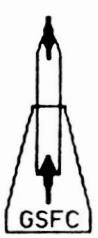
THE GODDARD SPACE FLIGHT CENTER MECHANICAL COOLER PROGRAM

APRIL 29, 1987

PRESENTED BY
DR. STEPHEN H. CASTLES



OUTLINE

- o NASA PROGRAMS REQUIRING LONG LIFETIME COOLER
- o PHILIPS COOLER PROGRAM
  - HISTORY OF PROGRAM
  - TECHNOLOGICAL DEVELOPMENTS
  - STATUS
- o CREARE COOLER PROGRAM
  - HISTORY OF PROGRAM
  - TECHNOLOGICAL DEVELOPMENTS
  - STATUS

40 K - 120 K (SINGLE STAGE COOLERS)

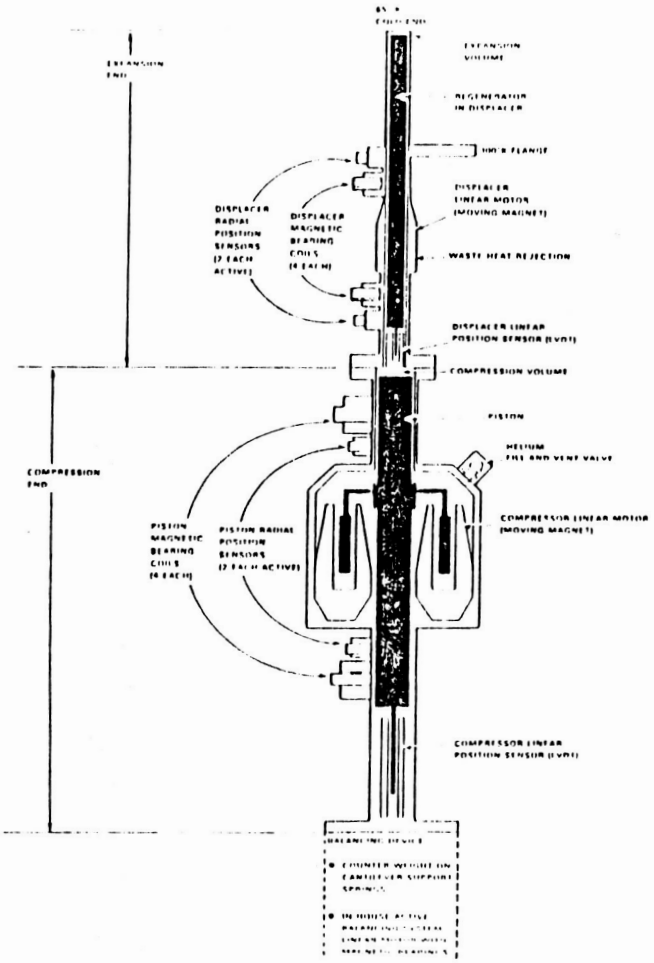
REQUIREMENTS (AND ILLUSTRATIVE EXAMPLES)

- o COOLING SENSORS
  - ADVANCED X-RAY ASTROPHYSICS INSTRUMENT
  - MODERATE RESOLUTION IMAGING SCANNER ON EARTH OBSERVING SYSTEM (EOS)
  - HIGH RESOLUTION IMAGING INFRARED SPECTROMETER ON EOS
  - 2 SECOND GENERATION SPACE TELESCOPE INSTRUMENTS (SOLID METHANE/AMMONIA COOLERS OR LONG LIFETIME MECHANICAL COOLERS)
- o LONG TERM STORAGE OF LIQUID HELIUM
  - ADVANCED X-RAY ASTROPHYSICS FACILITY INSTRUMENT
  - ASTROMAG
  - CRYOGENIC INTERFEROMETER SPECTROMETER ON EOS (TBD)

HISTORY OF LONG-LIFE STIRLING COOLER

- o PRELIMINARY STUDY - COMPLETE - 1979
- o ENGINEERING MODEL MET DESIGN SPECIFICATION - MARCH 29, 1982
- o ENGINEERING MODEL PASSES TWO YEARS RUN TIME WITH NO DEGRADATION - AUGUST, 1985
- o PROTOTYPE CONTRACT BEGINS - SEPTEMBER, 1981
- o AIR FORCE FUNDING BEGINS - DECEMBER, 1984
- o PROTOTYPE COOLER DELIVERABLE - DECEMBER, 1987

SINGLE EXPANSION CRYOGENIC COOLER WITH LINEAR MAGNETIC SUSPENSION



PROTOFLIGHT COOLER

MAJOR TECHNOLOGICAL FEATURES

- o MAGNETIC BEARINGS FOR LONG LIFE
- o RADIAL POSITION SENSORS WITH LOW DRIFT
- o AXIAL POSITION SENSORS WITH HIGHER FREQUENCY RESPONSE
- o LOWER DISPLACER POWER - MAGNETIC SPRINGS
- o HIGH EFFICIENCY DRIVERS FOR LINEAR MOTORS
- o COMPACT LONG LIFE ACTIVE COUNTERBALANCE - GAS SPRINGS
- o COATED INTERNAL SURFACES FOR SECONDARY BEARINGS
- o LOW FREQUENCY VIBRATION ISOLATION MOUNT

