NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TECHNICAL TRANSLATION F-87

DEVELOPMENT OF SOUNDING ROCKETS IN JAPAN

By Hideo Itokawa, et al.

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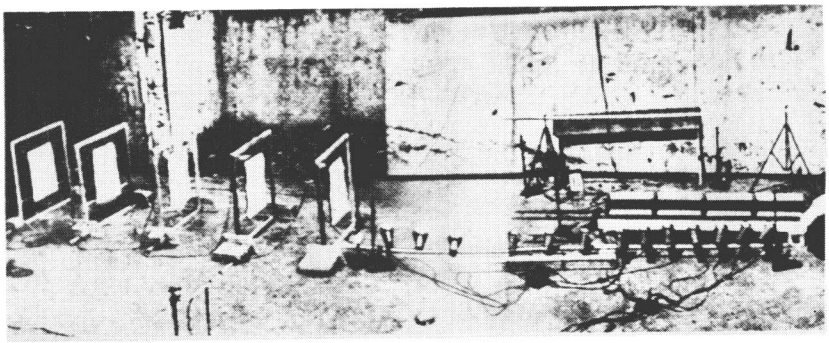
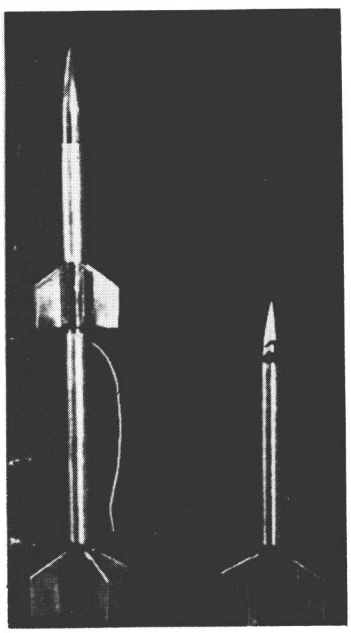
The PENCIL and BABY

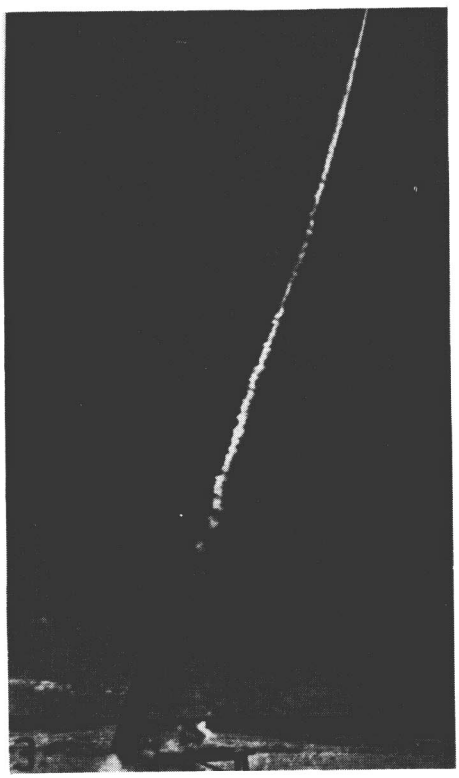
The first step in Rocket research began in 1955 with the PENCIL. In June of that year a proving ground was established on the coast of Dosen in Akita Prefecture and flight tests conducted of the PENCIL and BABY. The proving ground at that time was on the shore approximately 700m south of the present area.



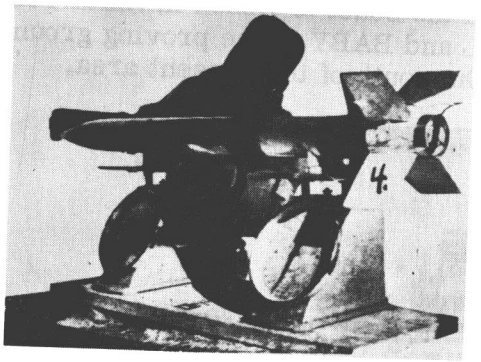
1. PENCIL Rocket launcher and electric targets. (April 1955)

2. PENCIL and 2 stage PENCIL.

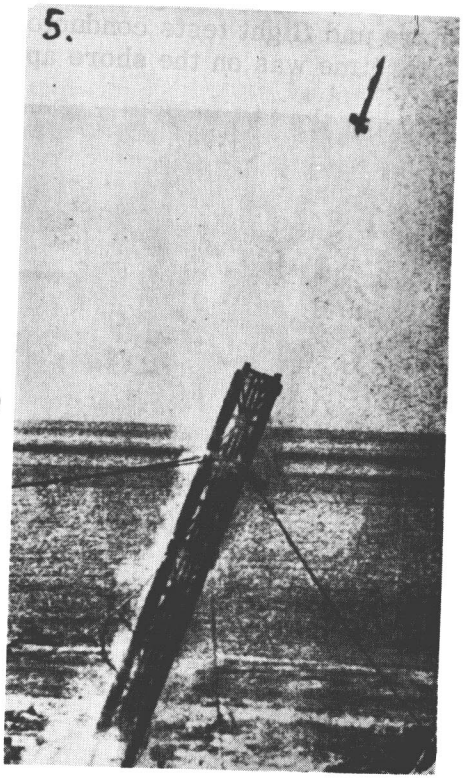




3. PENCIL launching on Dosen Beach. (August 1955)

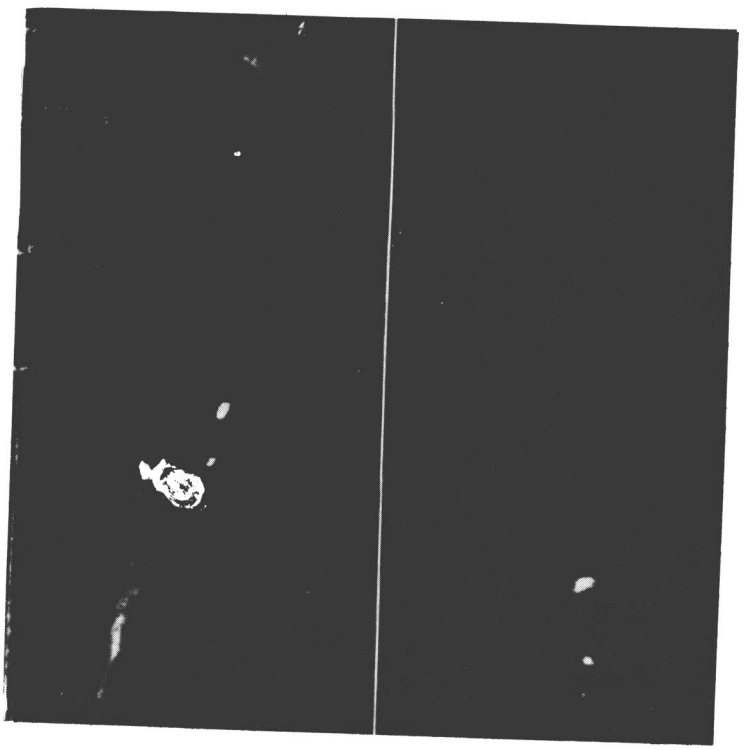


4. BABY Rocket (Measuring Center of Gravity)

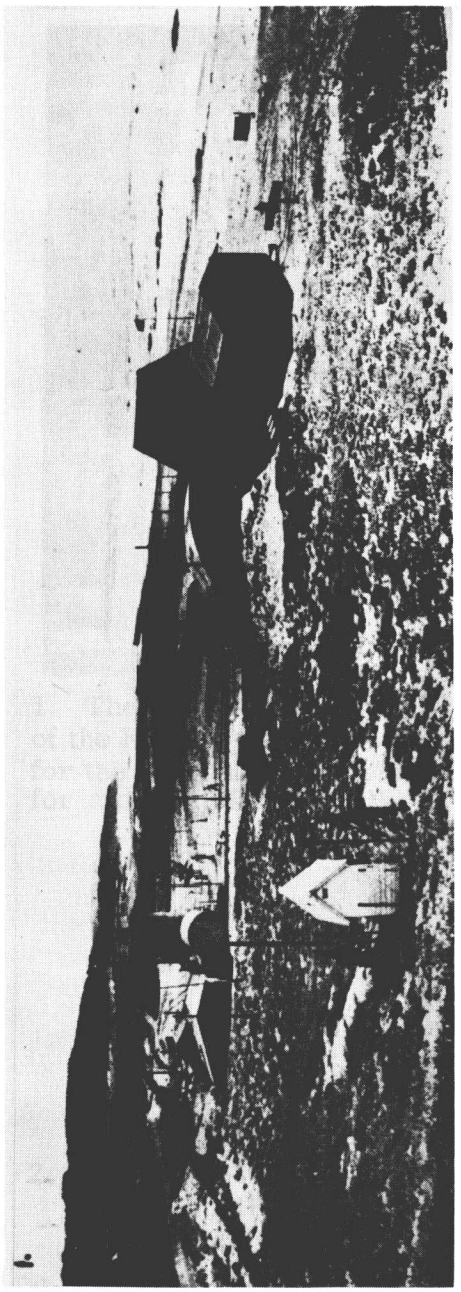


5. BABY-S Launching (August 1955)

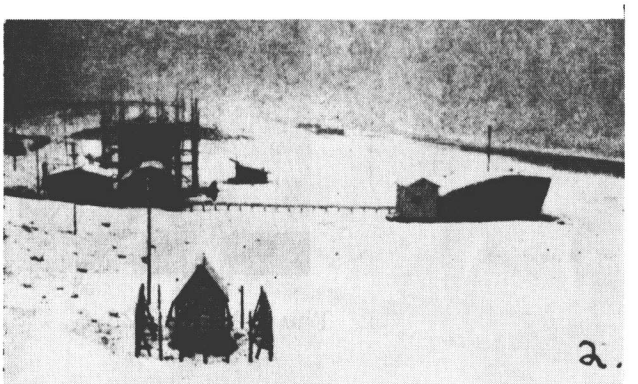
6. Recovery of BABY-R (left and right) (November 1955)



