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CONF-841117--12

UCRL- 90898
PREPRINT

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This paper was prepared for submittal to the
Eighth Conference on the Application of
Accelerators in Research & Industry
North Texas State University
Denton, Texas
November 12-14, 1984

August 20, 1984

Lawrence Livermore National Laboratory

DISCLAIMER

THE USE OF INDUCTION LINACS WITH NONLINEAR MAGNETIC DRIVE AS HIGH AVERAGE POWER ACCELERATORS*

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UCRL--[illegible]

August 20, 1984

DE85 000744

ABSTRACT

The marriage of induction linac technology with Nonlinear Magnetic Modulators has produced some unique capabilities. It appears possible to produce electron beams with average currents measured in amperes, at gradients exceeding 1 Mev/meter, and with power efficiencies approaching 50%. A 2 MeV, 5 kA electron accelerator is under construction at Lawrence Livermore National Laboratory (LLNL) to allow us to demonstrate some of these concepts. Progress on this project is reported here.

INTRODUCTION

Among the extended family of particle accelerators, the Linear Induction Accelerator (LIA) probably holds the position of being the least complex, at least in concept, because it is simply a pulse transformer in

* Work performed jointly under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract W-7405-ENG-48 and for the Department of Defense under Defense Advanced Research Projects Agency ARPA Order No. 4395, monitored by Naval Surface Weapons Center under document number N60921-84-WR-W0095.

which the secondary winding is comprised of an electron beam rather than a length of wire.

The accelerating structures themselves are full of the things transformers are typically full of such as, ferro-(or ferri-)magnetic material, and can be constructed so as to be quite rugged and relatively inexpensive. They appear to be ideally suited for applications requiring high currents (kiloamps) at modest energies.

The pulse lengths typically are limited by design practicalities to $\leq$100 ns, but machines with pulse lengths of up to 400 ns have been constructed. Until recently, the duty factors of these accelerators has been extremely modest, but in the near future we hope to demonstrate the capability of operation at repetition rates of order 10^4 Hz.

The performance of these accelerators has also been limited by the modulators which supply the drive. The requirements for very high power levels ($\geq 10^{10}$ watts/modulator) in very short times ($\leq 10^{-8}$s) could not be met reliably at high repetition rates and average power levels. However, recent advancements in magnetic compression technology have made available power conditioning systems for LIAs that provide essentially unlimited life times, high reliability, and average repetition rates exceeding 10^4 Hz. This relatively simple and inexpensive approach to the generation of electron beams makes them attractive for a number of applications, including sewage sterilization and food irradiation.

A DEMONSTRATION ACCELERATOR

Research conducted at LLNL over the past few years has culminated in modulators based on nonlinear magnetic compression which are applicable as drivers for LIAs.

A new 2 MeV, 10 ka LIA order construction at LLNL will provide a test bed for such drivers. While magnetic modulators have been deployed experimentally in isolated parts of both the Experimental Test Accelerator (ETA) and the Advanced Test Accelerator (ATA), this will be the first LIA where they are solely responsible for the accelerator drive. A simplified schematic of the accelerator and driver is provided by Fig. 1. The two magnetic modulators, designated there as MAG-I's, each supply a 15 gigawatt pulse of 80 ns duration to the accelerator (designated 2 MeV injector). The power is transported from each MAG-I to the accelerator via two 4-ohm water filled transmission lines. Due to anticipated difficulties in transmitting the full 500 kV drive voltage, the pulse sent through the cables is actually only one-third that level and is stepped up to full voltage by a transformer adjacent to each accelerator cell. Zn-Ni ferrite was chosen as the accelerator core material because of its excellent fidelity at these short time scales. The actual hardware involved in this transition is illustrated in Fig. 2.

A cross-sectional view of a MAG-I is provided by Fig. 3. These units provide a 25-fold compression of the 1000 J pulse delivered by each pair of intermediate storage units (IS-I) before sending it on to the accelerator.

INITIAL EXPERIMENTS

While most of the accelerator operating time will be dedicated to research on topics related to national defense, experiments on radiation food processing are already being scheduled.

These experiments will be carried out in conjunction with the University of California at Davis, and will be directed at documenting similarities and differences between this technique of radiation processing and the more conventional method of exposure to radioactive isotopes.

SUMMARY

The addition of pulse compression technology to the power conditioning system to LIAs makes possible the construction of rugged and versatile accelerators which can operate at unprecedented power levels. These devices may serve as useful tools in nondefense applications such as radiation processing.

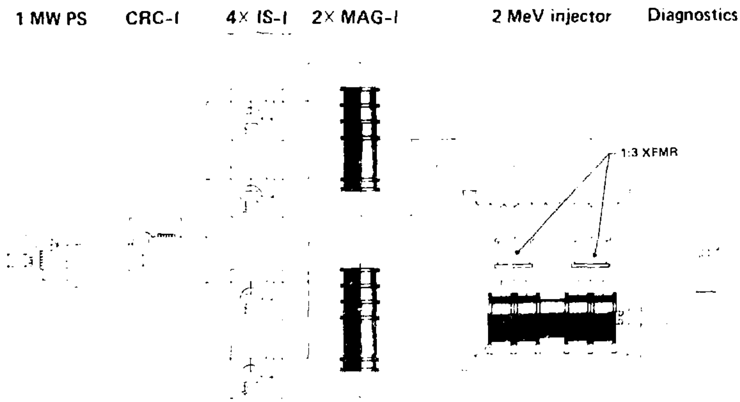

Figure 1. Initial configuration high brightness test stand (*HBTS*)

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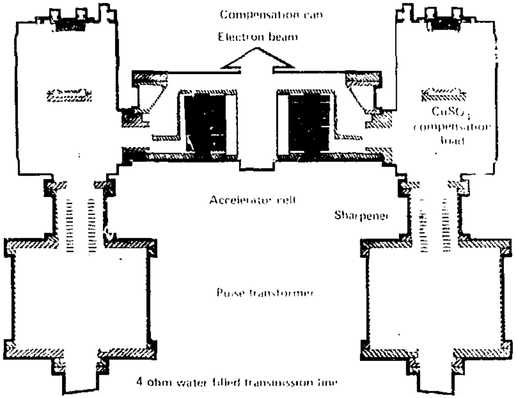

Figure 2. HV transition to accelerator cell.

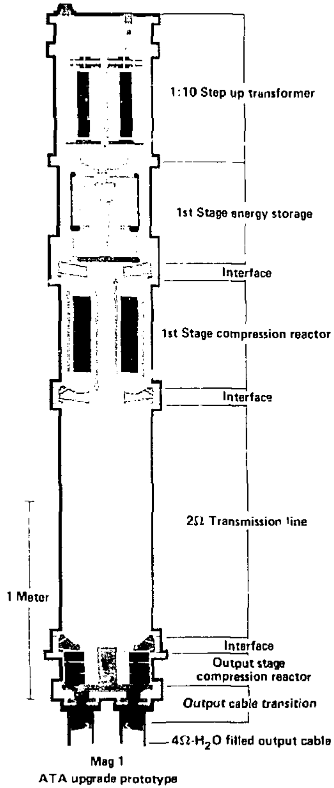

Figure 3. MAG-I cross-section.