JAPANESE PRIMARY ENERGY SUPPLY AND GEOPHYSICAL WELL LOGGING

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Japan is scarce in domestic natural resources. In fact, the degree of dependence on imports of basic raw materials is quite high. This paper describes primary energy supply as a background to the status of geothermal energy developments, and geophysical well logging in geothermal wells.

Primary Energy Supply of Japan

Although Japan made a high level of economic growth from 1960 until the oil crisis in 1973, the oil crisis has had such a considerable effect on the Japanese economy as to shake its foundation. As the base of Japan's energy policy, "The Long Range Prospects for Energy Supply and Policies" was issued in 1975 by the Energy Council. In Table 1, which is its long term energy supply program, the degree of dependence on imported oil will decrease from 77 percent in 1973 to 63 percent in 1985. On the other hand, in order to attain the target of reducing dependence on imported oil, acceleration of the development of domestic energy and the large-scale introduction of LNG will be necessary.

The Japanese government has decided to make a new energy plan by next year, paying due regard to the growing sense of energy crisis. The new energy policy will be founded on the following principles: (1) to decrease dependence on crude oil, (2) to secure the stable supply of hydrocarbon energy, (3) to realize that the present target for nuclear energy is doubtful, (4) to develop various sorts of energy resources and their technologies, (5) to promote energy saving, (6) to establish friendship trade with overseas countries through international cooperation.

The advisory committee of Energy Council announced its revised plan (Table 2) in June this year, though it is not yet final. The former government plan has been variously criticized ever since it was reported. In particular there were lively arguments about the feasibility of achieving the targets of the plan, mainly: (1) in the areas of nuclear energy and LNG, realization of the plan's target is doubtful; (2) the assurance of available funds should have been made clear, in order to carry through the plan; (3) the level of oil imports would not be so easy to achieve. Each of these points was an important indication for the necessity of revising the energy plan.

Table 1. Actual Results and Forecast of Primary Energy Supply

Sources		1			2
Primary Energy \ Year		FY 1973	FY 1975	FY 1985	FY 1985
Domestic Supply	Hydro-Power, 10^6KW	21.20	25.43	28.30	27.00
	Geothermal Energy, 10^6KW	0.03	0.05	2.10	0.50
	Oil & Natural Gas, 10^6KL	3.70	3.53	14.00	8.20
	Coal 10^6ton	21.68	18.60	20.00	20.00
	Nuclear Power, 10^6KW	2.30	5.95	49.00	27.00
Imported Supply	LNG, 10^6ton	2.37	5.06	42.00	27.00
	Coal, 10^6ton	58.00	62.34	102.40	(S) 88.60 (L) 81.48
	Crude oil & LPG, 10^6KL	318.00	285.27	485.00	(S)499.46 (L)440.63
	Total 10^{13}KCal	383.	366.	710.	(S)658. (L)597.

Notes:

a) Sources of Information

Source 1) Energy Council (Aug. 1975)

Source 2) The Institute of Energy Economics(Dec. 1976)

b) For Institute of Energy Economics,

(S) indicates standard case

(L) indicates low growth case

c) Conversion rates of petroleum to heat

1 liter of petroleum 9,400 KCal

Table 2. Japan's Energy Plan

Primary Energy \ Year		FY 1975 (Actual data)	FY 1985	
			Government Plan (1975. Aug.)	Revised Plan (1977. June)
Domestic Supply	Geothermal Energy, 10^6KW	0.05	2.10	1.0
	Oil & Natural Gas, 10^6KL	3.50	14.00	11.0
	Coal, 10^6ton	18.60	20.00	20.0
	Nuclear Power, 10^6KW	6.62	49.00	33.0
Imported Supply	LNG, 10^6ton	5.06	42.00	30.0
	Coal, 10^6ton	62.34	102.40	102.0
	Crude Oil & LPG, 10^6KL	286.00	485.00	432.0
	New Energy, 10^6KL	-	-	2.3

