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Sampling Techniques for Geothermal Fluids

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SAMPLING TECHNIQUES FOR GEOTHERMAL FLUIDS

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CONTENTS

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INTRODUCTION

This manual gives instructions for the collection of water and gas samples from geothermal wells, springs and fumaroles. It aims to provide a ready reference for those new to geothermal field work. For this reason emphasis is laid upon practical aspects of the various techniques and items of equipment rather than upon theoretical principles.

The techniques and devices described are those developed, employed and refined over some twenty-five years by the Chemistry Division of the D.S.I.R. at the Geothermal Research Centre, Wairakei, New Zealand.

In order that photocopied extracts might be complete within themselves, the duplication of those instructions common to several methods has sometimes been necessary.

It is very much the author's pleasure to acknowledge the many useful discussions he has had with Wairakei staff members concerning the compilation of this manual.

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EQUIPMENT

1. It is highly desirable that a vehicle be allocated solely to field work and, preferably, this should be of the long wheel base, four wheel drive type, e.g. British Leyland 'Landrover'.

   The cooling water, required in much field sampling, is best carried in a tank located beneath a false floor in the rear compartment of the vehicle. Perforated internal members serve as both structural components and slosh baffles. A submersible pump within the tank delivers cooling water to sampling sites inaccessible to the normal gravity flow. The tank is fitted with an external control valve and hose connection.

   The following items are standard equipment at Wairakei and are carried at all times:

2. Hand tools to suit local requirements. These are better protected, more readily accessible and less liable to loss when hung upon a wall shadow-board fitted with hinged retaining bar. A rubber backing eliminates excessive rattling.

3. 40 m of 12 mm plastic water hose fitted with an adjustable nozzle.

4. Retort stand and clamp for adjustable support of hose.

5. Three 1 m lengths of 21 mm OD x 7 mm ID butyl rubber tubing for gas sampling connections.

6. A comprehensive selection of pipe fittings appropriate to local wellhead sampling points. These should include three or four, 20 cm lengths of 25 mm taper threaded pipe which often are an asset when unusual wellhead layouts are encountered.

7. A selection of plastic bottles for water sample storage.

8. A selection of glass bottles fitted with screw-clip sealed butyl rubber neck extensions for dissolved CO_2 and H_2S sample storage.

9. A plastic dipper on a pole or, ideally, extendable poles for hot spring and wellhead weir box sampling.

10. A selection of mercury-in-glass standard and maximum thermometers and/or a digital electronic thermometer together with spare batteries.

11. A selection of pH papers and/or a miniature portable electronic pH meter together with spare batteries.

12. A portable Webre steam/water separator for gas and high pressure hot water sampling. Figs. 2 and 2a.

13. A high pressure hot water cooler for sampling from separated water lines: also performs as a simple condenser. Figs. 3 and 3a.

14. Tee-piece for gas sampling from separated steam lines. Figs. 4 and 4a.

15. A 'throw-in' type sampling vessel, incorporating a thermometer chamber, attached to a length of nylon cord for sampling natural water bodies to which close access is denied. Figs. 6 and 6a.

16. A Dräger type gas detector, together with an appropriate selection of detector tubes e.g. H_2S, CO_2 and, for volcanic emissions, SO_2.

17. Water-proof clothing, protective gloves and footwear, ear-protectors, hard hat and a gas mask together with spare acid gas filters.

18. An R.T. set for maintaining contact with base and other field teams.

19. A first aid kit.

20. A battery lantern, small trenching tool and fire extinguisher; the latter two items are mandatory when access to N.Z. Forestry areas is sought, appropriate maps, a compass, geothermal well data sheets, a camera and field note book.

The above comprises a basically equipped geothermal field sampling unit.

At Wairakei, the following additional items are carried when required:

(a) A 'Klyen' sub-surface sampler for the collection of fluid samples at selected depths in geothermal wells, MkI: Figs. 7; 7a and 7i, Mk II: Figs 8; 8a and 8i.

(b) A 'Mathey' type motorised wireline winch and associated recovery gear for running the sub-surface sampler. Figs. 7b and 8c.

(c) Fumarole sampling domes of various sizes for the collection of gases from fumaroles and/or steaming ground. Figs. 9 and 9a.

(d) Titanium tubing for the collection of gases from small vents and fissures for which the domes would be unsuitable. Fig. 10.

(e) Gas sampler for the collection of gases from submerged vents. Figs. 11, 11a and 11b.

WELLHEADS & SAMPLE POINTS

Typical geothermal wellhead designs are shown schematically in Figs. 1, 1A and 1B.

Fig. 1 shows a simple by-pass installation where the well discharges directly into a vertical, twin-tower, silencer. Locations from which representative steam and water samples, at pressures above atmospheric are best collected (by means of a miniature steam/water separator) are indicated at (B) and (C) and, less satisfactorily, at (A). Flash water, at atmospheric pressure, normally is collected from a weirbox at (E).

