Fig. 4. Sodium vaporizer ducting and planar nozzle showing heater jackets, heaters, and thermocouples clamped in position. Heater and thermocouple feedthrough flanges are also evident.

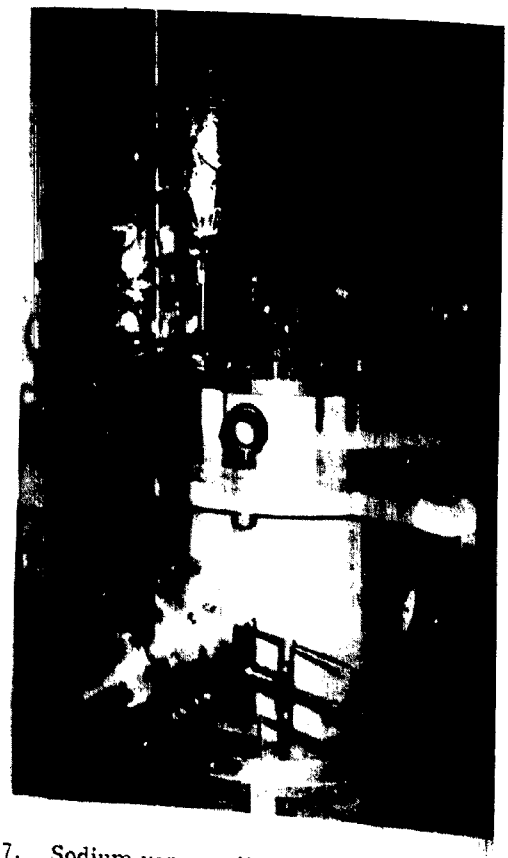

Fig. 7. Sodium vapor cell chamber installation seen from the beam entrance side. The feedthrough plate supporting the cell on its standoff insulator is evident. The test chamber and isolation valve are shown in the foreground. Sodium filling vessels are shown at upper left.

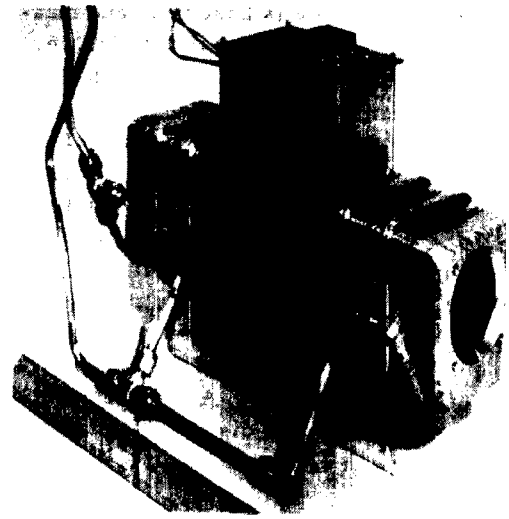

Fig. 5. Sodium condensing cell showing iml heaters and cooling tubing.

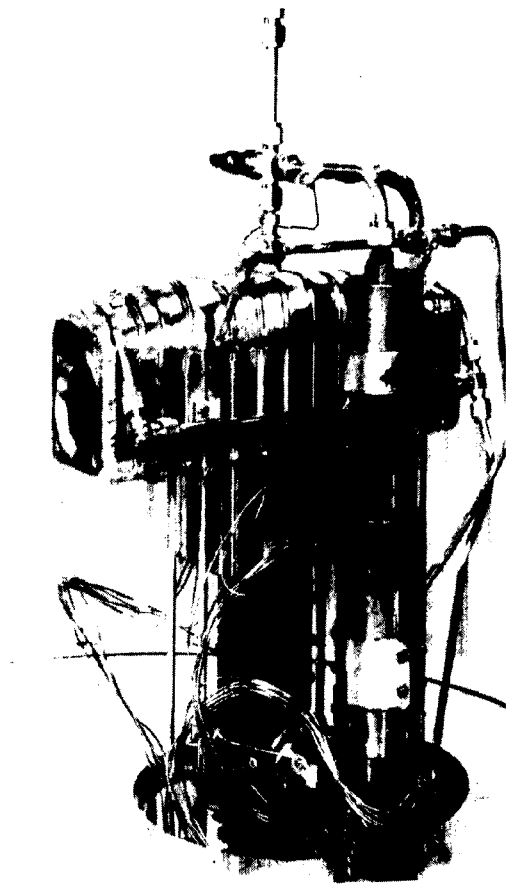

Fig. 6. Assembled sodium vapor cell unit m on vacuum chamber lid.