Table 3. Geothermal Power Plants in Operation and under Construction in Japan (1977, July)

	Name of Company	Name of Station	Location (Pref.)	Capacity (KW)	Starting Operation
In Operation	Japan Metals and Chemicals Co.	Matsukawa	Iwate	22,000	1966, Oct.
	Kyushu Electric Power Co.	Otake	Ōita	11,000	1967, Oct.
	Mitsubishi Metal Mining Co.	Ōnuma	Akita	10,000 (7,500)	1974, June
	Electric Power Development Co.	Onikobe	Miyagi	25,000 (12,500)	1975, Mar.
	Kyushu Electric Power Co.	Hatchobaru	Ōita	50,000 (23,000)	1977, June
	Sub-total			118,000 (76,000)*	*(actual data)
Under Construction	Japan Metals and Chemicals Co. / Tōhoku Electric Power Co.	Katsukonda (Takinoue)	Iwate	50,000	1977, Dec.
	Dohnan Geothermal Energy Co.	Mori (Nigorikawa)	Hokkaido	50,000	1979, Mar.
	Sub-total			100,000	

Geothermal Resources and Development in Japan

At present, five geothermal power stations are being operated, and another two stations are under construction, as shown in Table 3. An organized basic investigation for geothermal resources was started in the fiscal year of 1973 by the Geological Survey of Japan.

Japan is set on parts of a volcanic belt; that is, the volcanic ranges of Chishima, Nasu, Chokai, Fuji, Norikura, Hakusan, Kirishima and so on. Hot springs occurring in the vicinity of these volcanoes have been used for bathing. According to a report (1975) by the Geological Survey of Japan, there are 111 sites of steam fumaroles, boiling springs and hot springs having temperatures more than 90°C, although in total there are about 1,500 hot spring resorts in Japan. Prospective sites for geothermal energy development usually lie around the hot spring zones of volcanoes. As part of the long-term new energy research and development program named "Sunshine Project", the Geological Survey of Japan picked up the thirty high potentiality geothermal fields (Fig. 1) characterized by conspicuous geothermal anomalies, particularly fumaroles and hot springs of temperature above 90°C.

Geophysical Well Logging in Geothermal Wells

The purpose of geothermal well logging differs from that of oil or gas wells in some respects. Geothermal wells are usually drilled in hotter and harder formations, which often are fractured. This combination of high temperatures and hard formations (igneous or metamorphic, not sedimentary formations) causes some problems in geothermal well logging.

In Japanese geothermal energy development companies such as the Japan Metals & Chemicals Co., Ltd., geologists and reservoir engineers have mainly conducted research into the evaluation of fractures and geothermal reservoirs by electric logging (S.P., resistivity), temperature and pressure logging, caliper logging and so on.

Our governmental support for geothermal well logging may be grouped into two kinds. First, the Japan Geothermal Energy Development Center is now investigating geothermal potential and the feasibility of its development using surface surveys and boring wells (about 1,000 meters depth) under instructions from the Power generation section and the Geothermal resources development investigation committee, which belong to the Ministry of International Trade and Industry. The following geophysical measurements in these wells are available: temperature logging, electric logging (S.P., resistivity), core analysis (rock density, magnetic susceptibility, acoustic velocity, thermal conductivity) and so on.

A second kind is the Geothermal Energy Research and Development program of "Sunshine Project," planned by the Industrial Technology Agency. Included are the following four R & D groups:

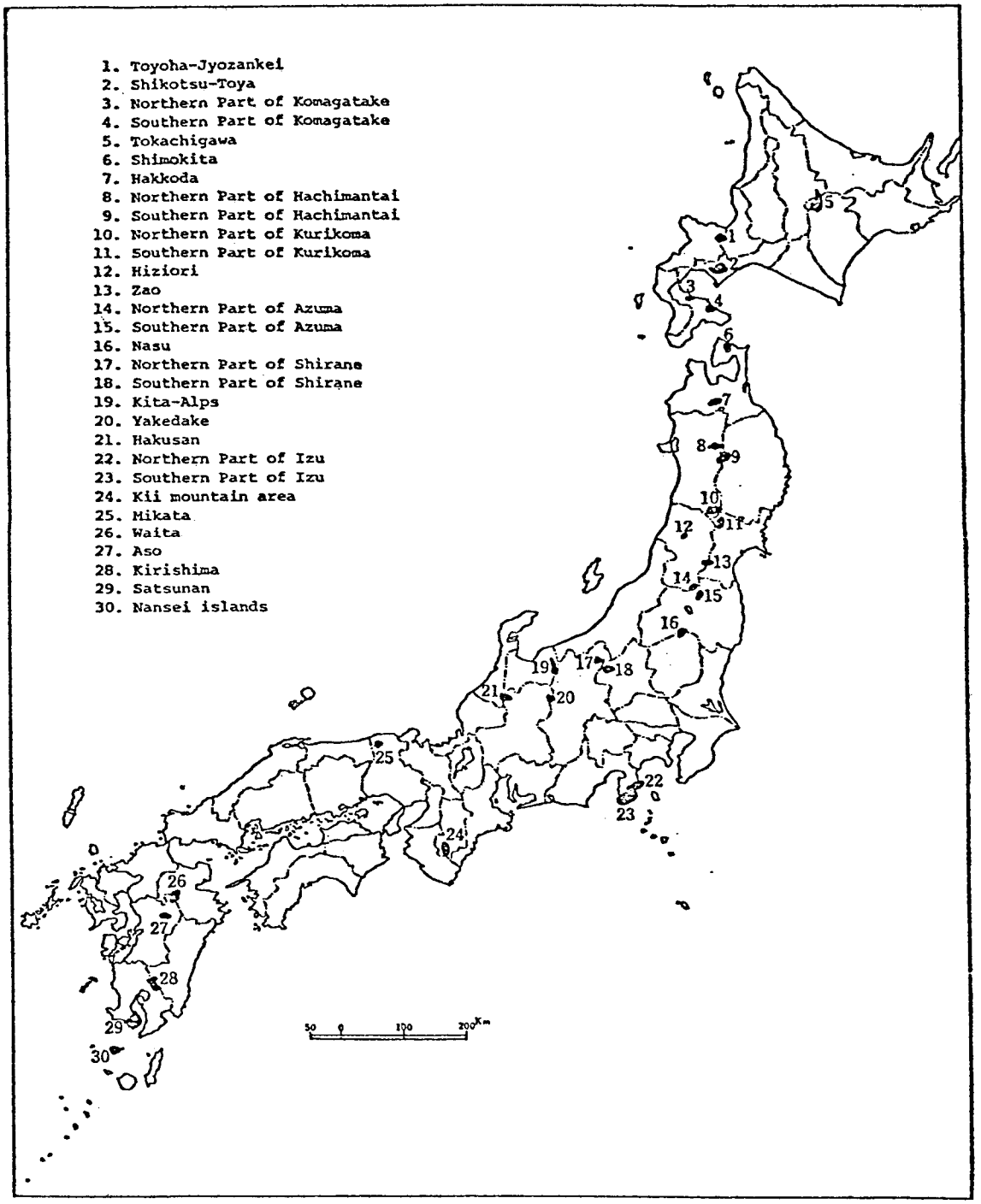


Figure 1. Locations of the 30 geothermal fields to be investigated by the Geological Survey of Japan.

(1) exploration, drilling and production, (2) geothermal power generation and plant, (3) recovery of volcanic energy, energy from dry hot rock etc., (4) environmental problems, multiple utilization of steam and hot water etc. One of them is the R & D on well logging probes and devices with a view of geothermal energy development. In 1975, the study was initiated by our Borehole Measurement (geothermal well logging) Committee which consists of members from the Geological Survey of Japan, University of Tokyo, Geothermal Energy Research and Development Co. (secretariate), Japan Metals & Chemicals Co., Teikoku Oil Co., Japan Petroleum Exploration Co. and so on.