Mahon (1961, and pers. comm.) specifies a high pressure sampling point at 1.2 m (six pipe diameters) downstream from the vertical leg of the wellhead and low pressure sampling point at 8.5 m (forty-two pipe diameters) downstream from any restriction. Two phase sampling points should be 25 mm steam gate valves, side mounted, and communicating through 19 mm ports to the steam/water mixture. Separated water sampling points should be 19 mm steam gate valves, bottom mounted, and communicating through 12 mm ports to the separated hot water. 9.5 mm stainless steel needle valves make excellent, long lasting, dry steam sampling points when vertically mounted and communicating through 5 mm ports to the dry steam.

Fig. 1A depicts a wellhead featuring single stage, cyclone separation. Steam and water, at pressures above atmospheric, may be sampled (by means of a miniature steam/water separator) from (A) but are better collected from the steam line, through a tee-piece at (B) and the waterline, through a cooler, at (C). Flash water, at atmospheric pressure, may be collected from a weirbox at (D).

In Fig. 1B a wellhead equipped with a two-stage separation assembly is shown. High pressure steam and water may be sampled (by means of a miniature steam/water separator) at (A) but are better collected from the high pressure steam line, through a tee-piece, at (B) and the high pressure water line, through a cooler, at (C). Low pressure steam samples are collected, through a tee-piece, from (D) and low pressure water, via a cooler, at (E). Flash water, at atmospheric pressure may be collected from a weir-box at (F).

NB: It is important to establish, prior to sampling, the purpose for which the analytical data is required. e.g. For the determination of reservoir compositions by means of gas geothermometry, or computer based chemical data reduction methods (Singers et al, in preparation), steam samples from a second-stage separator at point (D) are valueless due to the earlier removal of approximately 95% of the gas in the first separator.