ADVANTAGES OF PHILIPS COOLER

- o ENGINEERING MODEL HAS DEMONSTRATED LONG-LIFETIME, RELIABLE OPERATION
- o EFFICIENT
- o LOW VIBRATION (ACTIVE BALANCER)

REFRIGERATOR MECHANICAL RELIABILITY

PRELIMINARY

MISSION	FAILURE RATE*	RELIABILITY**
3 YEARS	.29105	.99258
4 YEARS	.29105	.98985

*FAILURE RATE PER MILLION HOURS OF OPERATION

**BASED ON: MILITARY HDBK-217D
MIL STANDARD 756B: "MILITARY STANDARD, RELIABILITY PREDICTION"
U.S. ARMY REDSTONE ARSONAL STORAGE REPORT LC-78-1: "MISSILE MATERIAL RELIABILITY PREDICTION HANDBOOK"
ROME AIR DEVELOPMENT CENTER REPORT NPRD-2: "NONE-ELECTRONIC RELIABILITY PARTS RELIABILITY DATA"
GIDEP: GOVERNMENT/INDUSTRY DATA EXCHANGE PROGRAM-SUMMARY OF FAILURE RATE DATA

STATUS OF PROTOFLIGHT DEVELOPMENT

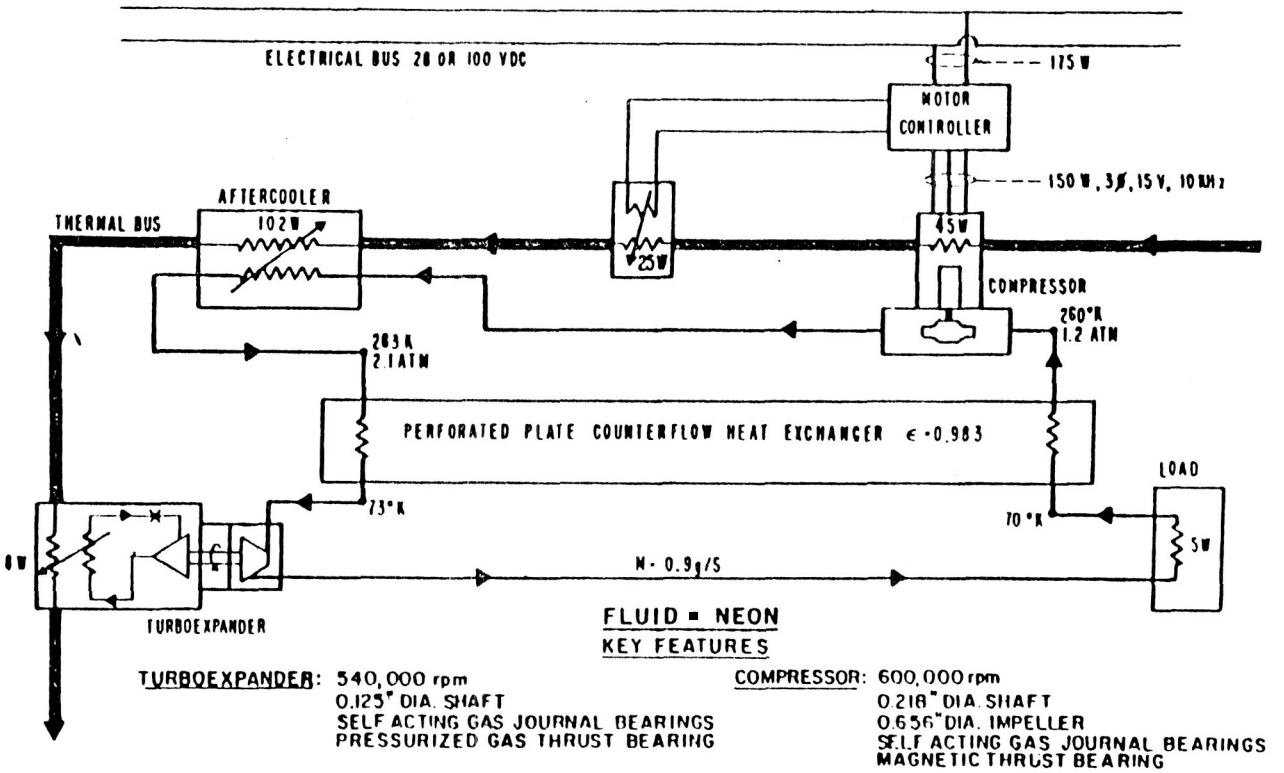
- o DESIGN COMPLETE
- o FABRICATION AND TEST OF SAMPLE CRITICAL SUBASSEMBLIES IS COMPLETE
  - RADIAL BEARINGS
  - LVDT
  - LINEAR MOTORS
- o ROUGH MACHINING OF HOUSING IS NEARING COMPLETION
- o FABRICATION AND ASSEMBLY COMPLETE BY 12/30/87