A feasibility study and selection of well logging tools were conducted in early stages of this study. These tools are usually designed for operation in an environment of 250°C and 200 ~ 300 Kg/cm^2. The following equipment will be constructed and operated by the coming March.

(1) Testing Vessel
(2) Downhole Flowmeter for hot water (continuous recording type)
(3) Acoustic Velocity Logging device measuring the compressional wave and shear wave simultaneously
(4) Bore Hole Television Camera
(5) Temperature Logging and Pressure Logging devices.

These hot spring zones have peculiar landscapes such as volcanic valleys and have often been designated as national parks or quasi-national parks. Geothermal development within the area of a national park needs prior permission of the Director of Environment Agency. The Governor's permission would not be easily obtained. However, in view of the very high dependence of Japan's energy supply on foreign resources, the development of the domestic geothermal energy resources should be promoted as a national policy.

References

1. Seiichi Hirakawa and Shigero Kusano, "Japan's Energy Policy and Role of LNG", 5th International Conference on LNG, Session 1, (1977).

2. Junji Suyama et al., "Assessment of Geothermal Resources of Japan", Geological Survey of Japan (1975).

3. Tsutomu Inoue, "Present Status and Future Prospects of the Geothermal Energy Development in Japan", 9th WEC, Division 3 (1974).

TABLE 4.

Comparison of field data with calculated results.

Test Well	Total Mass Rate (t/hr)	Predicted Flow Regime	Pressure Drop Δp_m (kgf/cm^2)	Pressure Drop Δp_c	Percent Difference
T-205-1	32.5	F,B	39.2	38.8	- 1.0
T-205-2	39.7	F.B	36.7	37.3	1.6
T-205-3	47.3	F,B	33.0	30.8	- 6.7
T-205-4	54.9	F,B	30.5	26.9	-11.8
C-1-1	78.1	F,B	62.82	59.13	- 5.9
C-1-2	147.5	F,B	52.06	52.81	1.4
C-1-3	198.6	F,B	44.52	47.72	7.1
C-2-1	127.5	F,B	56.05	58.02	3.5
C-2-2	209.9	F,B	50.65	53.02	4.8
C-2-3	229.0	F,B	48.65	48.78	0.2

F=Froth, B=Bubble,

Percent Difference $= \frac{(\Delta p_c - \Delta p_m)}{\Delta p_m} \times 100$

TABLE 5.

Well Data from Takinoue, Japan (1975-6).

Test Well	Reference Depth (m)	Cased Depth (m)	Steam Rate (t/hr)	Water Rate (t/hr)	Wellhead Pressure (kscg)	Wellhead Quality
T-205-1	700	500	1.9	30.6	12.7	0.058
T-205-2	700	500	3.3	36.4	10.6	0.083
T-205-3	700	500	5.2	42.1	9.8	0.110
T-205-4	700	500	7.7	47.2	8.0	0.140
C-1-1	950	752	6.5	71.6	10.9	0.083
C-1-2	950	752	14.8	132.7	10.2	0.100
C-1-3	950	752	17.9	180.7	9.3	0.090
C-2-1	880	829	6.9	120.6	13.98	0.054
C-2-2	860	829	21.4	188.5	13.98	0.102
C-2-3	860	829	26.8	202.2	13.22	0.117