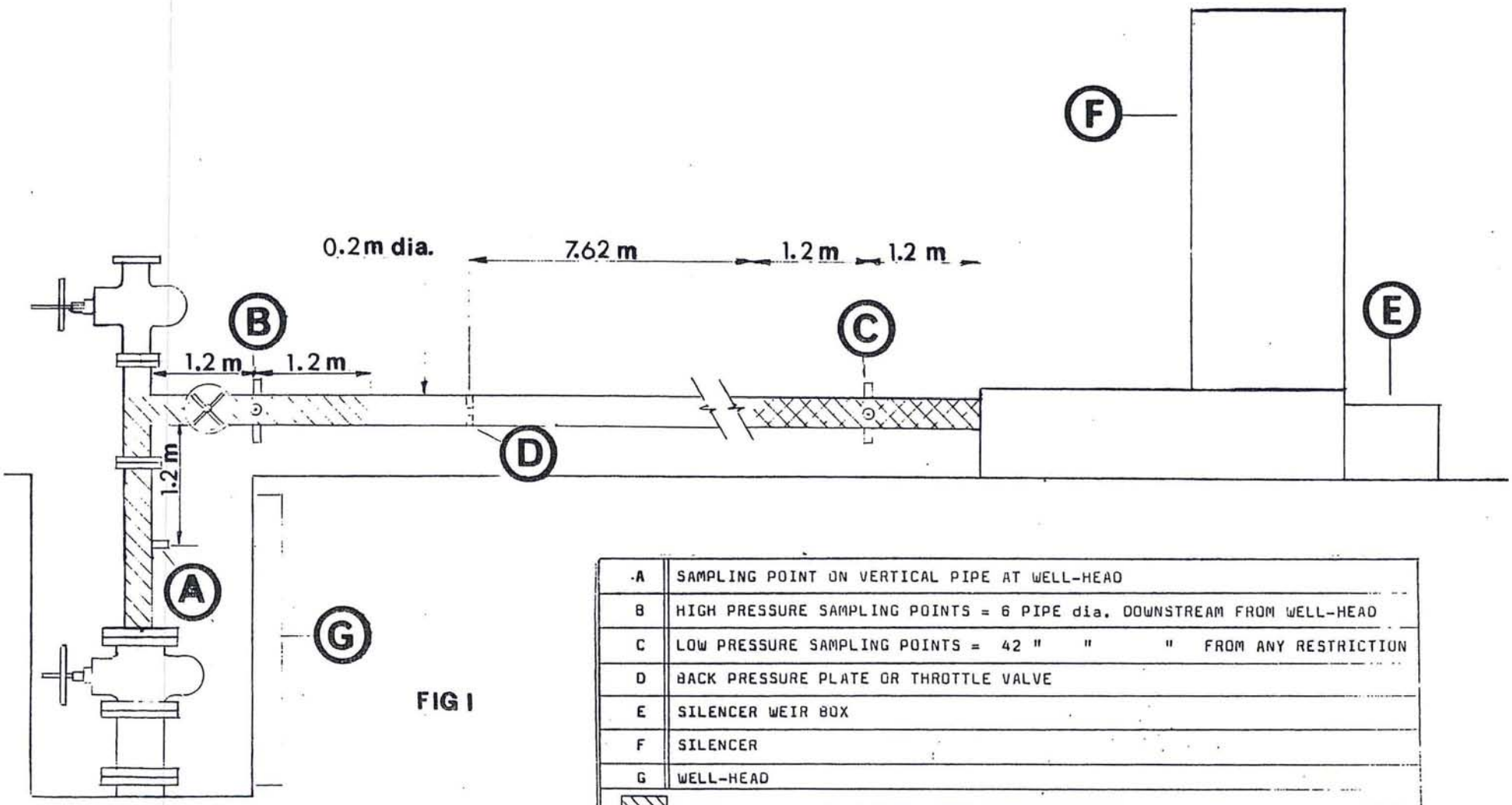


FIG I

A	SAMPLING POINT ON VERTICAL PIPE AT WELL-HEAD
B	HIGH PRESSURE SAMPLING POINTS = 6 PIPE dia. DOWNSTREAM FROM WELL-HEAD
C	LOW PRESSURE SAMPLING POINTS = 42 " " " FROM ANY RESTRICTION
D	BACK PRESSURE PLATE OR THROTTLE VALVE
E	SILENCER WEIR BOX
F	SILENCER
G	WELL-HEAD
	RANGE OF LOCATIONS FROM WHERE REPHESENTATIVE WATER SAMPLES ARE COLLECTED
	" " " " " " STEAM AND GAS " " "

NB: WITH 'D' IN BY-PASS 'C' MUST BE LOCATED 7.62m min. FROM 'D'

L.E. Klyen.

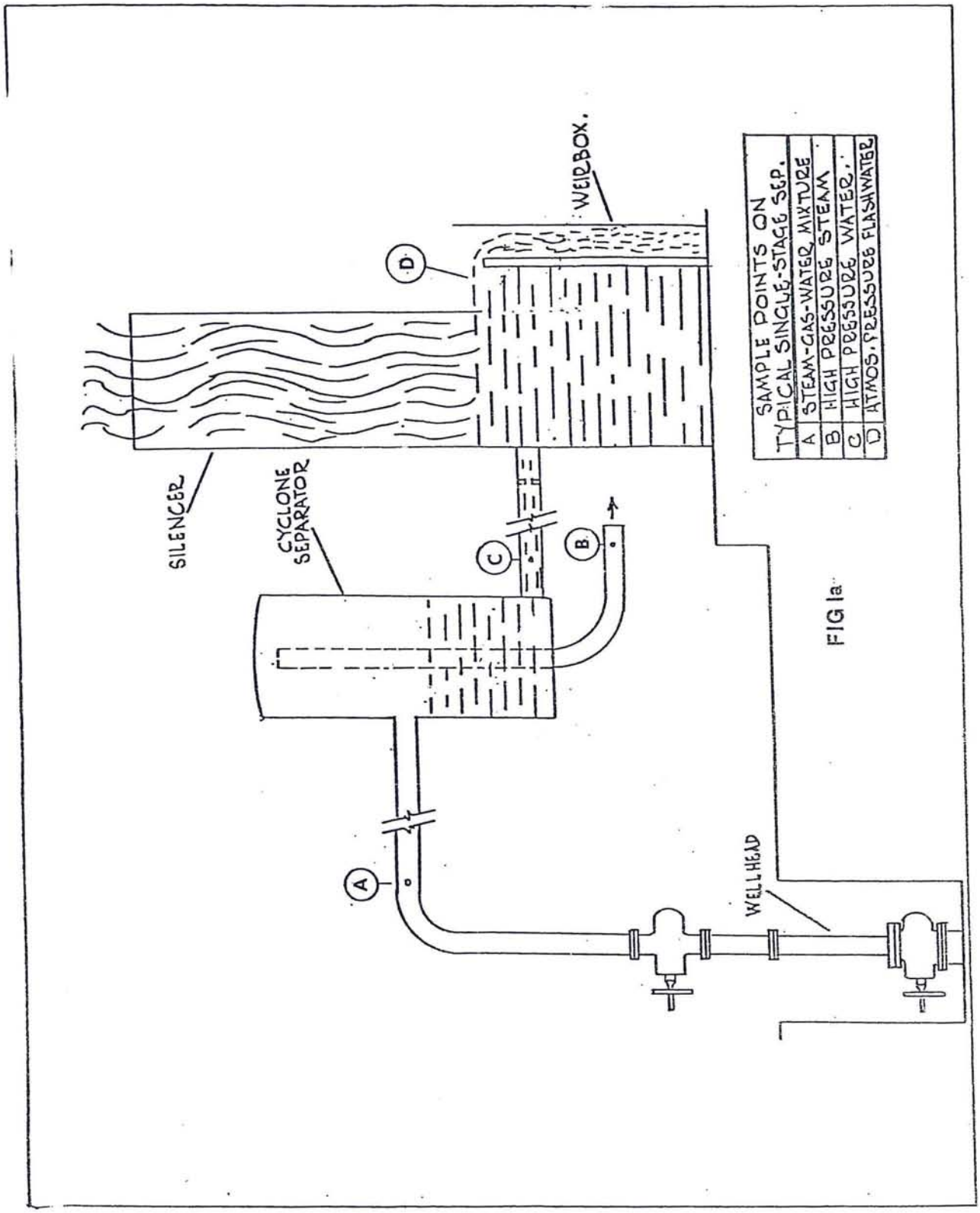

SAMPLE POINTS ON TYPICAL SINGLE-STAGE SEP.
A STEAM-GAS-WATER MIXTURE
B HIGH PRESSURE STEAM
C HIGH PRESSURE WATER.
D ATMOS. PRESSURE FLASHWATER
WEIRBOX.
SILENCER
CYCLONE SEPARATOR
WELLHEAD
A
B
C
D

