (if possible to be ready by 1968) and another firm investigates the feasibility of a 150 kG coil of one foot inner diameter. Coils of smaller dimension, in general around one inch useful diameter with up to 100 kG have been produced at several laboratories. Some people I have seen believe to be able to predict quantitatively within a few percents the behaviour of superconducting solenoids up to certain sizes and fields, and begin to treat the making of superconducting magnets as an engineering task rather than a research problem.

The current qualitative picture of the mechanism replaces a "degradation" effect by instabilities in a material that in most cases is characterized by internal stresses and dislocations.



It has been found in sample tests that a certain point P on the H, i curve can be reached reproducibly by rising the current at constant field, but not by rising the field at a preset current, where the sample might go normal erratically within a certain field range. It has also been found that the magnetic moment of a superconducting sample, after increasing almost linearly (almost complete flux screening) up to a certain value, suddenly jumps wildly within a certain field region and then drops to zero. This effect is explained as a disruptive penetration of flux into parts of the material ("flux jumping"). The field region where flux jumping occurs coincides with the above instability region and lies, according to the material, at a few or up to 20 kG.



It is supposed that energy is set free in the lattice by the flux jumps and that this energy may sometimes be sufficient to make the sample go normal. At the same time it is supposed that in a coil a primary flux jump may induce flux jumps in adjacent turns or layers. Accordingly, solenoïds are being "stabilized" by plating the superconducting wire with Ag or Cu, by inserting layers of anodized Al or Cu instead of insulating materials or by adding some Cu strands to cables of superconducting material. The plating material is supposed to carry the current until the heat has been cooled away and at the same time to improve the heat transfer to the He. The plating and further normal material would also provide electro-magnetic shielding against the propagation of flux jumps within the coil. All high field superconducting solenoïds that have lately been built make use of these techniques and it appears that the addition of large amounts of normal material is considered for future tests. It may increase the size of the magnet, but permits the expensive superconductor to be used to the limit of its capabilities. It also provides safety against rapid accidental release of the stored energy in the winding.

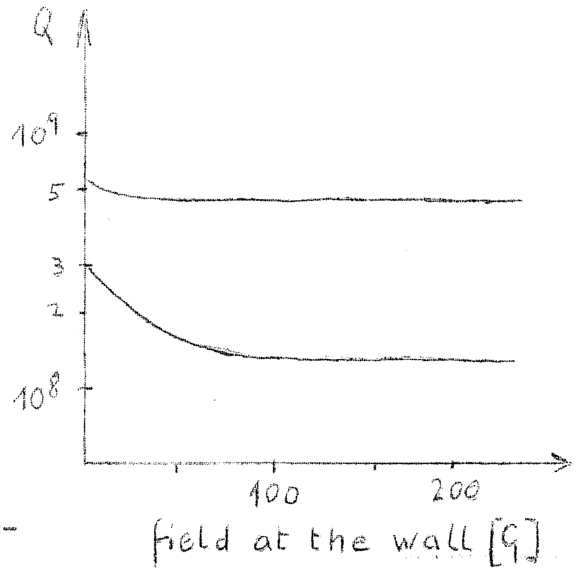
As a second consequence of the exposed picture, the high field solenoïds are made out of several cylindrical sections, such that each works in a stable region of the H, i diagramme. Ideally one might hope to develop materials that do not exhibit the flux jumps.

In agreement with these hypothesis, no degradation effect has been found with solenoïds of soft superconducting material at Oak Ridge, when end effects were avoided and an infinitely long coil was simulated with the help of guard sections of hard superconductor. Field measuring microprobes with approx. 10^{-2} mm^2 effective surface (Hall effect in Bi at the He temperatures) have been developed for measurements between closely spaced conductors in an attempt to investigate "proximity effects".-Work to improve the He - chamber magnet by the stranded cable technique is under way at Argonne. Superconducting coils will there also be used in a reduced scale model of a large bubble chamber magnet (avoiding the cooling problem that would exist with normal coils).-An anisotropy in the critical current behaviour of Nb_3 Sn tape and wire in transverse fields has been observed at Brookhaven, but an even more pronounced effect with Nb Zr found elsewhere disappeared after heat treatment.

Among the most promising materials are at present Nb_3 Sn tape (stainless steel like tape with Nb_3 Sn chemically deposited, no heat treatment), Nb Zr wire for lower field applications, and the new Nb Ti wire Hi 120 from Westinghouse. All these materials require no treatment after winding and can be unwound and rewound without practical limit.

Cavities

Experiments are under way at Stanford to produce a superconducting acceleration cavity. Sn, Pb, Nb cavities (electroplated) have been tested with satisfactory results. Typical Q vs power (resp. magnetic field at the wall) curves are shown for 2 Pb cavities at 3^{0} K. Good heat transfer (complete He-bath) is essential and may account for difficulties at CERN at the higher power levels. A disc-loaded 1 foot S - band cavity is under construction for acceleration tests. Mark II linac might be equipped with similar cavities if tests are successful.



6. Other solenoïds

Large solenoïds are used in many fusion experiments, of which I have seen the ALICE, DCX - 2 and ASTRON installations.

Of interest are the cryogenic Na-coils developed at Livermore in conjunction with the ALICE magnetic mirror experiment. The coils are made by filling specially distilled Na into stainless steel tubes and run at 10^{0} K (He-gas cooling). At 20 kG a resistivity of $2 \cdot 10^{-9}\,\Omega$ cm has been measured and experiments at higher fields are under way. Cu-coils at N_2 - temperature are in regular operation in the mirror experiment.

