UNITED STATES
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
FLIGHT PROPULSION RESEARCH LABORATORY
CLEVELAND AIRPORT
CLEVELAND, OHIO

SPECIFICATIONS
FOR
CYCLOTRON

SPECIFICATION NO. C-723 DECEMBER 12, 1947

I. General

These specifications cover a cyclotron having a nominal pole face diameter of 60-inches. The cyclotron shall be installed in a building to be furnished by the NACA. The bidder shall provide engineering supervision of installation, assembly and testing at the Flight Propulsion Research Laboratory, Cleveland, Ohio, with labor to be supplied by the NACA. No shielding crane or building auxiliaries such as lights or heat shall be supplied by the bidder.

II. Adjusted Performance for Acceptance

The cyclotron shall be so adjusted that it delivers for a continuous period of at least 4 hours an emergent beam to an outside target, of 20,000,000-volt deuterons having the following characteristics:

(a) Total current delivered to the outside target not less than 100 microamperes.
(b) At least 40 microamperes of the beam current shall be within a one-centimeter square of the beam cross-section. 20% Addendum
(c) At least 50 percent of the emergent beam shall be within plus or minus five percent of the mean value of the beam energy.

The methods of checking intensity and range shall be agreed upon between the Government and the Contractor. In event of disagreement, the final decision shall be made by the National Bureau of Standards or by an independent agency recommended by the National Bureau of Standards.

III. Potential Performance

The magnetic field intensity, final orbit radius, and range of oscillator frequency shall be such as to permit theoretical attainment of deuteron beams of 35,000,000 electron-volts energy. Bidders shall state the values of field intensity, orbit radius, and frequency range that they expect to furnish.

IV. Minimum Mechanical Equipment Requirement

The vacuum chamber shall have a port for insertion of an internal probe between the dee-stems, an internal target holder with vacuum gate and seal to permit oscillation of the internal probe; an enclosed electrostatic deflector and a replaceable tungsten deflector with external positioning controls and vacuum seals; an ion source assembly with filament stems removable through vacuum seals; piping for gas feed to the ion source; an external target port with vacuum seal; an aluminum beam exit window with provision for cooling the window and for attachment of auxiliary equipment to the outside of the vacuum chamber, in line with the beam; internal and external target port vacuum gates and probe holders designed to provide for remote control; and chamber installation and handling equipment including removable rail and cart.

The vacuum chamber and dee-stems shall be provided with pumps of at least one liter per second capacity at 10^{-5} mm. of mercury per liter of volume to be evacuated; refrigerated baffles for oil-vapor; remotely-controlled high-vacuum valves; and liquid air cold trap. Operating vacuum shall be better than 10^{-5} mm. of mercury; vacuum gages of the ionization and thermocouple type shall be provided; automatic protection of gages and pumps against loss of vacuum or failure of the cooling system shall be provided. A mass spectrograph type of leak detector shall be provided.

Valves, regulators, and flow indicators shall be provided for hydrogen, deuterium, and helium supplies and shall include means for remote control of the flow.

A heat exchanger, pumps, and auxiliary apparatus shall be provided for any closed oil or distilled water cooling circuits; a still and storage tank for distilled water shall be provided, if needed.

All special alignment jigs, fixtures, tools, and non-standard instruments used in adjusting the final performance of the cyclotron shall become the property of the Government.

A supply of replacement parts, such as ion source filaments, cone tips, tungsten deflectors, etc. shall be furnished sufficient for operation of the cyclotron for 1000 hours.

V. Minimum Electrical Requirements.

The cyclotron shall have a 60-inch nominal pole face diameter electromagnet assembly with cooling and exciting coils capable of maintaining approximately 18000 gauss in the median plane of the dees; motor-generator set with at least 25 percent overload rating; automatic means for current stabilization to 0.01 percent for at least four hours; a radio-frequency dee supply with frequency ad-

justable between 10 and 14 megacycles or wider; final tuning adjustment to be possible while cyclotron is in operation; radio-frequency anode power supply of at least 200 kilowatts output adjustable between 25 and 100 percent and having not more than two percent ripple; an enclosed-arc ion source with at least a 5-kilowatt radio frequency filament supply and at least a 10-ampere direct current anode supply; provision for pulsing the ion beam at 60-cycles per second with pulses of one to eight milliseconds duration, through a pair of external terminals for a switch to be provided by the Government; direct-current deflecting power supply having not more than one percent ripple and rated at not less than 100 kilovolts and not less than 50 milliamperes; automatic protection of the mechanical and electrical equipment against damage because of any failure or excessive variation in the vacuums, electrical power supplies, or cooling facilities; complete shielding of all radio-frequency equipment and transmission lines to prevent radiation to adjacent electronic instruments; an operating console for complete remote control and operation of the cyclotron, including all necessary meters and alarm signals; an auxiliary enclosed control rack or cabinet for all controls and equipment that are located in the cyclotron room; all special electrical instruments and equipment necessary for adjustment, maintenance, and periodic test of the cyclotron; and all electrical power distribution equipment such as power transformer banks, switchgear, and battery charging equipment.