FIG 1a

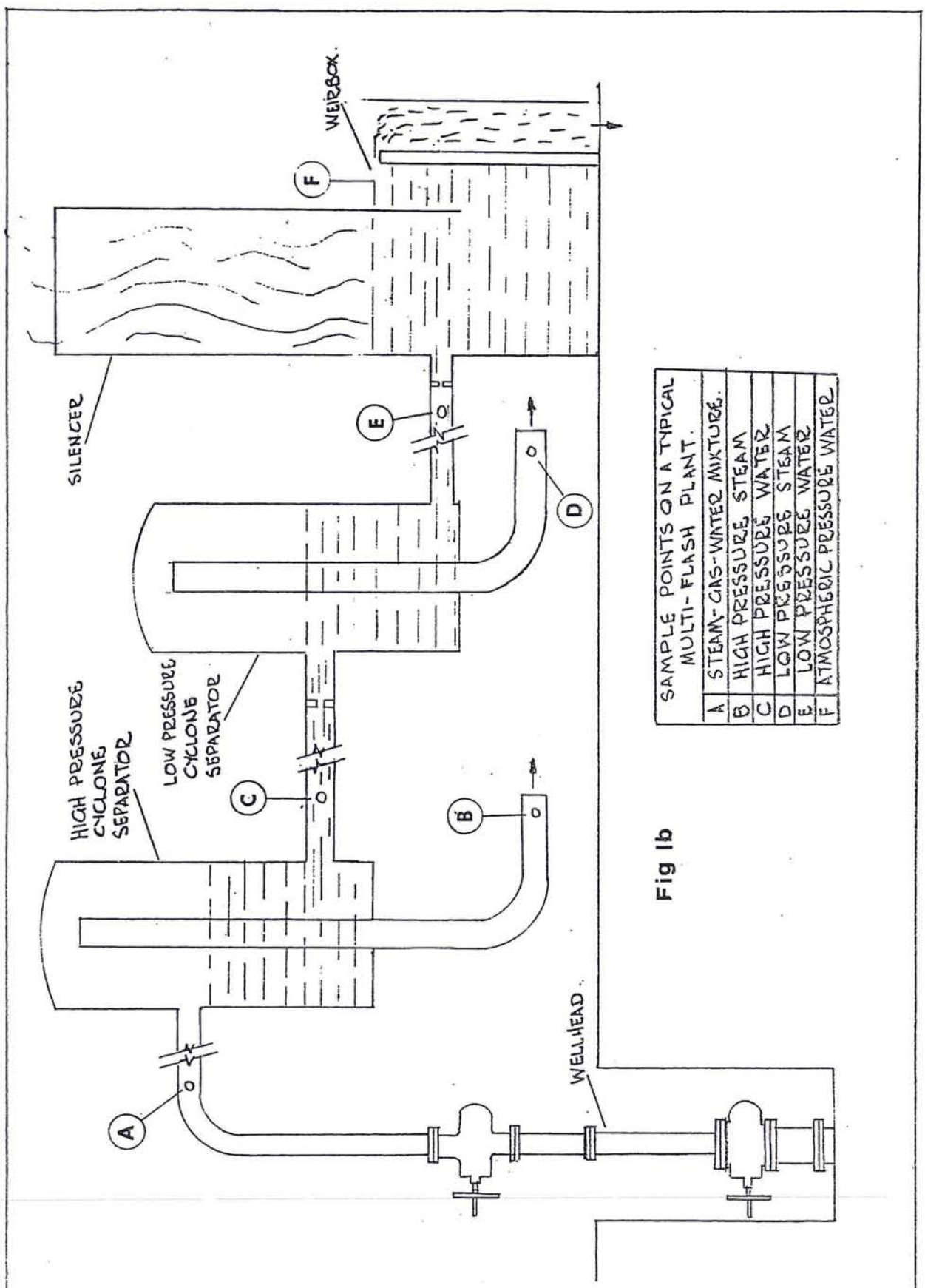

WEIRBOX
F
SILENCER
E
D
HIGH PRESSURE CYCLONE SEPARATOR
LOW PRESSURE CYCLONE SEPARATOR
C
B
A
WELLHEAD
SAMPLE POINTS ON A TYPICAL MULTI-FLASH PLANT.
A STEAM-GAS-WATER MIXTURE.
B HIGH PRESSURE STEAM
C HIGH PRESSURE WATER
D LOW PRESSURE STEAM
E LOW PRESSURE WATER
F ATMOSPHERIC PRESSURE WATER

Fig 1b

WEBRE CYCLONE SEPARATOR*

Function

To separate the vapour and water fractions of a two-phase steam/water mixture of a geothermal well. Working press: 0.7-40 bar gauge.

Use

(i) For the collection of geothermal well gas samples
(ii) For the collection of geothermal well hot water samples above atmospheric pressure.