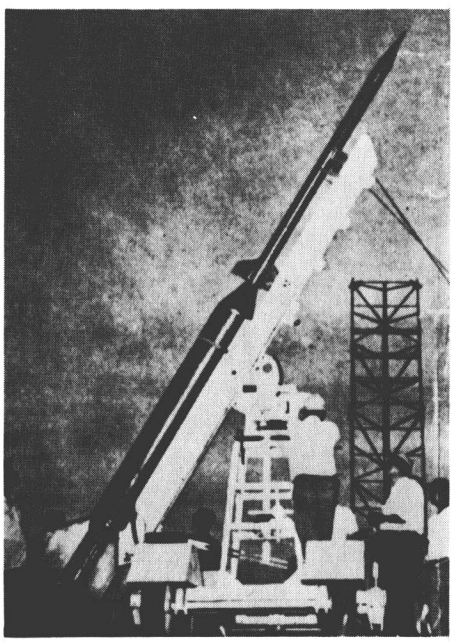
Akita Proving Grounds and the KAPPA-128, 2, 3, 4. Construction was begun on the present Akita Proving Grounds in the beginning of 1956 and used in August 1956 since the tests of the KAPPA-128. (Location: Akita Prefecture, Yuri-gun, Iwashiro-cho, Owaza, Kattewaza, Nakanoshima.) In April 1957, dummy tests took place on a 2-stage rocket (KAPPA-2) and subsequently flight tests were made on the KAPPA-3. Then, in September 1957 flight tests were made of the larger two stage KAPPA-4.



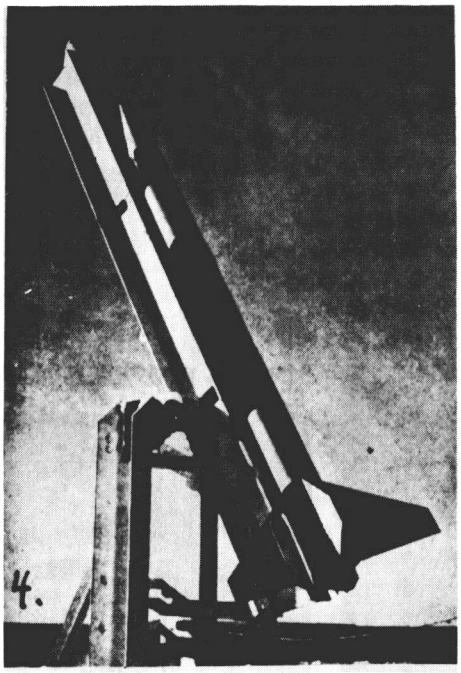
1. Present proving grounds. (September 1960)



2. Proving grounds in the winter of 1956.



3. The KAPPA-4. (September 1957)

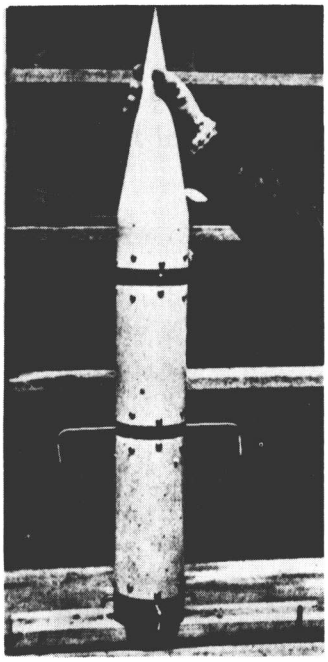


4. The KAPPA 128-S. (September 1956)

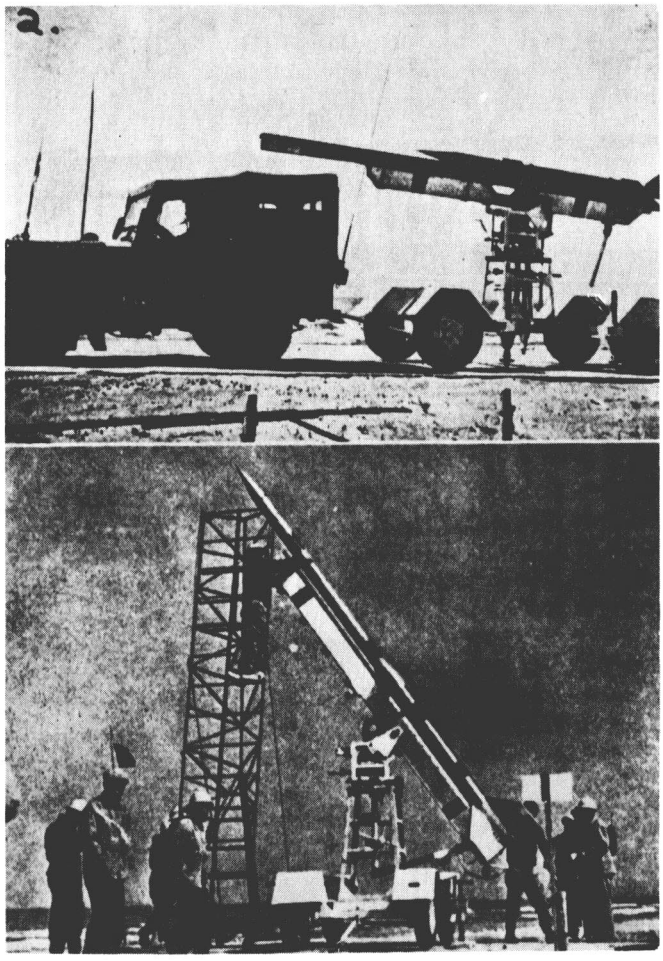
5. The KAPPA-3. (April 1957)

The KAPPA 122, 150, 5 and 6

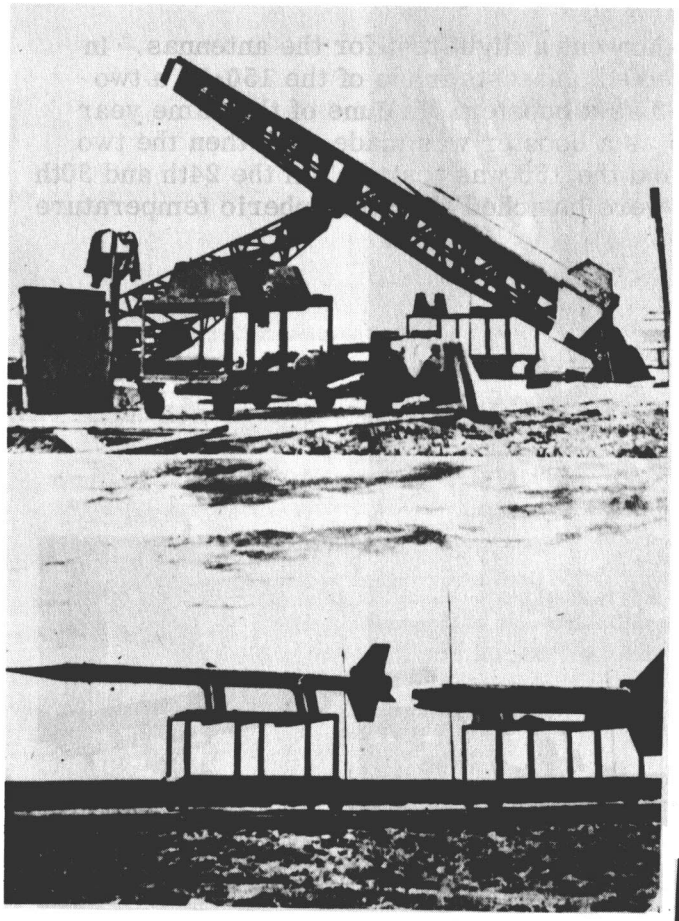
In December 1957, the 122 underwent a flight test for the antennas. In April 1958 the KAPPA 150 was perfected and tests made of the 150-5, a two stage rocket made with the KAPPA-3 as a booster. In June of the same year an individual test of the KAPPA-245 as a booster was made, and then the two stage KAPPA-6, consisting of this and the 150 was tested. On the 24th and 30th of the same month, the TW-1 and 2 were launched and atmospheric temperature and wind observed by the TW-2.