At Oak Ridge 2 solenoïds of 65 kG and 80 kG with 16 cm inner diameter of design similar to the NPA/MSC coil, are available for tests on superconducting materials and another one with 80 kG over 32 cm diameter is planned. For the

Oak Ridge Nat. Lab.

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D.B. Montgomery

AVCO - Everett Lab. Everett / Mass.

M. Lucas

F. Steckly

J. De Winter

Appendix II

List of reports collected during the trip

High Energy Physics

- Some Aspects of Target Area Design for SLAC by J. Ballam et al.
  M. Report Nr. 200, Summer 1960
- Some Aspects of prospective Experimental Use of SLAC by W. Chinozvski et al.
  SLAC Report Nr. 5, Summer 1962
- 1963 Summer Study Report by K. Berkelmann et al.
  SLAC Report Nr. 25
- Storage Rings, Accelerators and Experimentation
  1963 Brookhaven Summer Study, edited by J.W. Bittner BNL 7534
- Notes on a lecture on Symmetries given by Berman at Stanford (1963/64)
- Proposals for Neutrino Experiments at the ZGS (Argonne) by R.A. Lundy et al.
  March 21, 1963 and August 22, 1963

High Magnetic Field Design

- Calculation of Fields, Forces and Mutual Inductances... by M.W. Garrett
  Reprint from J. Appl. Phys. 34, 2567 (1963)
- Some Basic Concepts for Magnet Coil Design by W.F. Gauster AIEE Meeting,
  Oct. 1959
- Magnetic Field Design in Thermonuclear Research by W.F. Gauster
  Reprint from Oesterr. Ing. Arch. 15 (1961)
- Calculation of Trajectories and Magnetic Fields... by W.F. Gauster et al.
  Reprint from Nucl. Fusion, 1962 Suppl. 1
- Current Engineering Status of ORNL Exp. Devices for CTR by W.F. Gauster
  and J.F. Potts, Repr. from Fusion Conf. 1962, Paris
- The Generation of High Magnetic Fields by D.B. Montgomery, Repr. from
  Rep. Progr. Phys. 26, 69 (1963).

Superconductivity

- Degradation Factor and Diamagnetic Currents in Supermagnets by B.S. Chandrasekhar et al. Repr. Appl. Phys. Letters 2 228 (1963)
- Flux Trapping in Hollow Soft Superconducting Cylinders by D.L. Coffey et al. Repr. Appl. Phys. Letters 3 75 (1963)
- High Field Nb_3Sn Superconducting Magnets by Magnetic Field Stabilization by J.C. Fakan et al. Repr. Appl. Phys. Letters 4 105 (1964)
- Some Concepts for the Design of Superconducting Solenoïds by W.F. Gauster and C.E. Parker - MIT - High Field Conf. 1961.
- Development of Superconducting Magnets by W.F. Gauster - IEEE Conf. Paper (1963)
- Current Carrying Capacity and Transition State of Superconducting Solenoïds by W.E. Gauster and D.L. Coffey - Cryogenic Eng. Conf., Boulder 1963
- Discussions on Applications of Superconducting Materials - Proc. IEE 111 407, (Febr. 1964).
- Development of Superconducting Magnets by W.F. Gauster - Repr. Electr. and Power, March 1964
- Vapour Deposition of Nb_3Sn by J.J. Hanak, Repr. A.M.I.E. 19
- Magnetization of Nb_3Sn Films in Transverse Fields by J.J. Hanak (Preprint)
- Test of ANL - SBC Magnet Assembly at AVCO by C. Laverick - ANL-SBC-57 (1964)
- Current Carrying Capacity of Superconducting Nb-Zr Solenoïds by D.B. Montgomery - Appl. Physics Letters 1 41 (1962)
- Superconducting Magnets by D.B. Montgomery - IEEE Spectrum Febr. 1964
- Reports on Research in Superconductivity at Thermonuclear Division, dated Oct. 31, 1962; April 30, 1963; Oct. 31, 1963; Jan. 1964

Beam Extraction

- Comparison of Lumped and Distributed Inflector Magnets by E.B. Forsythe Brookhaven Int. Report EBF - 2 (1963)
- A Hydrogen Thyratron Magnet Pulser by E.B. Forsythe (Preprint)
- Bevatron External Beam Programme by W.A. Wenzel, Int. Report Bev-763 (1962)
- Bevatron External Proton Beam by W.A. Wenzel UCRL - 10868 (1963)

Miscellaneous

- Investigation of Tape Wound Coils For Large Spark Chamber Magnet by R.L. Kuskowski and G.E. Yurka (1963)
- Preliminary Study for a Large Spark Chamber Magnet by A. Roberts (1963)
- High Current Linear Induction Accelerator for Electrons by N.C. Christophilos et al. - UCRL - 7408 Rev.1 (1964)
- New Design for a Proton Linear Accelerator by J.P. Blewett - Brookhaven Int. Rep. AADD-23 (1963)
- Oberflächeneffekte beim elektrischen Durchbruch von Flüssigkeiten by W.F. Gauster, Repr. from Oesterr. Arch. 10 (1956).
- Hydrogen Thyratron Data Sheets for KU 275 A
  KU 274 B
  ZT 7004
  KU 71
  GL 789 a