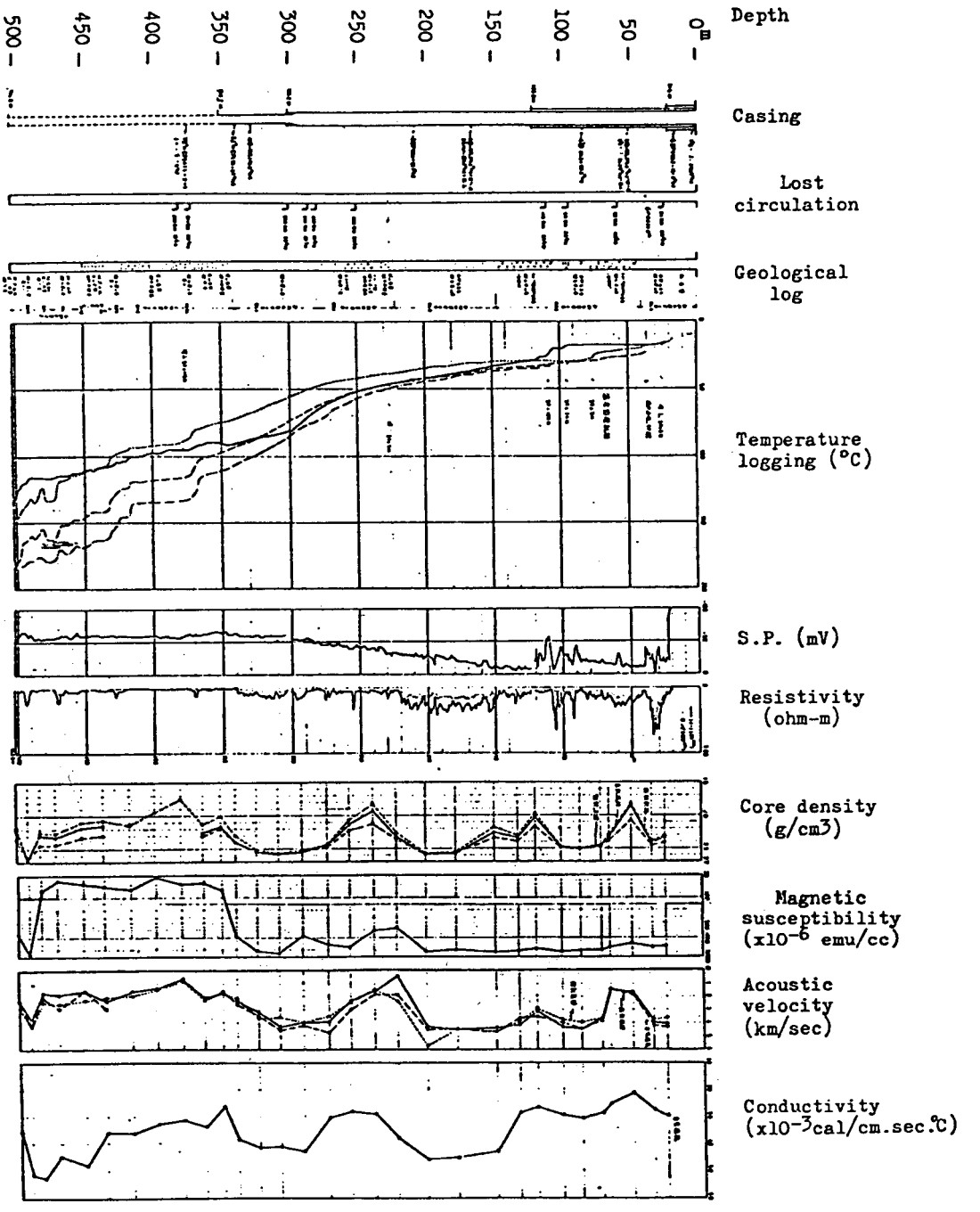

500 –
450 –
400 –
350 –
300 –
250 –
200 –
150 –
100 –
50 –
0m –
Depth
Casing
Lost circulation
Geological log
Temperature logging (°C)
S.P. (mV)
Resistivity (ohm-m)
Core density (g/cm3)
Magnetic susceptibility (x10-6 emu/cc)
Acoustic velocity (km/sec)
Conductivity (x10-3cal/cm.sec.°C)

Figure 2.