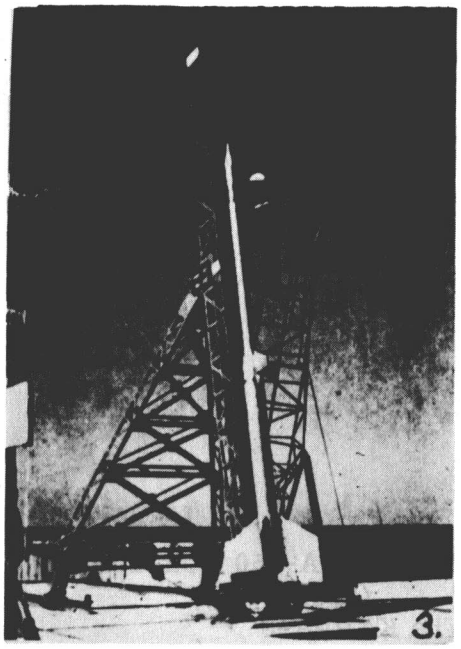
1. The protruding antennas of the KAPPA-122. Above is for the telemeter and below for radar. (March 1958)



2. The KAPPA-150 from above. (April 1958)
The KAPPA-5



2. (cont.)
The KAPPA-245 (June 1958)
The KAPPA-6 (June 1958)



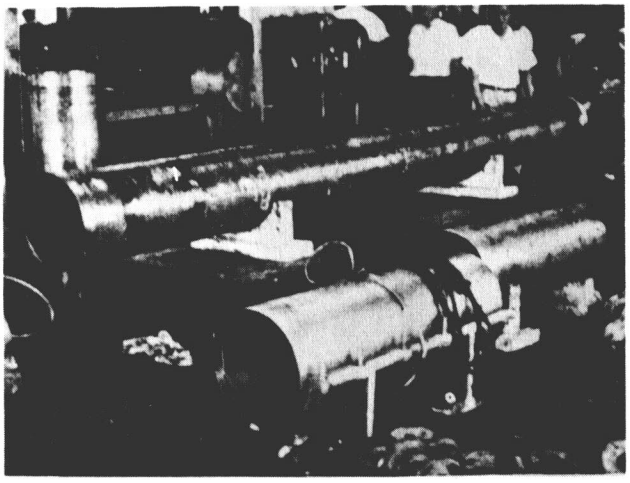
3. The KAPPA-6 (June 1958)

The KAPPA 7 and 8

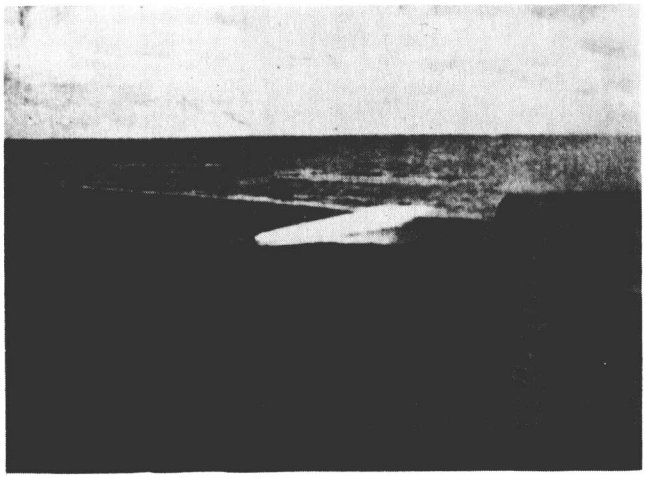
At the end of the IGY, sounding rocket development entered a new stage. The 7 used a welded chamber of high tensile steel, with a diameter of 42cm. The first ground burning test took place at Akita Proving Grounds in September 1959.

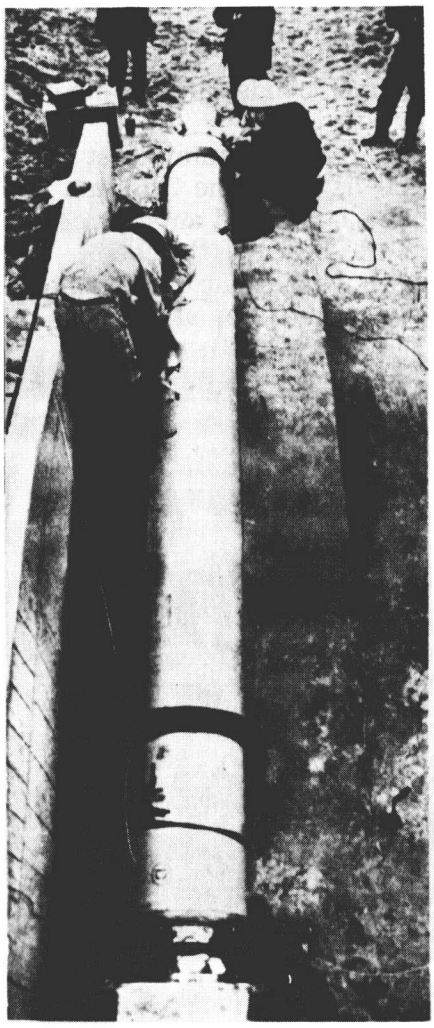
In November a flight test was made of the KAPPA-7 and a dummy test made of the KAPPA-8, a two stage rocket consisting of the 7 and the 245, in March 1960. In July of the same year the KAPPA-8 No. 1 reached an altitude of 150km for the first time. By this it became possible to observe the ionosphere and in July and September three sounding rockets were launched. In September observation of cosmic rays was made at the same time, and an altitude of 200km was reached. In September 1960, the KAPPA-6H, an improvement in the capability of the 6, was used for measuring air temperature and wind.

1. Manufacture of chamber. (July 1959)

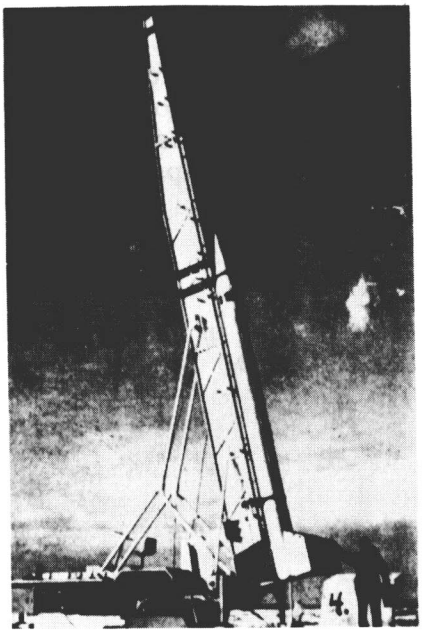


2. Ground test of 420 engine at Akita Proving ground. (Sept. 1959)

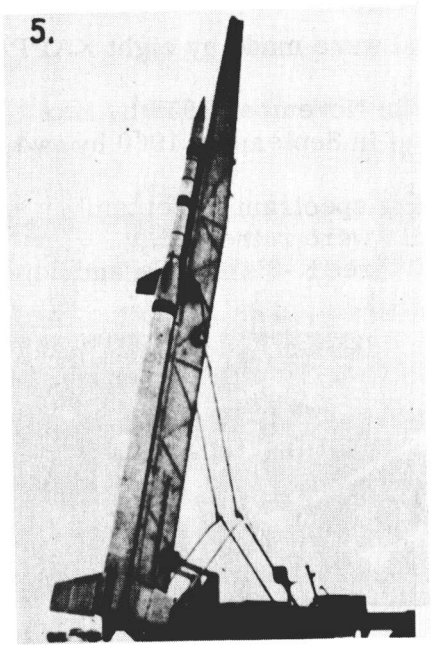




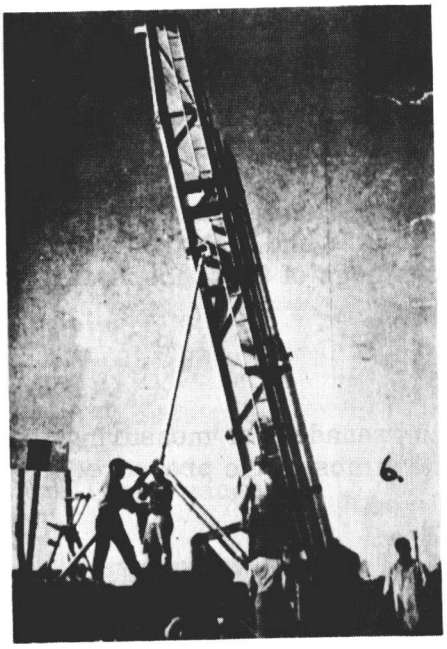
3. Ground test of 420 engine. (Akita)



4. The KAPPA-7. (November 1959)



5. The KAPPA-8 No. 1.
(July 1960)



6. The KAPPA-6H.
(September 1960)

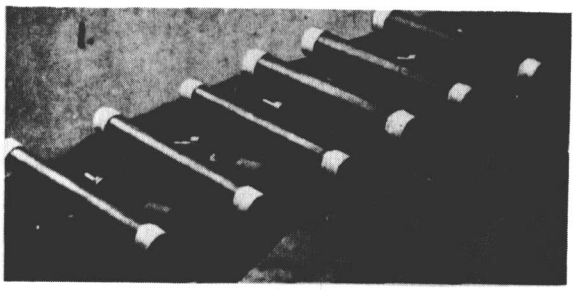
Sounding the Upper Atmosphere

Measurements of air temperature and wind were made by eight KAPPA-6's and one 6H from June 1958 to August 1960.