The Contractor shall supply any replacement parts necessary for operation of the cyclotron for 1000 hours.

VI. Electrical Power Distribution Equipment and Switchgear

1. Scope:

Power will be supplied to the cyclotron substation at 2400 volts, 3 phase, 60 cycles. The Contractor shall furnish a complete unit substation for supplying power for the operation of the cyclotron and its auxiliary equipment and for lighting and power for the cyclotron building.

2. 2400-Volt Switching Section:

The 2400-volt section of the unit substation shall consist of an outdoor type fully metal enclosed with hinged doors and metal enclosed transition compartment forming a weatherproof connection to the transformer section. This section shall contain the main circuit breaker,

transformer, and motor-generator breakers and other breakers necessary for the operation of the cyclotron. Circuit breakers shall be of the air break drawout type of suitable ampere capacity rated at not less than 5000 volts. The breakers shall have an interrupting capacity of 150,000 kilovolt-amperes. Circuit breakers shall be designed for 125-volt direct current operation with direct current trip coils. Station type storage battery of suitable size, for the operation of the switchgear with indicating pilot end cell, charger and battery rack shall be furnished under this contract.

Meters, meter transformers, relays and other equipment necessary for the operation of the substation and the equipment connected thereto shall be furnished under this contract.

The Contractor shall furnish one transfer truck and one test truck necessary for the testing and servicing of the substation.

3. Transformer Section:

Transformer shall be of the outdoor type of a kilovolt-ampere rating sufficient to supply the cyclotron and in addition 100 kilovolt-ampere for the cyclotron building services. The transformer shall be 3-phase, 60 cycles, 2400-volts delta primary - 208Y/120-volt four-wire grounded neutral secondary and shall be self-cooled Askarel filled with a maximum 55 degree C temperature rise. The transformer shall be manufactured in accordance with the latest practice and design of the transformer industry and shall conform to the standards of the AIEE, NEMA, and ASA and shall be in accordance with the National Electrical Code. Four approximately 2-1/2 percent rated kilovolt-ampere capacity taps shall be supplied in the high voltage winding, two above and two below rated primary voltage, brought to externally operated manual tap changers which are to be operated only when the transformer is de-energized.

The following accessories shall be furnished:

Drain Valve and Sampling Device	Liquid Level Gage
Filling Connection	Sampling Device
Filter Press Connection	Lifting Lugs
Jack Bosses	Cover Lifting Eyes
Thermometer	Pressure Test Connection and Air Vent
Ground Lug	

The transformer section shall be properly coordinated to bolt integral with the metal bus duct connection to the low-voltage switch section.

The 2400-volt switching section and the transformer will be located outdoors. The low voltage control section will be located in the electrical and equipment room. The feeders between the transformer and the low voltage control section will be furnished and installed by others.

4. Low Voltage Control Section:

The low-voltage control section will be located in the electrical equipment room and shall consist of the necessary metal enclosed factory assembled air break manually-operated air circuit breakers for the operation and control of the cyclotron and for building services. The transformer secondary air circuit breaker shall be of capacity corresponding to the size of the transformer rated at not less than 600 volts and 25,000 ampere interrupting capacity.

The Contractor shall provide a tie air circuit breaker rated at 600 amperes, 600 volts, 25,000 ampere interrupting capacity manually operated magnetic type, instantaneous short circuit trip, and interlocked with the transformer main breaker so that only one of these breakers can be closed at the same time.

The Contractor shall provide two feeder air circuit breakers each rated 225 amperes, 600 volts, 15,000 ampere interrupting capacity manually operated for building services and space.

The Contractor shall provide and mount the following equipment in the low-voltage control section:

voltmeter test block
triplex ammeter

All indicating instruments shall be concentric scale switchboard type, General Electric type AB-15 or approved equal.

It shall be the responsibility of the Contractor to furnish coordinated and matched units of equipment designed to be readily assembled in the field.