Description (refer Fig. 2)

Centrifugal separation takes place in Cyclone (B) from which dry steam and gas is discharged through the tee-piece at (A1). The tee-piece provides pressure relief before gas samples are directed, for collection, into evacuated pyrex flasks. Separated water is directed into Cyclone (B), which operates in a slightly flooded condition, and discharged together with any remaining traces of steam and gas at (B1). Steam and gas free water from Cyclone (B) may be fed to the cooling system (C) and collected at atmospheric pressure from (C1).

Method (refer Figs. 2, 2a, 2b and 2c)

(i) The separator is connected to a sampling point by a mac-union fitting on the two-phase discharge line of a geothermal well. Appropriate adjustment of valves (A1 and (B1) will give a dry steam and gas discharge at (A1) and a water/steam mixture at (B1). Gas and dry steam are directed through a butyl rubber hose into a water cooled, evacuated, pyrex flask - usually of 5 litre volume - containing a measured quantity of 70% sodium hydroxide (NaOH) i.e. 70 g NaOH dissolved in 100 mls H_2O. This solution normally is further diluted, preventing the precipitation of $NaCO_3$, and providing a less viscous and more easily dispensed fluid. Solution quantities and dilutions are dictated by local field gas concentrations. NaOH solutions in 5 litre collection flasks, for typical New Zealand conditions are:

Field	mmoles CO_2/100 moles in separated steam	mls 70% NaOH	mls H_2O
Wairakei	50	20	80
Broadlands	1300	100	100
Ngawha	4000	300	200

* Manufactured to Chemistry Div., D.S.I.R. specifications by Burns & Ferral Ltd., P.O. Box 12-030, 940 Great South Road, Penrose, Auckland, 5, New Zealand.

As gas and steam bubble through the sodium hydroxide, hydrogen sulphide and carbon dioxide are taken into solution. Cold water applied to the exterior of the collection flask promotes the condensation of dry steam whilst retaining a negative interior pressure and, thus, the continued entry of gases. 'Rotoflo' type flasks of 0.3 litre volume may be used with an advantage of reduced sampling times and volumes but incurring, also, the possible disadvantage of a smaller amount of noncondensible gases.

(ii) Separated water is collected directly from (C1) after cooling through water jacket (C).

Operation for gas collection (refer Figs. 1, 2, 2a, 2b and 2c)

(1) Attach separator to a correctly located sample point (Mahon, 1961, and item 'Wellheads' p9 in this pub.) by means of a stainless steel mac-union and socket assembly fitted with a stainless steel 1 mm mesh filter.

(2) Mount and secure separator with cyclones positioned vertically.

(3) Shut all separator valves.

(4) Wear protective eye-glasses from here on until sample point is reclosed after sampling.

(5) Crack sample point valve and check for leaks.

(6) If the system is leakage free open COMPLETELY the sample point valve.

(7) Crack separator valve (D) and note sample point pressure on the gauge at (D). If gauge reading fluctuates excessively progressively close valve (D) to throttle pressure until the fluctuation is reduced sufficiently to allow pressure measurement. Leave (D) open throughout sampling period.

(8) Open valve at (A1) until a vapour plume of 1-2 metres is produced from the tee-piece discharge port at (A1).

(9) Open valve (B1) until plume at (A1) goes dry. This condition may be recognised by:

(i) Briefly obstructing (A1) tee-piece discharge with a suitably gloved hand and observing if water is deposited. Little, or no, water will appear when optimum dry steam separation is achieved.

(ii) Closely observing the fringe of water adhering to the lip of the tee-piece discharge port at (A1). In most cases the fringe will disappear upon attainment of dry steam separation.

(iii) Under optimum conditions a smokey-blue tinge appears in the dry discharge plume and a transparent interval of dry steam separates the plume from the discharge port.

(10) Read separation pressure and continue to trim (A1) and (B1) settings until optimum separation with minimum pressure drop is achieved. Note sampling pressure.

(11) Securely connect dry discharge hose to a prepared collection flask after purging all intermediate connections.

(12) Clamp flask input hose downstream of the flask sealing clip using self-locking artery forceps.

(13) Position flask so that sample input will bubble through the NaOH solution thus eliminating the need for continuous manual shaking.

(14) Fully release the flask sealing clip.

(15) Carefully release artery forceps whilst observing that the tee discharge plume is maintained at all times throughout sampling period. If sample discharge into the evacuated collection flask is too fast internal pressure at the tee discharge point (A1) could be sufficiently reduced to allow atmospheric entry. Should this occur the sample is immediately contaminated and must be discarded.

(16) Continue to control the flask input by manipulation of the forceps until manual control may safely be abandoned without loss of the tee discharge plume.

(17) Apply cooling water to the walls of the collection flask whilst ensuring that the resultant internal pressure drop does not induce atmospheric contamination as discussed in 15.

(18) Exercise a close supervision throughout sampling period to ensure that optimum separation is maintained, together with minimum difference, between the sample point pressure and the sampling pressure.