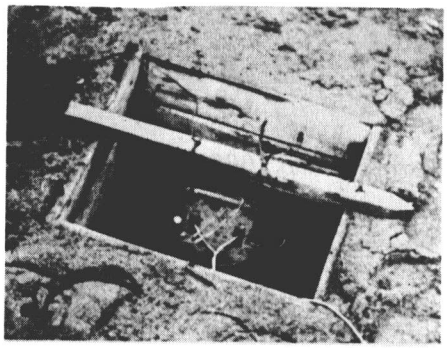
Measurements of cosmic rays were made in November 1958 by two KAPPA-6's (including atmospheric pressure) and in September 1960 by two KAPPA-8's.

Four K-6's made measurements of the solar spectrum in September and November 1958 and in March 1959, but no results were retreived.

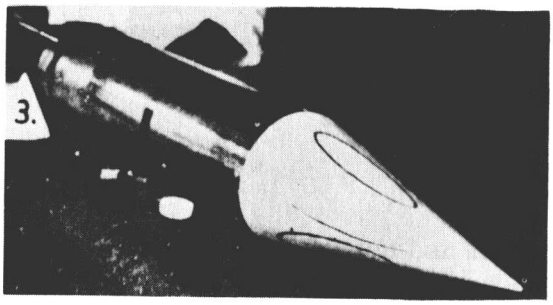
Soundings of the ionosphere were made by three K-8's in July and September 1960.



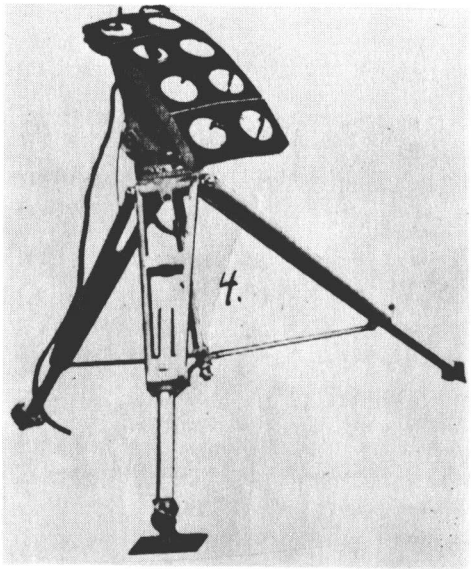
1. Sound grenades for measuring wind and atmospheric pressure.



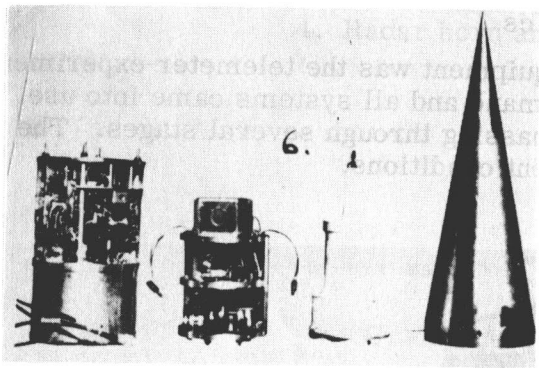
2. Receiver microphone for sound grenades



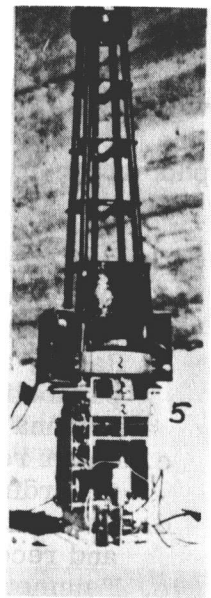
3. Nose cone including sound grenades.



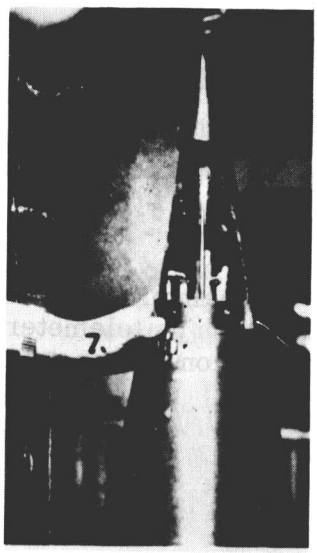
4. Sound grenade, infrared detector.



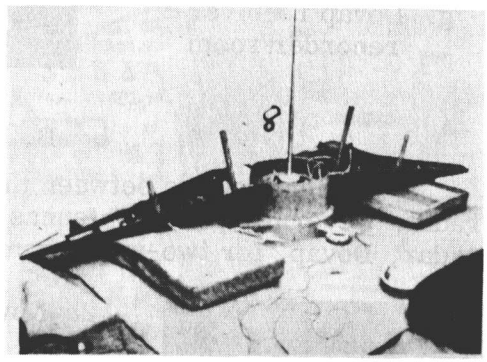
5. Solar spectroscope.



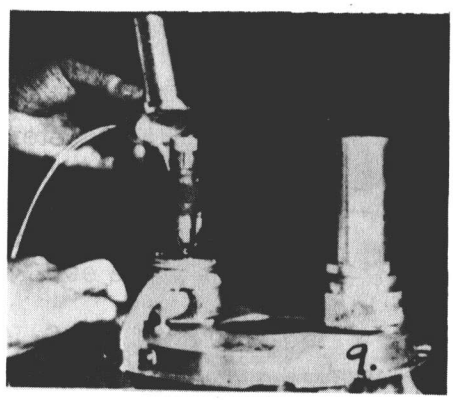
6. From the right: nose cone, geiger counter, Pirani gauge, telemeter (for K-6).



7. Probe for measuring positive ion density.



8. Testing the opening of nose section.

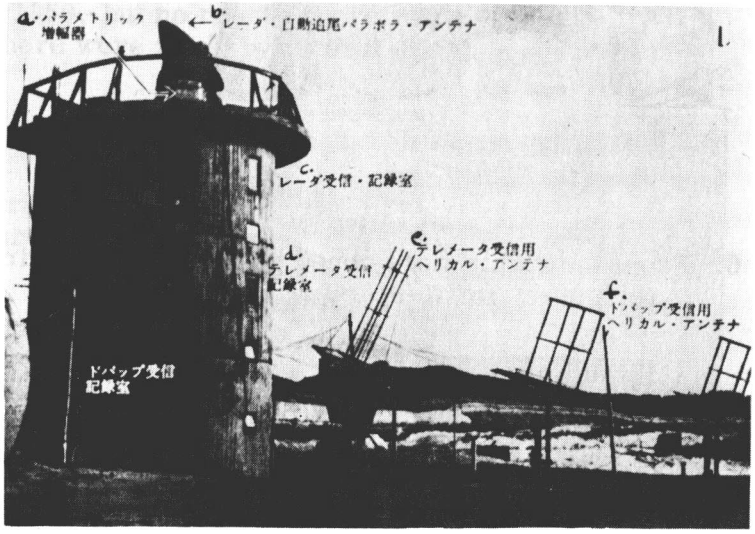


9. Geiger counter for K-8.

A. Electronics

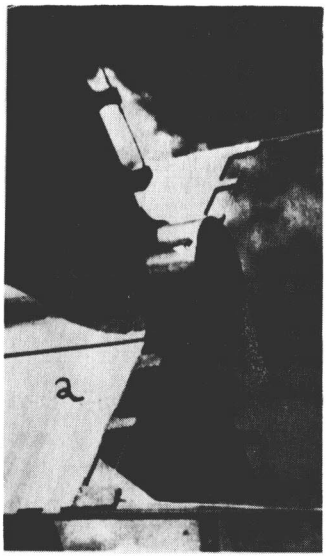
The first step in rocket electronic equipment was the telemeter experiment with the BABY-T, and radar, Dovap, command and all systems came into use. The present stage has been reached after passing through several stages. The photographs presented here show the present conditions.

