MAF-1

14UD TANK OPENING REPORT NO.3.

April 12th to April 28th,1976.

(The above interval includes Easter, and the ANZAC long weekend.)

Reasons for going into the tank:

1) We had lost power from the main lower alternator.

2) Continued fluctuations of charging current on chain 1, (see Report No.2, page 3), committed us to running with one chain only, since we had no chain 3.

3) We were uncertain about the performance of new oilers fitted at the last opening, a month ago.

4) A foil change was required.

5) An opening was compatible with the run requests from experimenters.

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SHAFTS AND BEARINGS:

Once in the tank we found the loss of power at the lower alternator was because the upper shaft bearing in the 15 MeV casting had seized, causing the flexible coupling to shear and it had become a mess of melted rubber. The shaft in unit 15, and the lower main alternator, were not turning; the shaft sections in units 16 to 28 were rotating normally.

Mr. Malone, a technician, especially competent in bearing matters, spent some time listening with a conductive stethoscope to all the shaft bearings. He found several of them in very bad condition and about 30% of the remainder exhibiting early stages of failure.

The effect on bearing grease of repeated evacuation of the tank had to be considered and the possibility that breakdown products of SF_6 were contributing to grease failure was not dismissed. The distribution of faulty bearings was random, with no positional concentration to point to radiation damage.

We got in touch with Mobil, and one of their consultants told us that sealed bearings could not be relied on beyond about 5,000 hours at the degree to which we continually operate them. (Our shafts have clocked about 8,500 hours.) The consultant recommended a high temperature grease loaded with molybdenum disulphide; some of the justification for this is that, when the grease is exuded, or has become degraded, the loading itself will remain effective for sufficiently longer time to extend the lifetime of the bearing significantly beyond the 5,000 allocated hours, or the 8,500 hours experienced.

It must be taken into account that, if 5,000 hours is the true limitation of shaft bearings, it will be necessary to schedule a complete bearing change in something of the order of 18 to 24 months. These instances could coincide with point and/or chain renewals.

In the light of the information from the Mobil consultant, (who recommended Mobil 78), and taking into account the fact that to change any casting bearing it is necessary to remove the section of shaft and expose the bearings in the unit above, whether or not those bearings have failed, made us decide to change every shaft bearing in the machine.

To check outgassing properties of Mobil 78 a sample was put in a chamber and pumped down to about 10 microns. No mass movement or separation of components was observed, simply a slight cratering of the surface.

New bearings were bought, and their grease washed out with pet. ether; they were dried, residual solvent blown out with gas and the same amount of Mobil 78 put in. Unfortunately we were unable to get, at short notice, sufficient bearings with replaceable seals and therefore most of the new ones had to be fitted without an upper dust cover.

The bearings in the main alternators, and those in the shaft motors, have been changed since initial installation at times of electrical failure. The 3 charging motors, at about 6,000 hours, still have their original bearings which are quiet. The terminal and driving pulley bearings are somewhat noisy, but they have grease nipples and were greased in situ.

CHAINS:

After the last button-up we suspended in the tower the longest piece of chain which survived the break (it was 285 links) with a 28 lb. weight on the end of it. We looked for twist which might have led the chain to ride up on rivets, but neither straight away, nor after a week or more, could we observe any twist of more than a degree or so; 5 degrees at the very outside.

New pellets arrived from N.E.C. and were added to the undamaged lengths we had taken from the tank, giving us a full chain to install.

When we first examined chains 1 and 2 in the tank the glaringly obvious thing was oil. About 50 ml had gone from the reservoirs; the rims of the pulleys were covered with oil and droplets of oil hung from the lower rims of the up-going pellets a foot or so above the pulleys. Higher pellets had no dripping oil and it seems reasonable to conclude that the oil was collected by the pellets only in the last moment before the chain stopped. There was a pool of oil on the floor of the tank beneath each driving pulley. The rivets were parallel to the axis of the motor shafts and, when the chains were turned by hand, there was no sound of creaking such as we heard when the chains were newly installed.

Before starting work in the tank we ran the motors and both watched and listened to the chains. Chain 2 ran as it had run at last button-up, immaculately. Chain 1 which (Report 2, page 2), was buttoned-up having an oscillation in the stiff direction, was now also running immaculately, without ripple in either direction; the improvement is due to the profuse oiling. We found it significant that, in spite of the excess oil which we did not wipe off before testing, there was no chain slip so far as we could tell by observation; moreover, during actual operation prior to the tank opening, there was no evidence of slip so far as the metered parameters indicated, even when the load of volts on the terminal, and SF_6 "windage", were imposed on the chains. Chain 2 easily put up 100 microamps to the terminal at 12 MV during the last week of running. (Later we established that idlers for both chains were equally adjusted.)