(19) If the sample is required only for H_2S and/or CO_2 determinations sampling may normally be terminated upon the collection of not less than one litre of total liquid (i.e. NaOH solution plus condensate) where standard five litre collection flasks are used. But check with analyst as to what volume is required. If the sample is required for non-condensible gas, and/or CH_4 and CO_2 isotope, determinations allow sample collection to continue until input bubbling has almost ceased. Where stable isotope determinations such as ^{18}O and D are required collect not less than 50 mls of sample into a cooled, evacuated, one litre flask without NaOH solution. For NH_3 determinations collect not less than 100 mls into a cooled, evacuated, one litre flask without NaOH solution. Upon completion of sampling retighten sealing clip with flask in sampling position and with continued cooling until flask is fully sealed.

(20) Where H_2S collection takes place in standard five litre flasks, fitted with butyl rubber hoses, analysis should be undertaken without delay. If collection is into teflon sealed, 'Rotoflo' type flasks, haste is unnecessary but be certain always to retighten gently the valves after about one hour following completion of sampling.

Operation for separated water collection (refer Figs. 2 and 2d)

1. Attach to the valve outlet at (C1) sufficient 12 mm OD x 6 mm ID butyl rubber tube to reach the bottom of a transparent collection bottle.

2. Apply cooling water to the lower water jacket connection of (C).

3. Set up the separator to deliver optimum separation as described above.

4. Open the valve at (C1) sufficiently to produce a small flow of separated water at a temperature not exceeding 30°C.

5. Allow to run for two minutes then check flow temperature.

6. If the separated flow remains below 30°C allow a further 200 mls of discharge and begin sample collection with the butyl rubber tube located close to the bottom of the transparent collection bottle. If flow temperature has increased reduce sampling rate until temperature is acceptable before collection begins.
   NB: Always precede sample collection by twice washing out the sample vessel with sample water.

7. Ensure that no bubbles are emitted from the butyl rubber tube during sample collection. If bubbling continues, even when the sample flow is cool, check for poor separation and adjust accordingly. Any remaining bubbles will probably be due to dissolved gases coming out of solution and may safely be ignored.

8. Sample volume may be dictated by analytical requirements but usually 250-500 mls is sufficient.

Routine Maintenance

1. Flush all steam and water channels, including the mac union/ filter assembly, thoroughly with clean tap water after use.

2. Check pressure gauge and recalibrate where necessary.

Fault finding

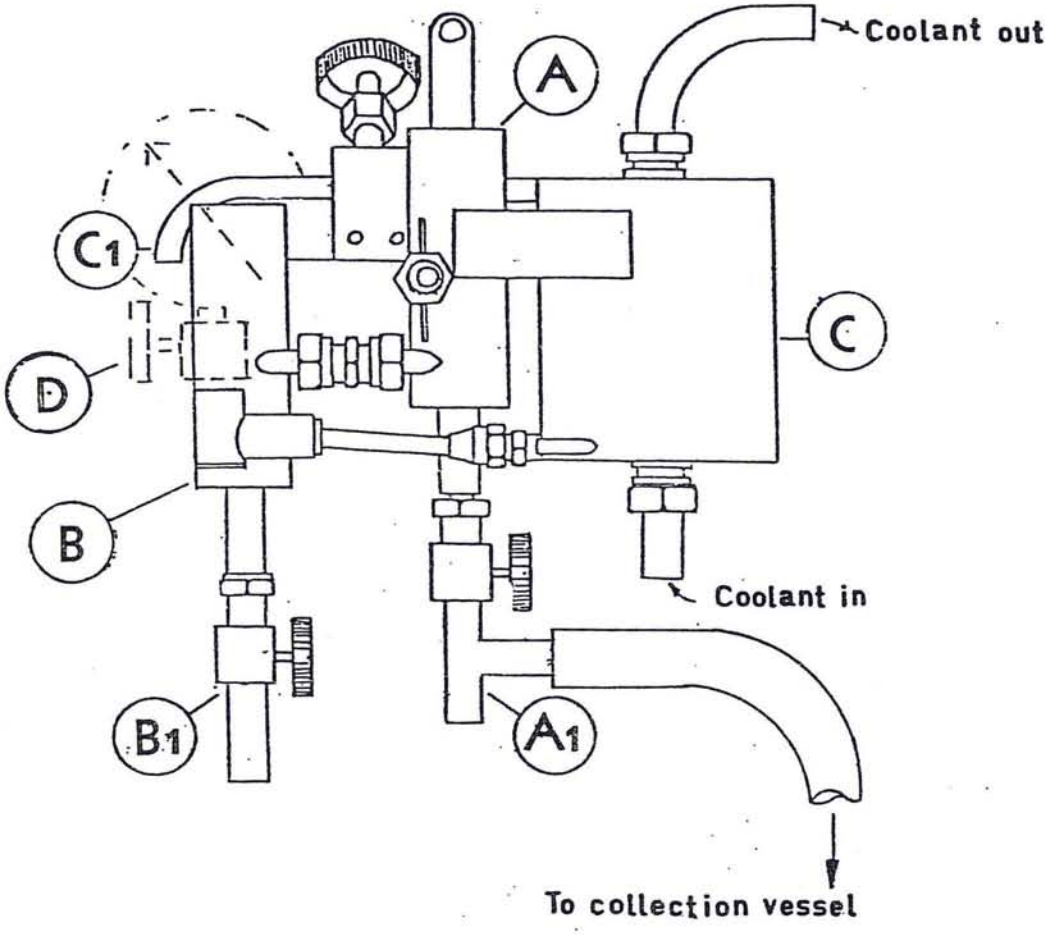
1. Failure to achieve good separation at some point through the range of Webre settings will be due to the nature of the well's discharge; e.g., sample point pressure below 0.7 bar, too wet, intermittent steam/water fluctuations. Nevertheless, it is a rare event when satisfactory separation cannot finally be attained. Should such an occasion arise the field technician must strive for the best results obtainable under the prevailing limitations. It is of the utmost importance that the section supervisor and analyst be notified of any departure from standard sampling procedures and that any such departure is carefully recorded in the chemical data file.