1. Overal View of Observation Building
   a. Parametric amplifier
   b. Radar, automatic parabolic tracking antenna
   c. Radar receiver and recording room
   d. Telemeter receiver and recording room
   e. Telemeter receiver helical antenna
   f. Dovap receiver helical antenna
   g. Dovap receiver-recorder room



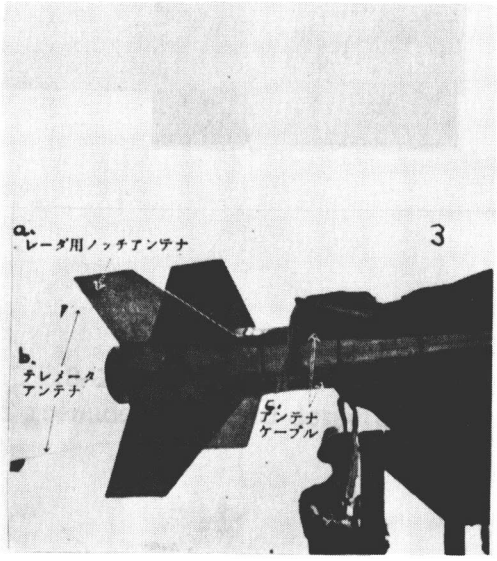
B. Rocket Antennas

Communications between the rocket and the ground are maintained by radio. Several types of antennas are necessary on a rocket such as telemeter, radar, Dovap, for two-way communication with the ground station.

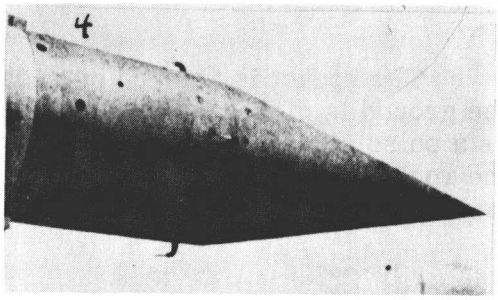


2. Dovap antenna

3. Rocket telemeter and radar antennas
   a. Radar notch antenna
   b. Telemeter antenna
   c. Antenna cable



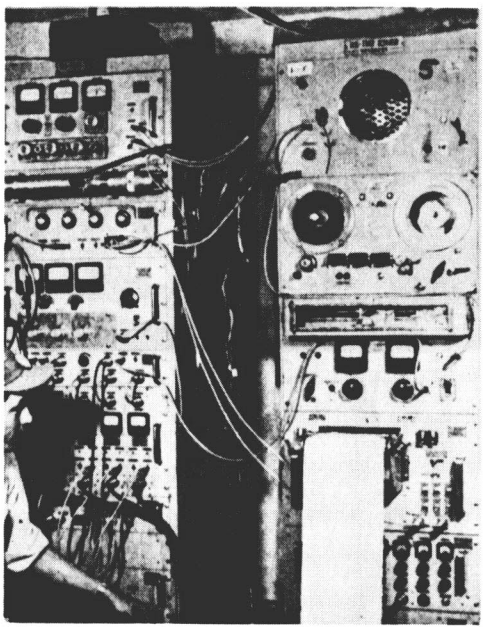
4. Radar horn antenna



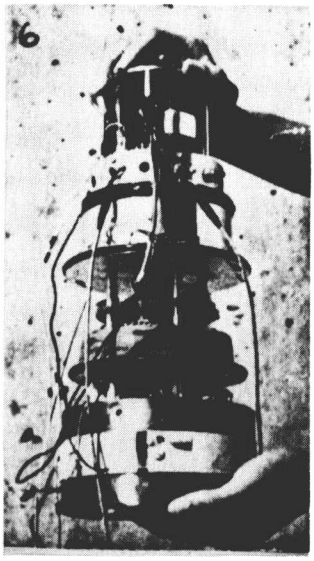
C. Telemetering Equipment

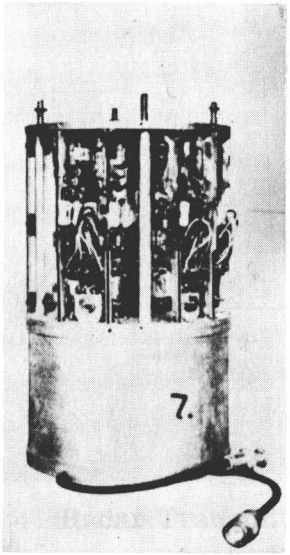
This equipment transmits to the ground by radio, and records measured quantities from instruments carried on the rocket. The system now in use is a 225Mc/s FM-FM system which can transmit simultaneously five types of measured quantities.

5. Telemeter receiving and recording equipment.



6. Payload of KAPPA-6 Experimental Rocket. from above: accelerometer, resistor-wire strain meter, thermometer.

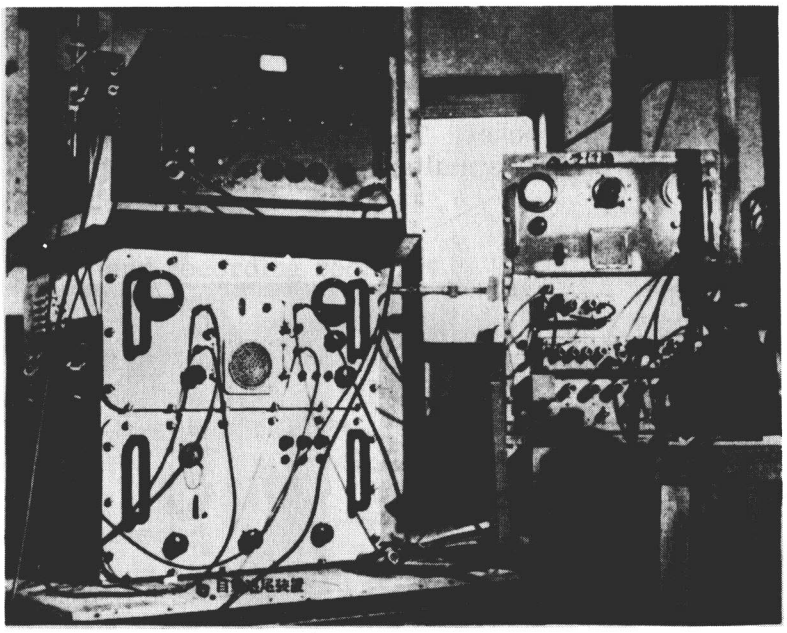




7. Telemeter transmitter in use since the KAPPA-6.

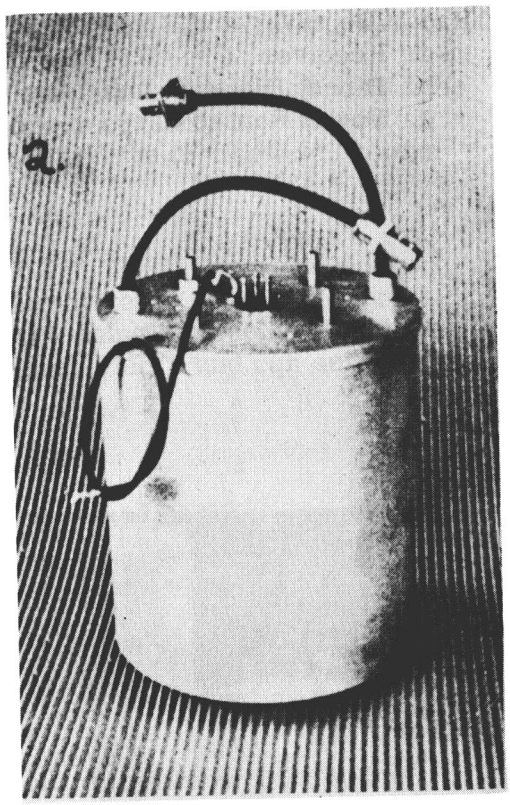
Radar Equipment

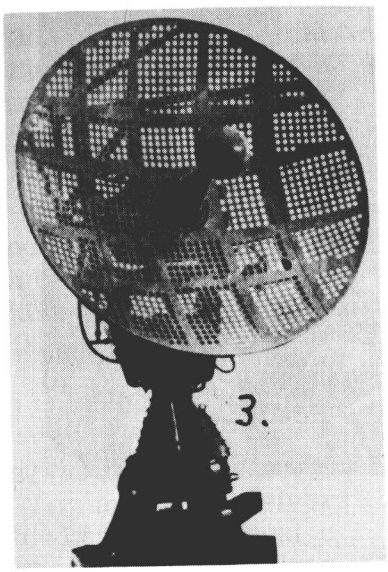
The rocket is tracked by radar. When a 1680Mc pulse signal sent from the ground is picked up by the rocket-borne transponder, it is returned to earth as a pulse signal. Direct distance is found by the arrival time of the signal from the rocket, direction determined by an extremely sensitive parabolic antenna, and from the present position of the rocket is found.