SUMMARY OF PHILIPS PROGRAM

- o PHILIPS COOLER IS BASELINED FOR FLIGHT ON THE X-RAY SPECTROMETER INSTRUMENT ON THE ADVANCED X-RAY ASTROPHYSICS FACILITY
- o PROTOTYPE COOLER IS 75% COMPLETE.
- o MEETING NASA'S SCIENTIFIC GOALS IN BOTH EARTH SCIENCES AND ASTROPHYSICS IS DEPENDENT ON THE AVAILABILITY OF A RELIABLE MECHANICAL COOLER

CREARE, INC.

NASA / GODDARD SPACEBORNE CRYOCOOLER



FLUID = NEON

KEY FEATURES

TURBOEXPANDER: 540,000 rpm
0.125" DIA. SHAFT
SELF ACTING GAS JOURNAL BEARINGS
PRESSURIZED GAS THRUST BEARING

COMPRESSOR: 600,000 rpm
0.218" DIA. SHAFT
0.656" DIA. IMPELLER
SELF ACTING GAS JOURNAL BEARINGS
MAGNETIC THRUST BEARING

MAJOR TECHNOLOGICAL FEATURES

- o MINIATURE CENTRIFUGAL COMPRESSOR
  - 600,000 RPM
  - .218 INCH DIAMETER SHAFT
  - .656 INCH DIAMETER IMPELLER (DOUBLE SIDED)
  - SELF ACTING GAS JOURNAL BEARINGS (TILTED PAD TYPE)
  - MAGNETIC THRUST BEARINGS (PERMANENT MAGNETS)

- o MINIATURE TURBOEXPANDER
  - 500,000 RPM
  - .125 INCH DIAMETER SHAFT
  - SELF ACTING GAS JOURNAL BEARINGS (TILTED PAD TYPE)
  - PRESSURIZED GAS THRUST BEARING

- o ALL METAL COUNTERFLOW HEAT EXCHANGER (SLOTTED COPPER PLATES)
  - 0.985 PREDICTED EFFECTIVENESS

POTENTIAL ADVANTAGES OF THE CREARE REVERSE BRAYTON CYCLE COOLER

- o LOW VIBRATION (SELF BALANCING)
  - ACTIVE BALANCING NOT REQUIRED

- o SIMPLE CONTROL ELECTRONICS (PRIMARILY HIGH FREQUENCY INVERTER)
  - ELECTRONICS MORE RELIABLE
  - COST, WEIGHT AND POWER SAVINGS

- o MINIATURE MOVING PARTS DO NOT REQUIRE A LAUNCH LOCK

- o INTERFACE WITH OBJECT TO BE COOLED IS RELATIVELY SIMPLE BECAUSE OF LOW VIBRATION

- o LOW SYSTEM WEIGHT AND SIZE

- o FLEXIBILITY IN PACKAGING OF COMPONENTS

HISTORY OF GODDARD'S FUNDING OF CREARE

- o TECHNOLOGY DEMONSTATION MODEL REVERSE BRAYTON CYCLE COOLER
  - DESIGN 12/84 TO 6/85
  - FAB & TEST 4/86 TO 4/88
- o ALL-METAL COMPACT HEAT EXCHANGER
  - DESIGN 2/86 TO 8/86
  - FAB & TEST 5/87 TO 5/89

SUMMARY

- o THE PHILIPS STIRLING COOLER PROGRAM WILL ENSURE THAT A COOLER IS AVAILABLE TO MEET NASA'S NEEDS IN THE 40 TO 120K TEMPERATURE RANGE IN THE EARLY 1990'S
- o THE CREARE TURBOMACHINERY BASED COOLER MAY PROVIDE AN IMPROVED COOLER FOR THE 40 TO 120K RANGE
- o DESIGN OF ADVANCED MULTISTAGE COOLERS FOR USE DOWN TO 2 KELVIN WILL BEGIN IN 1988
  - NEW LOW TEMPERATURE REGENERATOR CONCEPTS WILL BE EXPLORED

SPEAKER: STEPHEN H. CASTLES/GODDARD SPACE FLIGHT CENTER

John R. Schuster/General Dynamics Space Systems:

What is the status of the development work that was being done on a two stage Stirling machine?

Castles:

The two-stage Stirling machine is being produced by Magnavox Space Division, which is also a division of North American Phillips, and, as far as I know, the Air Force has completely ceased funding that program; it is at a total standstill. The machine was fairly well along; most of the hardware was complete, but as far as I know it is sitting at this time. That machine incorporated essentially the same technology that we had in our engineering model.