What we refer to as 'Type 2' pulleys, with shimstock rims and no contact springs, and without channels for such springs, were fitted in some places after the first chain break. However, N.E.C. has expressed the view that pulleys without grooves might well give the chain a tendency to ride up the wall of the rim. If this idea is valid we wonder if the considerable amount of oil on our pulleys made the walls too slippery to ride up.

Before the tank opening we had put forward the idea that the charging current fluctuations on chain 1 might be due to a defective d.c. idler in the terminal, thus giving intermittent "doubling" because of interruption to the cross-over voltage. We found that all idlers were intact and that they turned normally as the chains were turned briskly by hand; this led us to run chain 1 with varying volts

on the inductors and to monitor current at the terminal as well as on the driving pulley. We found fluctuations in terminal current and soon noticed that the chain entirely towed away from the up d.c. idler when at speed. We adjusted the idler to be more snugly in contact with the chain and immediately the intermittent effect disappeared; charging current became rock steady.

Chain 3, part new pellets and part undamaged ones from the last chain break, was installed and fully adjusted.

In order to deepen our knowledge of the chains, we studied them with a stroboscope at different heights of the column. Nothing came to our attention up the column, but, in the terminal, the stroboscope allowed us to see that contact springs on some d.c. idlers did not emerge from their slots while others did so clearly. Testing the contacts with a small probe we found no significant difference between the good ones and the faulty ones. By adjustment we made the contacts operate correctly, nevertheless we put new d.c. idlers on all 6 positions, with newly established "snugness".

We then ran the chains and stroboscope again. The idlers seemed to be performing excellently and we observed on the terminal pulleys a definite slip which we had not detected by eye during our initial observations.

Accepting this slip as normal we nevertheless discussed it with the engineer who had conducted the tensile tests on the chain samples (Report 2; page 2), and he assured us that, with friction drives, slip on the driven pulley is classical, and forms the basis of examination questions.

We recorded the following table of r.p.m. observed in the terminal by stroboscope:

CHAIN	PULLEY	UP IDLER	DOWN IDLER
1	600	3,400	3,815
2	600	3,600	3,800
3	600	3,804	3,850

The stroboscope was not calibrated, but the nominal speed of the charging motors is 580 r.p.m. for 240 volts and a range of mains frequencies. Multiplying by the ratio of pulley to idler diameters the speed of the idlers is seen to be of the right order.

After gassing up, and initial trials, we found the chains to be performing excellently. Next day, during the first experimental use of the machine since button-up, we observed the most stable performance of the charging systems in about a year.

OILERS:

As stated in the preliminary to the discussion on chains, the oilers fitted at the last opening left much to be desired. Their performance in air, using Shell Turbo 29, seemed adequate enough to justify trying them for one tank closure of moderate duration; indeed, so far as the chains, and their charging performances are concerned, the flood of oil we unintentionally dispensed resulted in unusual mechanical stability and zero self-charge for the first time that we recall in the life of the machine; while true, we recognize that the effect is obscure.

Clearly, too large a fraction of oil introduced by our new oilers had been in mist form. We have found that passing the oil mist through a sintered bronze filter, taken from an oil burner nozzle, caused the mist to be converted to fluid drops which allow controlled wetting of the rims. This modification has been installed. We expect to use a pressure differential of 60 p.s.i. and a daily burst of 1 second, compared with 20 seconds for the earlier version. The oil delivery is approximately 2×10^{-4} cc/sec in the form of drops, not mist.

Reverting to the possible effects of the month we ran with misting oilers on the 2 chains available, we report that, where the usual dusty white plus brown stain occurs on the terminal opposite the triode stabilizing needles, we found this time a stain with distinctly oily characteristics. Led from this to the conventional brown stains on the reverse (pointless) surfaces of the tube and column point units we found the same effect. We emphasize that there was no oil, as such, but a wetness never before present; we attribute the effect to our having injected oil mist into the tank gas but concede that a substance from the melted rubber of the damaged shaft coupling might have been the origin.

As a check we re-activated the gas recirculator and fed the exhaust into an open bottle; there was no evidence of oil on the water which was collected.

For the coming closure we intend to oil for a 1-second burst a day, excepting weekends and statutory holidays. We imply that, until we have fuller information about oiler performance, we do not intend to put this apparently very critical function in the hands of experimenters who might operate the machine with varying degrees of effectiveness and concern.