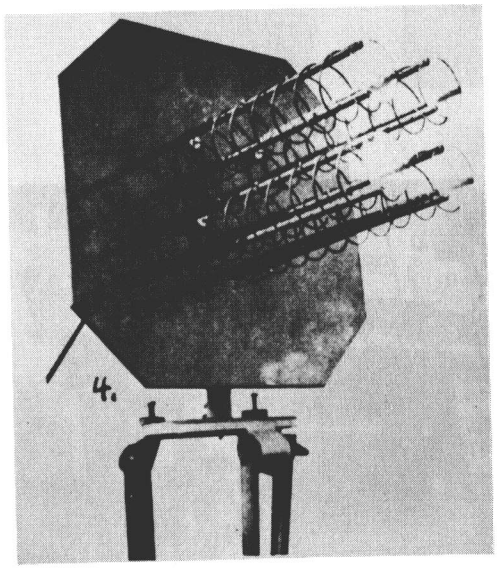
1. Radar receiver. Automatic Tracking Equipment.
a. Receiver
b. Automatic Tracking Equipment

2. Radar transponder



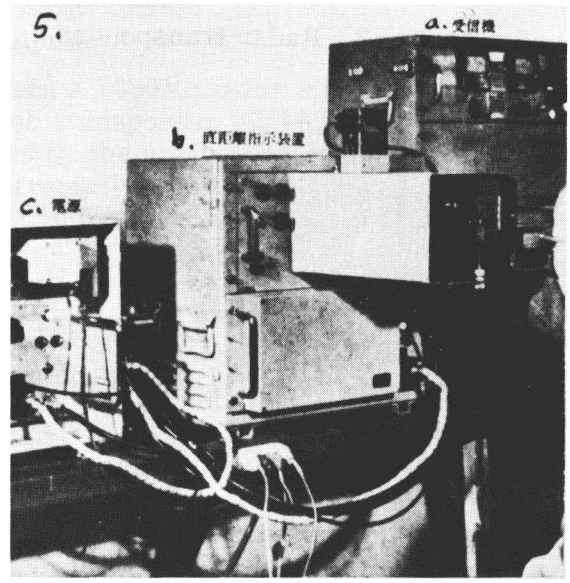


3. Radar Automatic Parabolic Tracking Antenna

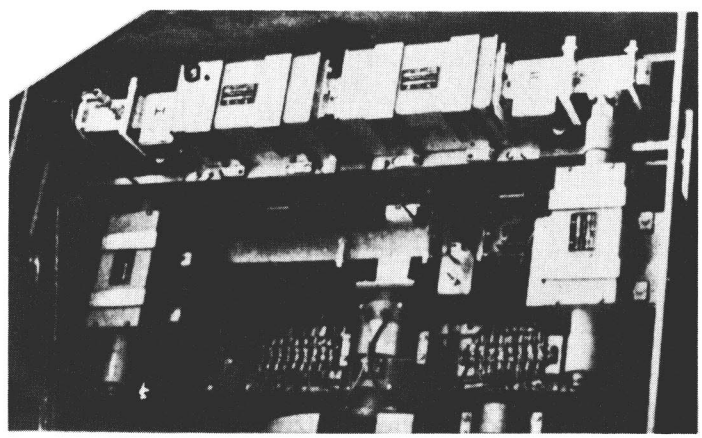


4. Radar Transmitter Antenna

5. Radar Receiver and Range Finder
   a. Receiver
   b. Direct Distance Indicator
   c. Power Source



6. Low Noise Parametric Amplifier for Radar Receiver



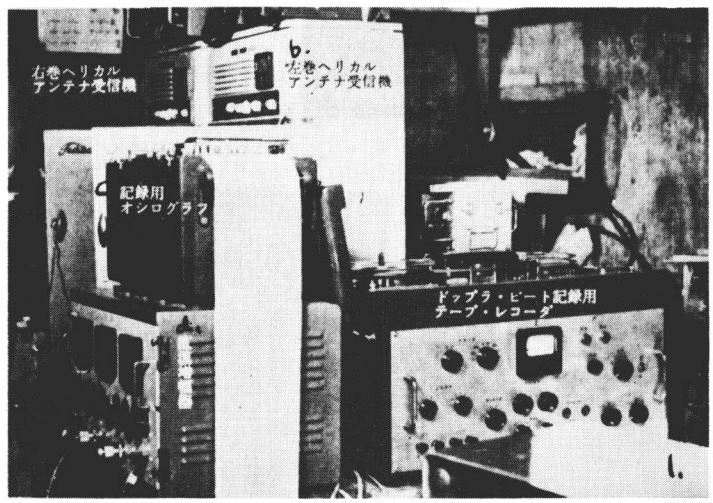
A. Dovap Equipment

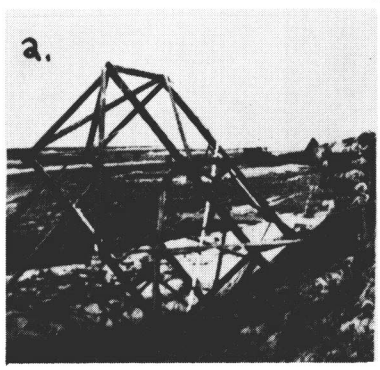
This equipment finds relative velocity by changes in frequency due to the Doppler effect of radio waves, and finds the range accurately by integration. The ground transmission frequency is 39.95Mc/s and the transponder return frequency is twice that, or 79.9Mc/s.

B. Command Equipment

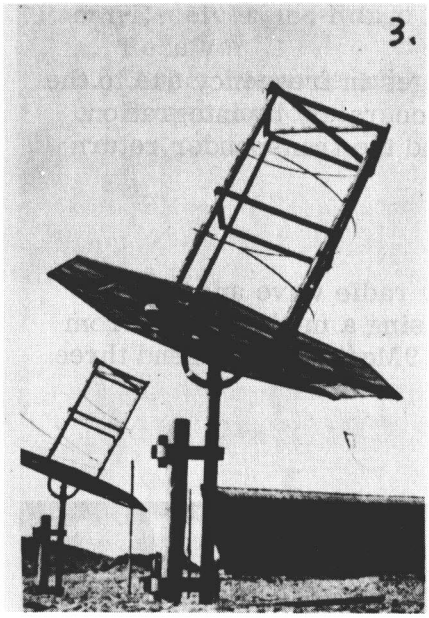
This equipment transmits command signals by radio wave and carries out remote control operations. It is used for releasing a model rocket from a balloon in the rockoon. The frequency used is 79.9Mc/s and can send three kinds of command signals.

1. Dovap receiver and recorder.
a. Right-wind helical antenna receiver
b. Left-wind helical antenna receiver
c. Recorder oscillograph
d. DC amplifier
e. Tape recorder for recording Dovap beats.



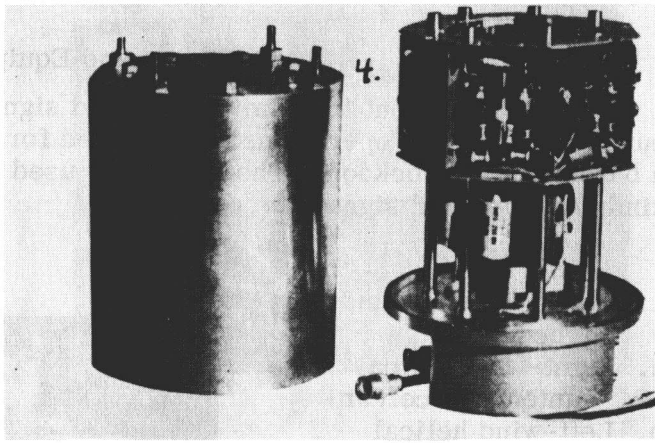


2. Dovap transmitter antenna

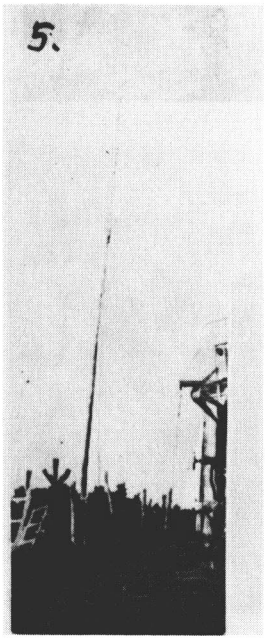


3. Dovap Receiver Antenna

Two helical antennas are used, a left-wind (foreground) and a right-wind in order to eliminate errors in Doppler effect due to spin.