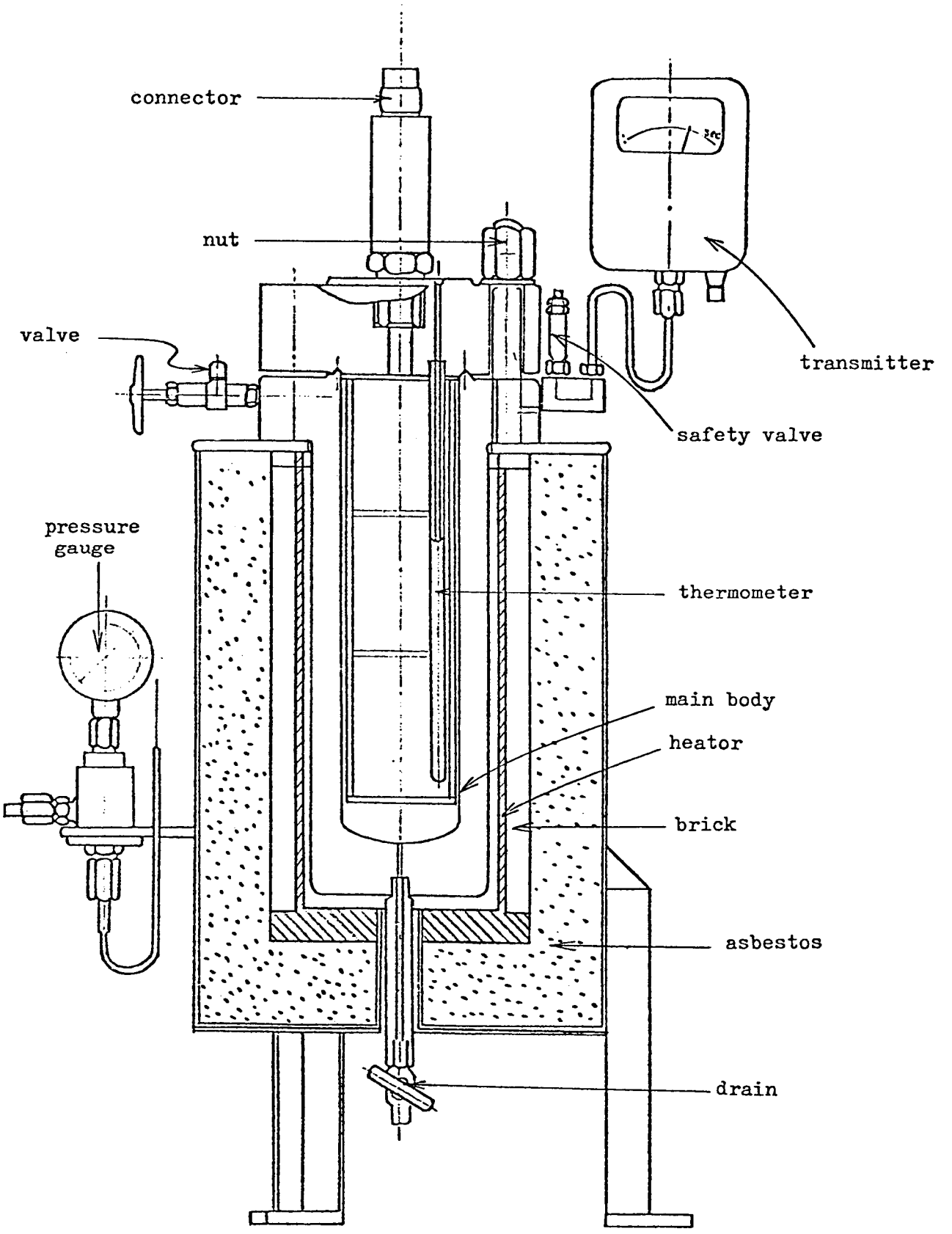


Figure 3. Testing Vessel

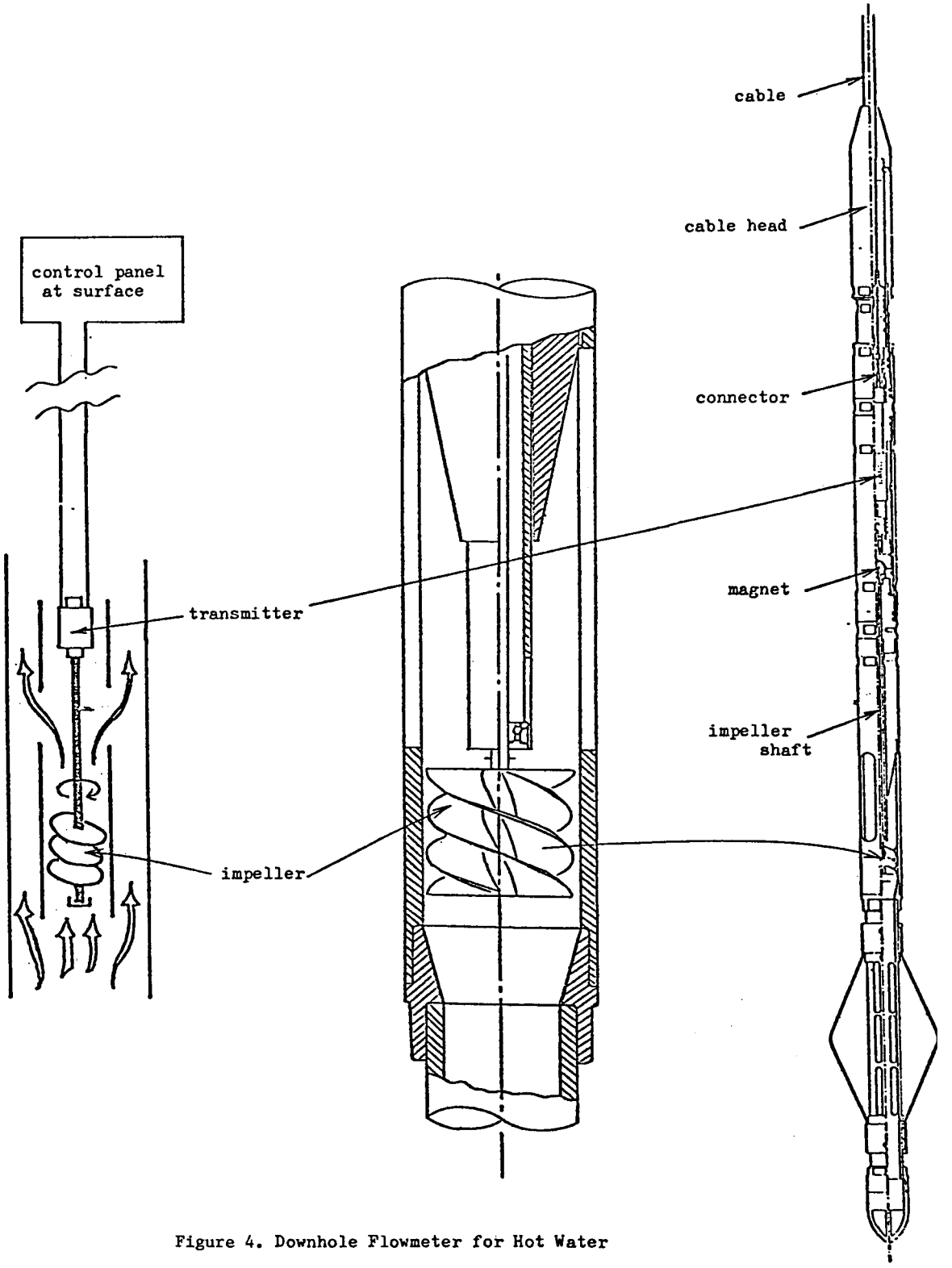