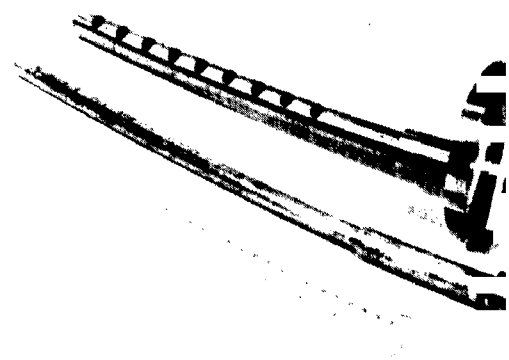

Fig. 8. Probe and multiapertured housing for forming density measurements on the sodium j

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OPERATING EXPERIENCE WITH THE POLARIZED ELECTRON GUN AT SLAC*

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During the two years of operation of the SLAC Polarized Electron Gun (PEGGY), the electron intensity delivered to the target has increased from 7×10^7 e^-/pulse to 1×10^9 e^-/pulse. The polarization is 0.85 with no measurable degradation caused by acceleration through the linear accelerator. The predominant cause of downtime is replenishment of lithium, which now averages 43 hours. The lifetime of a lithium load is about 175 hours.

The Polarized Electron Gun (PEGGY) has been in operation on the SLAC three-kilometer linear accelerator for about two years.[1,2] Figure 1 shows that during this time the electron beam intensity, I_e, has increased by an order of magnitude while the figure of merit $P_e\sqrt{I_e}$ - where P_e is the electron polarization - has tripled. (For a fixed time interval

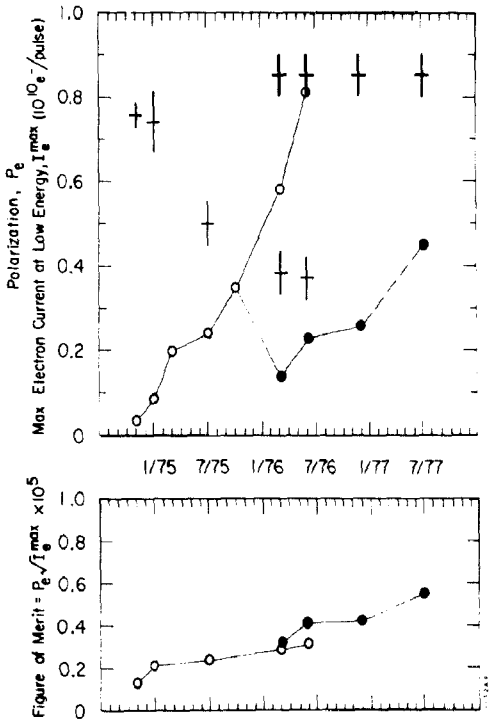

Fig. 1. PEGGY's development as a function of time and projection for the near future. The open circles and thin crosses in the upper plot are, respectively, maximum current and polarization measurements with resonant depolarization effects present. The filled dots and heavy crosses are measurements with resonant depolarization effects removed.

during which a spin-dependent scattering asymmetry is measured, the statistical error is inversely proportional to this figure of merit.) During this same period the availability of the polarized electron beam has increased from ~40% to ~75%. Transmission of the PEGGY electron beam through the accelerator to the target has averaged ~40%.

The longitudinally polarized electrons are produced by the photoionization of a state-selected lithium atomic beam.[3] Improvements in the source[4] since the initial operation on the linac include a larger oven which triples the lifetime of a lithium oven load. The atomic beam intensity has been increased by using a larger bore six-pole magnet. A new vortex-stabilized flash lamp and an ellipsoidal mirror which subtends a larger solid angle have greatly increased the UV light available for photoionization.