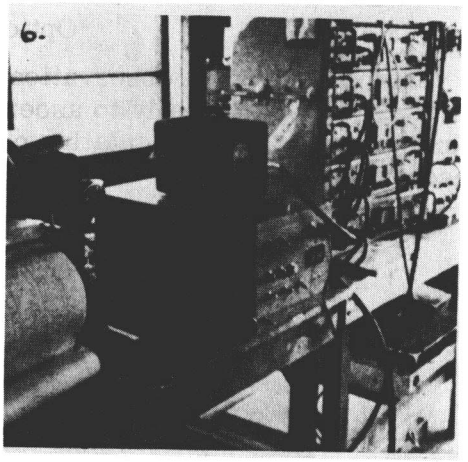


4. Dovap Transponder



5. Command antenna

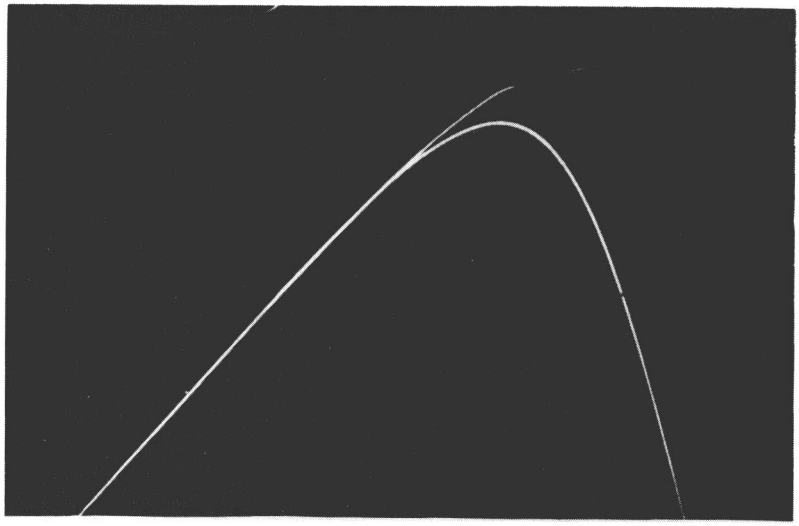
6. Command Output Gauge (above)
Transmitter (below)



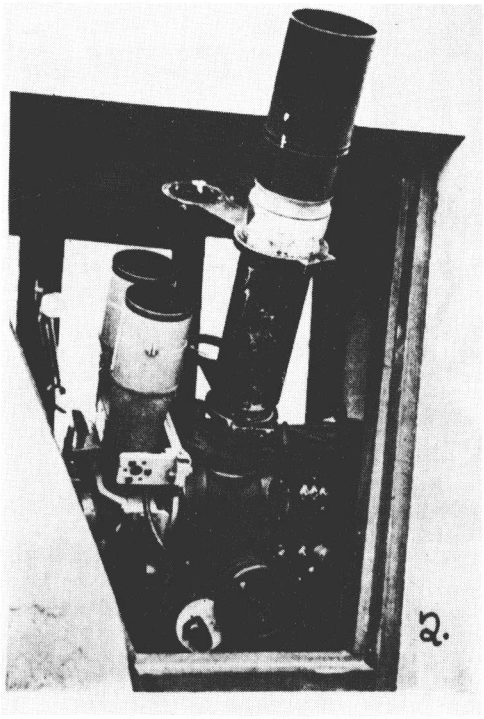
7. Receiver

Optical Observation

Since the optical observation system can record the rocket directly on film it contributed greatly to ascertaining flight capability. The photographs given here are of representative observation equipment being used at the present time.

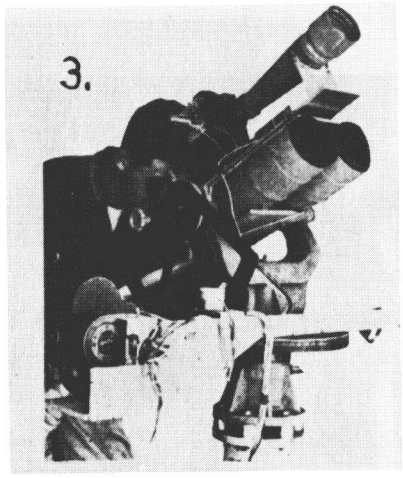


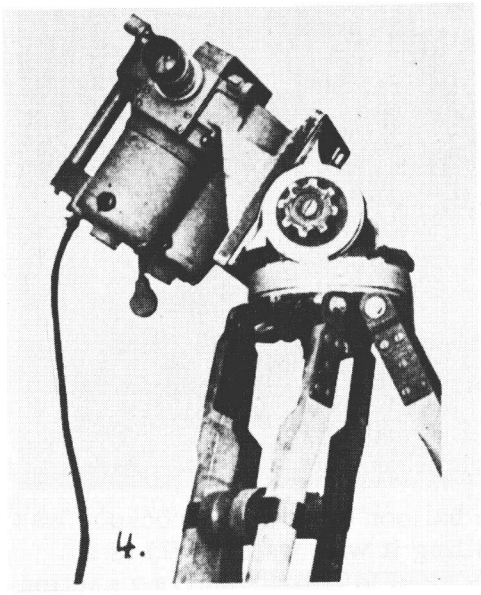
1. Flight path of the KAPPA-3 No. 3 taken at night by a fixed camera.



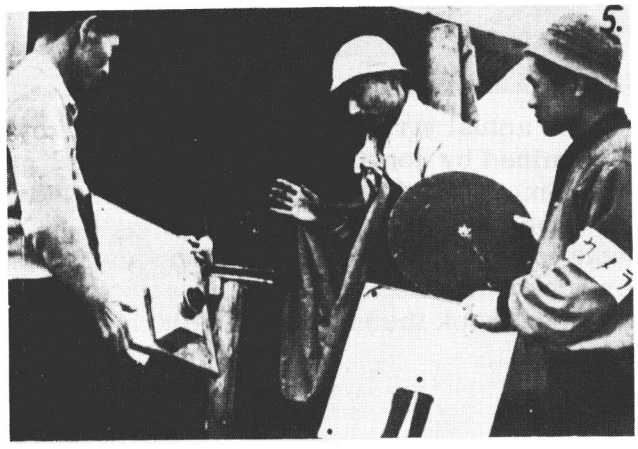
2. Telescopic tracking camera placed directly behind the launcher.

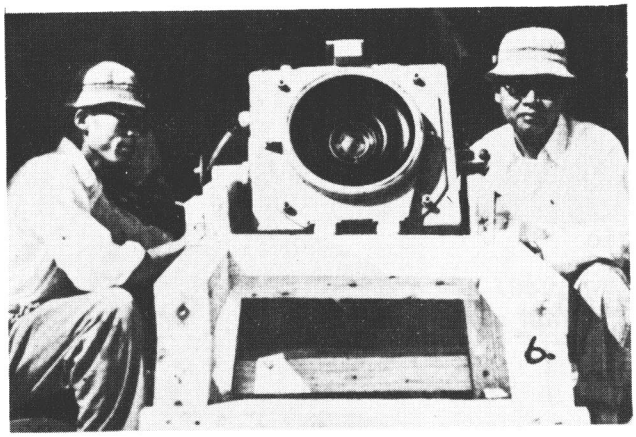
3. Telescopic tracking camera. It follows the rocket by 15 binoculars and simultaneously records angles and takes photographs.





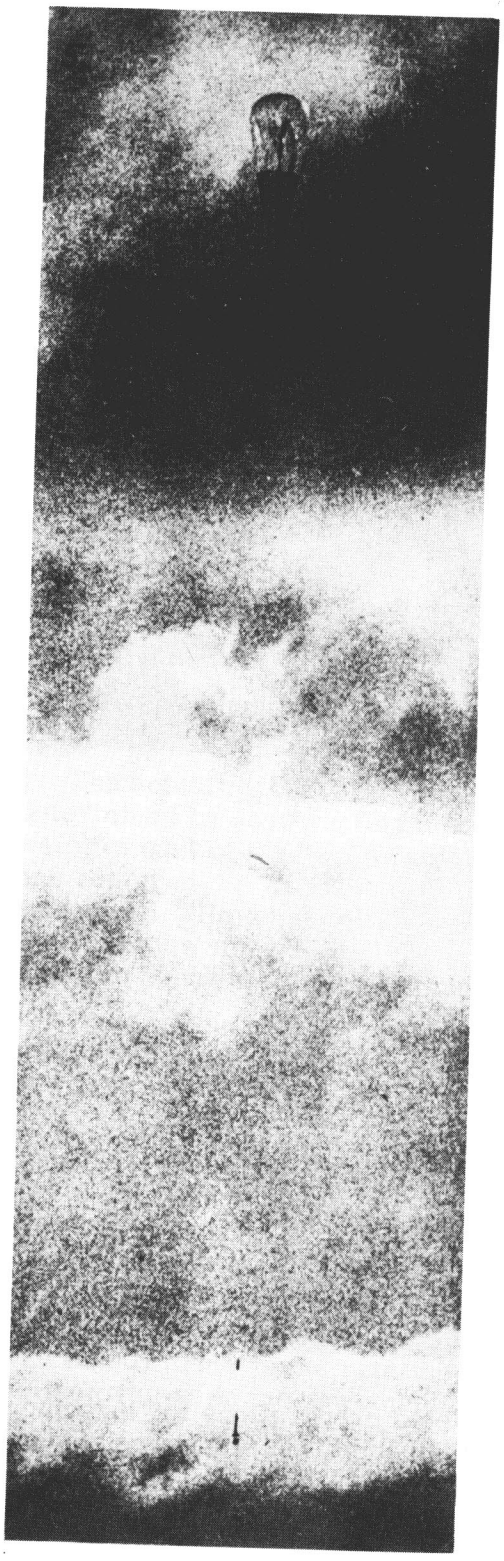
4. 16mm High-speed camera Fastax. This has provided valuable data for analysis of characteristics at time of launching, since the PENCIL.