GENERAL MATTERS:

POINTS:

None were seen to have failed in any way. The initial sharpness at the time of installation had faded detectably, but that was all.

The needles on the terminal corona stabilizer were changed.

VACUUM:

The tube was let up to nitrogen and foils changed. At the same time the 10 ℓ/sec pumps at midsection, and the L.E. end outside the tank, were interchanged in order to investigate the large irreducible current of 200 microamps at the midsection pump. We find that both interchanged pumps are now reading less than 40 microamps (2×10^{-7}) using an external mains operated power supply. With the tank pressurized, the mid-section pump current reverted to $\sim$ 250 μA ($\sim 8 \times 10^{-7}$ torr).

Sublimers on the upper and lower terminal pumps were changed by simple external connections.

PLATFORM CONTROL CABLE:

This had been isolated not long after the previous button-up because of obvious spark damage. It was found to be badly burnt and both cable and reel were taken out of the tank. It is intended to locate the reel above a support cable port and feed the control cable through at each open-up, using suitable guides to protect it from the steel cable in that port, removing it at each button-up.

A new 100 ft. length of control cable has arrived from N.E.C. and will replace the temporary dangling cables being used at this current opening. We are quite clear that we shall never leave the control cable in the tank again, preferring to

spend a few minutes disconnecting 14 wires from a barrier strip, then removing the service cable entirely from the environment which has inflicted on it so much damage in the past, at the same time threatening the tank feedthroughs, damage to which can only invite loss of SF_6.

SHORTING ROD CONTACT UNITS:

Some of the A.N.U. roller type units fitted throughout the machine were found to be seized, or had rollers which were worn flat. Because these were made in a hurry poor workmanship was accepted and we acknowledge that the tolerances probably do not allow the rollers of upper and lower units to operate vertically above each other, thereby imposing undesirable sideways displacement of one or another roller. However, the A.N.U. Type 2 contact units tried out in the 26 MeV casting seemed to be in good condition, and they have been used as much as any others in the accelerator since they were fitted.

PYROTENAX:

We have kept a watch on this since it was installed some time ago (Report No.1; page 3) and we found that it meggered at higher than 20 megohms, comparable to the previous value. This encourages us to use this material more extensively in future.

FOILS:

Prior to this opening there had been a sudden onset of inconsistent performance of stripper foils. A substantial effort was applied to understanding the effect which was eventually traced to inconsistent, and also heavy coatings of collodion. We believe that the difficulty has been overcome by a different method of applying the collodion; this we now do through immersion of the carbon coated glass slide in a beaker which drains in one minute. The centres of a sample of the foils so made are heated in air by a projector lamp. We find that no significant increase in opacity occurs, and this is distinctly different from the behaviour of the previous foils. We have now used 16 foils for NH^- at 10 MV and have found two half current foils. Using the terminal triplet with thin molecular beam increases transmission by about 15%.

HIGH VOLTAGE PERFORMANCE:

During the period prior to this opening high voltage operation was limited to around 12 MV. There was a good deal of evidence that chain 1 was causing variations in terminal voltage to a degree that drove the machine hundreds of kilovolts beyond its conditioned voltage, precipitating sparks.

Once in the tank we found that a failed mains power cable at the L.E. end had deposited droplets of molten copper and steel from Greenfield onto rings and terminal. There were no spark marks in the area, but high voltage operation must have been impaired.

CLEANING:

Stains made on the castings by grease from bearings were cleaned with acetone so that grease from future bearing troubles will show up. The column was vacuum cleaned in the usual way and rings wiped with alcohol.

OILING:

The new oilers were given a final brief burst so that we could leave on the rims a quantity of oil in excess of that traditionally left in the past, but by no means as profuse as the amount present when we went into the tank.

TESTING:

All chains were run at 2, 4, 6 and 8 kV inductor voltages and behaved smoothly, with substantially equal charging currents. The onset of sparking from inductors to chains occurred at a somewhat higher voltage than usual and we observed that the increase in oil caused the little trails of sparks which run up the chains to be absent from chains 1 and 3, and much reduced for chain 2.

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After gassing up, the machine went straight away to 9.5 MV with charging parameters remarkably steady. A few hours of conditioning were needed to attain troublefree performance at 10.2 MV, the minimum voltage required by the experimenters. This low voltage is not an unusual threshold after the tube has been up to air; additionally, the column had been considerably disturbed.

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