As the light intensity increased, significant depolarization associated with the resonant excitation of the 2P atomic state was observed.[5,6] With the resonant excitation light removed with a UV filter, we now measure the electron polarization, P_e, to be independent of light intensity and equal to the calculated atomic beam polarization of 0.85. The results of simultaneous polarization measurements by Mott scattering at 70 keV and by Møller scattering at GeV energies show no degradation of electron polarization caused by acceleration through the linear accelerator.

The present PEGGY operating characteristics, summarized in Table I, are matched to the requirements of high-energy experiments with polarized-proton targets,[2] viz., high polarization but target limited intensity. The electron

TABLE I

Operating Characteristics of Polarized Electron Beam

Characteristic	Experimental Value 12/76	Projected Value for Near Future
Pulse length	1.5 μs	No change
Repetition rate[a]	180 pps	No change
Electron intensity (e^-/pulse)		
At 70 keV	$(2.0 \pm 0.3) \times 10^9$ (2.6×10^9 max.)	4×10^9
At GeV energies	$(0.74 \pm 0.14) \times 10^9$ (1.1×10^9 max.)	1.7×10^9
Pulse to pulse intensity variation	<5%	No change
Electron polarization, P_e	0.85	No change
Polarization reversal time	3 s	No change
Intensity difference upon reversal	<5%[b]	<2%
Lifetime of lithium oven load[c]	175 h	150 h
Time to reload lithium	43 h	36 h
Overall availability	75%	No change

[a] Modulator and flash lamp are usually operated at a repetition rate of 180 pps with 120 pps injected into accelerator and 60 pps used for polarization measurement at low energy.

[b] The intensity difference can be reduced to <1%.

[c] Lifetime based on filling oven to 740 g capacity.

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intensity shown is the average over the last full accelerator cycle, which includes about 940 hours of PEGGY operation. Minor improvements in the source throughout the cycle resulted in an electron intensity averaged over the last third of the cycle that was 10% higher than the overall average. Additional improvements, primarily in the atomic beam intensity, are expected to result in a doubling of the electron beam intensity in the near future.

The latest PEGGY operating costs are given in Table II.

TABLE II

Monthly Operating Costs

Lithium	1200 g @ \$0.30 per g[a]
Other materials	\$800
Shop support	\$1200
Manning	4 man-months

[a]Special ERDA rate.

About 50% of the lithium actually used is recycled. During operation the source is manned 100% of the time by one operator with three persons required for a 6-hour period during the lithium-replenishment downtime. Future plans include the possibility of substantial periods of remote operation.

Significantly higher electron intensities without loss of polarization may be possible by optically pumping the 2P state of lithium with circularly polarized light.[6] The increased figure of merit which would result is desirable for high-energy experiments when the intensity is not target limited. A solid-state polarized-electron gun which is expected to produce high intensities with moderate polarization is currently under development at SLAC.[7]

We wish to acknowledge the invaluable assistance of the members of the groups that have done the experiments with the polarized electron beam at SLAC and in addition the SLAC Accelerator Operations Group.

References

1. P. S. Cooper et al., Phys. Rev. Lett. 34, 1589 (1975).
2. M. J. Alguard et al., Phys. Rev. Lett. 37, 1258 and 1261 (1976).
3. V. W. Hughes et al., Phys. Rev. A 5, 195 (1972); M. J. Alguard et al., in Proc. IXth Int. Conf. on High Energy Accelerators, Stanford Linear Accelerator Center, Stanford, California, May 2-7, 1974 (CONF-740522, available NTIS), p. 309.
4. A paper which describes in detail the present PEGGY design is under preparation.
5. J. E. Clendenin et al., in Abstracts of the 5th Int. Conf. on Atomic Physics, Berkeley, 1976, p. 431.
6. M. J. Alguard et al., submitted to Phys. Rev. A.
7. C. K. Sinclair et al., in High Energy Physics with Polarized Beams and Targets, AIP Conf. Proc. No. 35, Particles and Fields Subseries No. 12 (AIP, New York, 1976), p. 424.