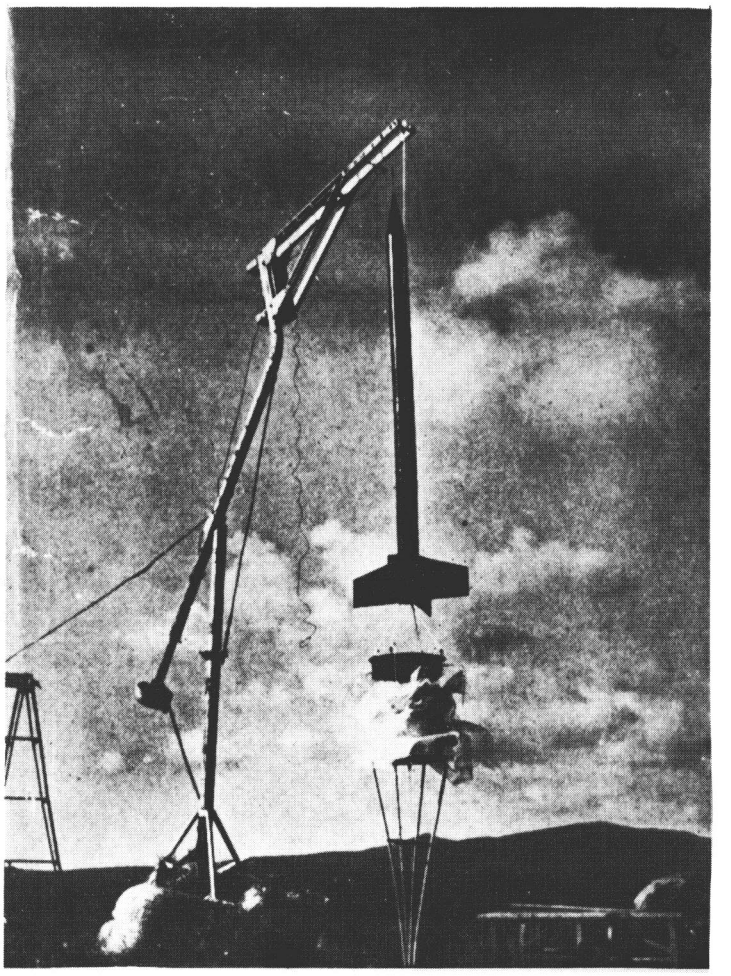


5. Sector Frame Camera.
A fixed camera capable of dividing the movements of a rocket, it was especially developed and used for this purpose.

6. Wide Angle Fixed Camera.
A 20mm lens-attached air navigation camera. It recorded the flight path of rockets having luminous pipes in night experiments.

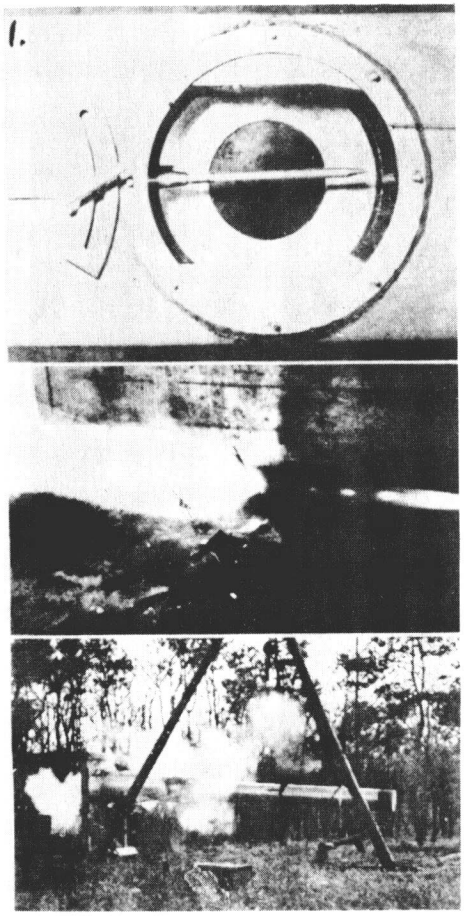


5. Conditions when the auxiliary balloon was released after launching. The black spot below the large balloon is the Rawinsonde, and the black spot above the rocket is the parachute. The length of the rope is about 120m.

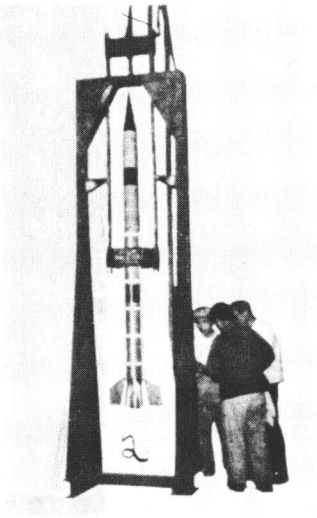


6. Conditions when a suspension meter was attached to a dummy SIGMA-4 Rocket and the assembly mounted on the rocket launcher.

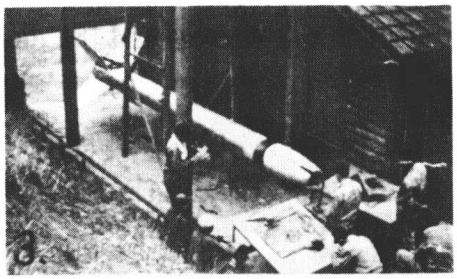
Ground Tests



1. Above left: Aerodynamic test in supersonic speed impact wind tunnel.
Center left: Test of tail heating due to jet of exhaust gas.
Below: Cutting test of main booster.



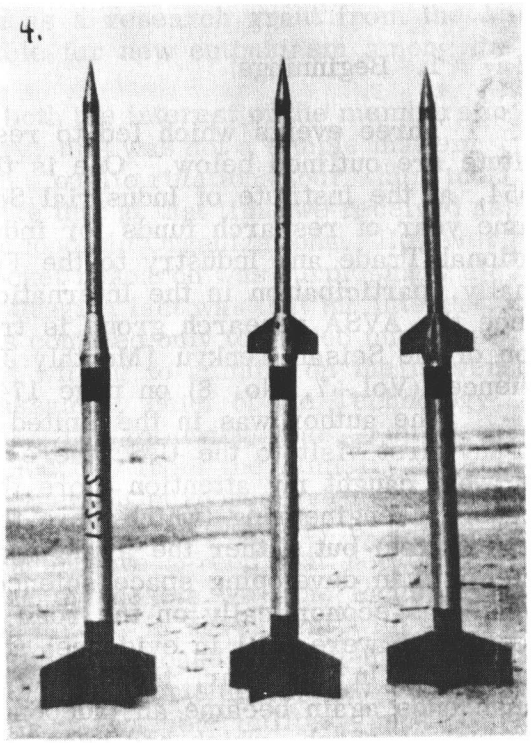
2. Impact test.



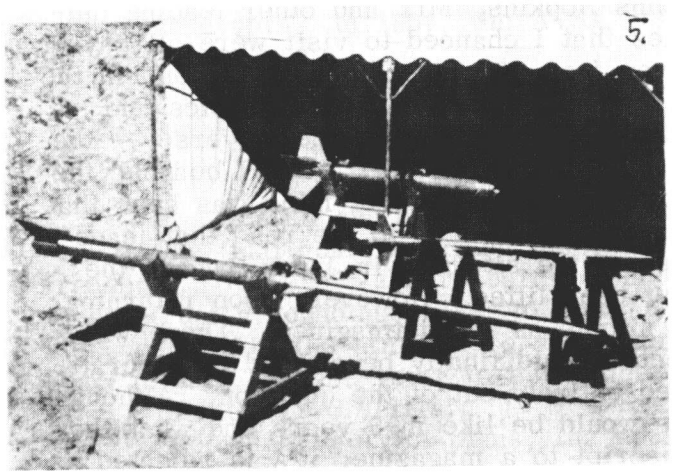
3. Measurement of moment of inertia.

Small Tests

Besides ground tests for the problems of aerodynamic elasticity and stability, and basic analyses, we are in the process of doing research with small test rockets.



4. Stability test rockets (Akita, February 1960)



5. Flutter test rockets (Ibargi Prefecture, shore of Oarai, November 1958).