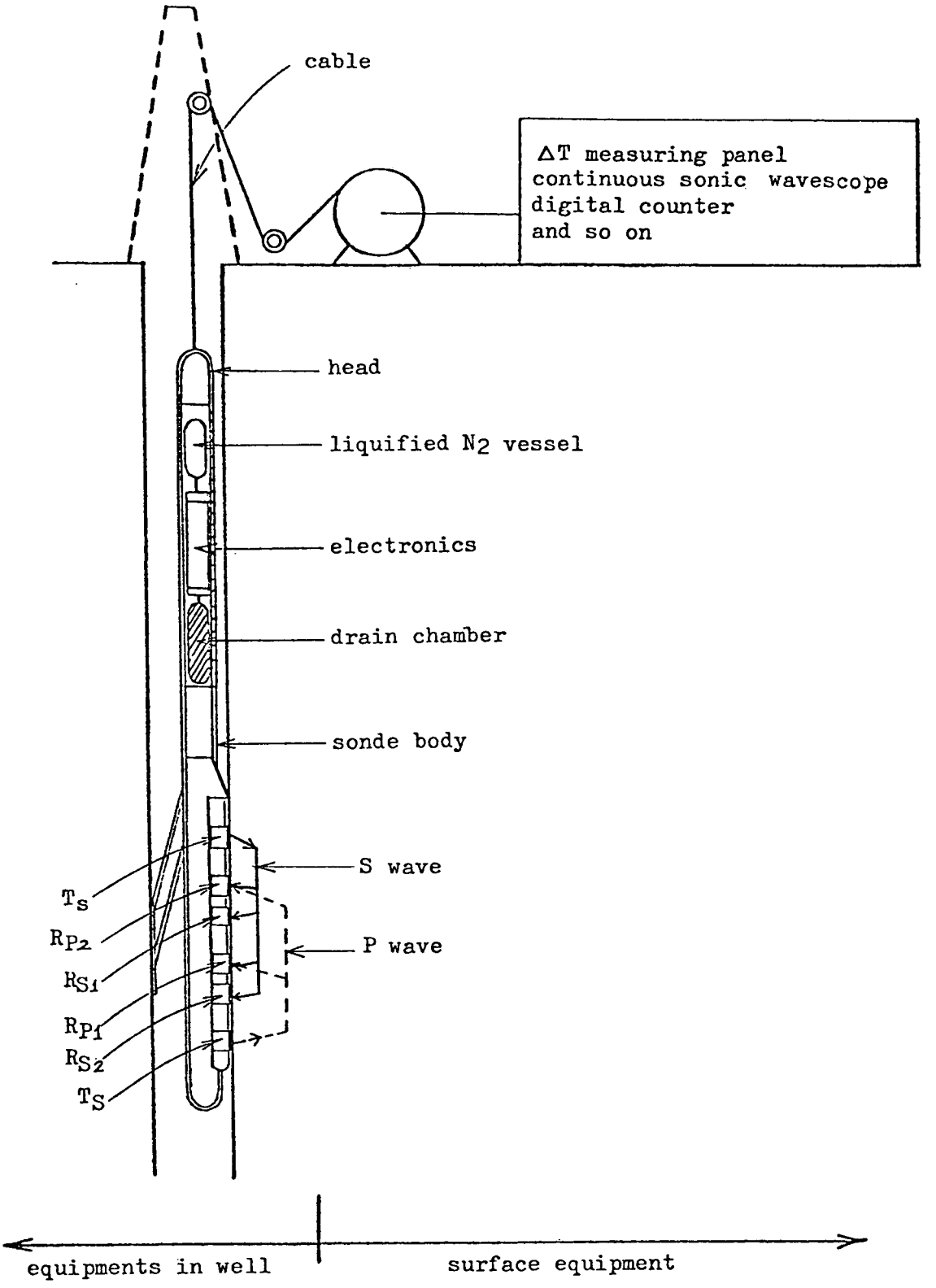


Figure 4. Downhole Flowmeter for Hot Water


cable
ΔT measuring panel
continuous sonic wavescope
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surface equipment

Figure 5.