2. Loss of separated water flow at (C1) usually is due to well debris blocking the system within, and immediately upstream from (C1). To clean blockage attach the Webre separator to a sample point of pressure in excess of 1 bar. Remove the valve at (C1), at the hexagonal nipple connection and momentarily open the sample point valve to discharge a two phase flow through the Webre's separated water path. Dismantle the valve at (C1), remove debris, and reassemble.

Specimen Field Notes

Well No:	Date:
Webre Gas Sample	WHP (Wellhead pressure) = bar gauge
Flask No:	SPP (Sample point pressure: = bar gauge
Webre Water Sample Bottle No.	SP (Sample pressure) = bar gauge
Weir Box Sample Bottle No*	
Weir box temperature ^{o}C	
NaOH Vol. = mls	H_2O = mls

* It is customary to collect an additional 500 ml water sample directly from the weirbox situated at the foot of the silencer by means of a simple baler.



WEBRE SEPARATOR Fig 2

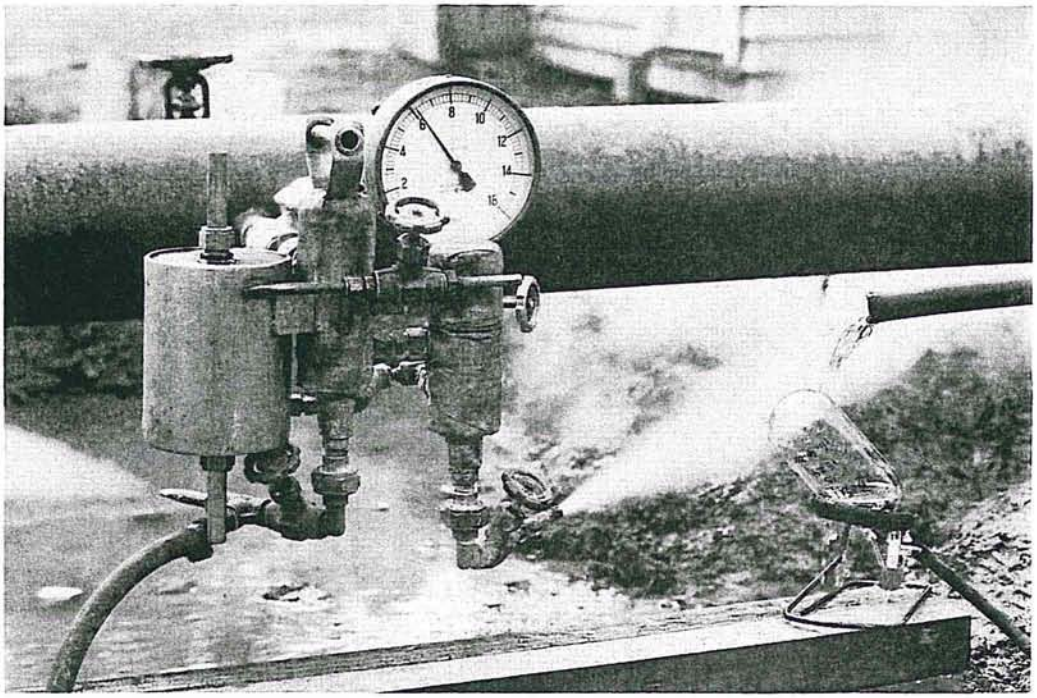


Figure 2a

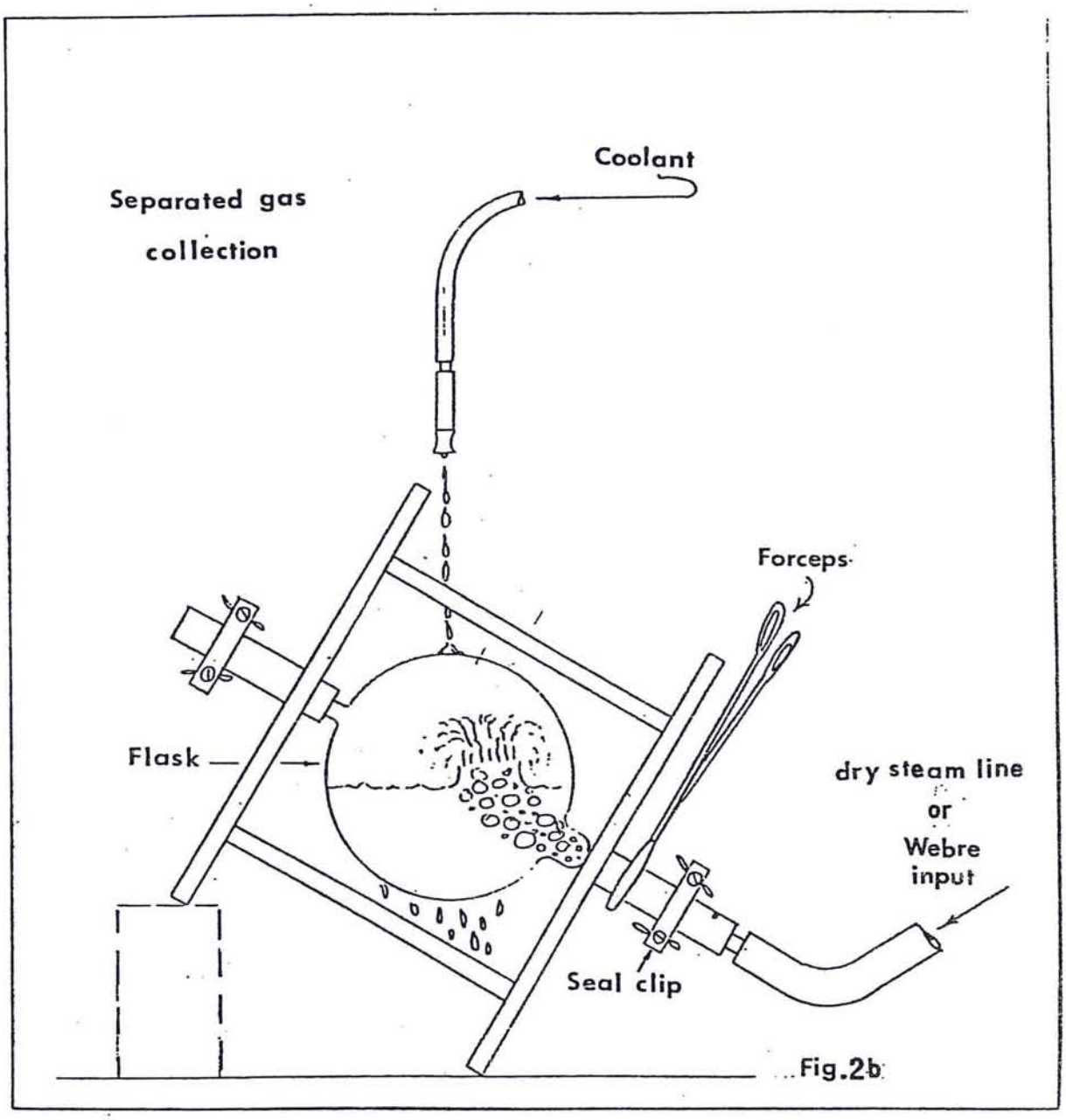

Coolant
Separated gas
collection
Forceps
Flask
dry steam line
or
Webre
input
Seal clip

Fig.2b

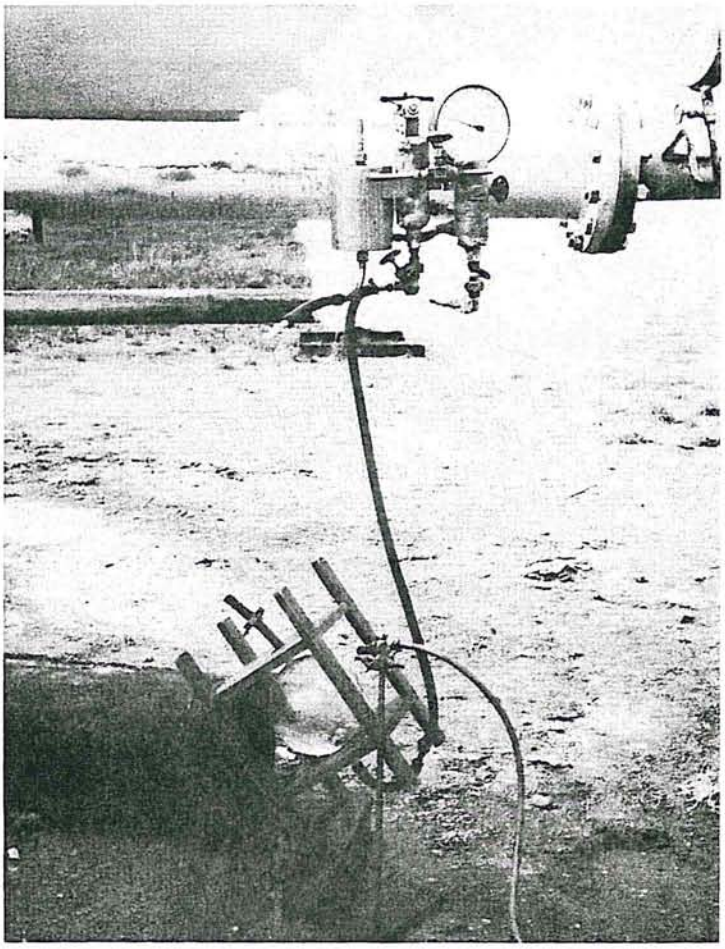


Fig 2c

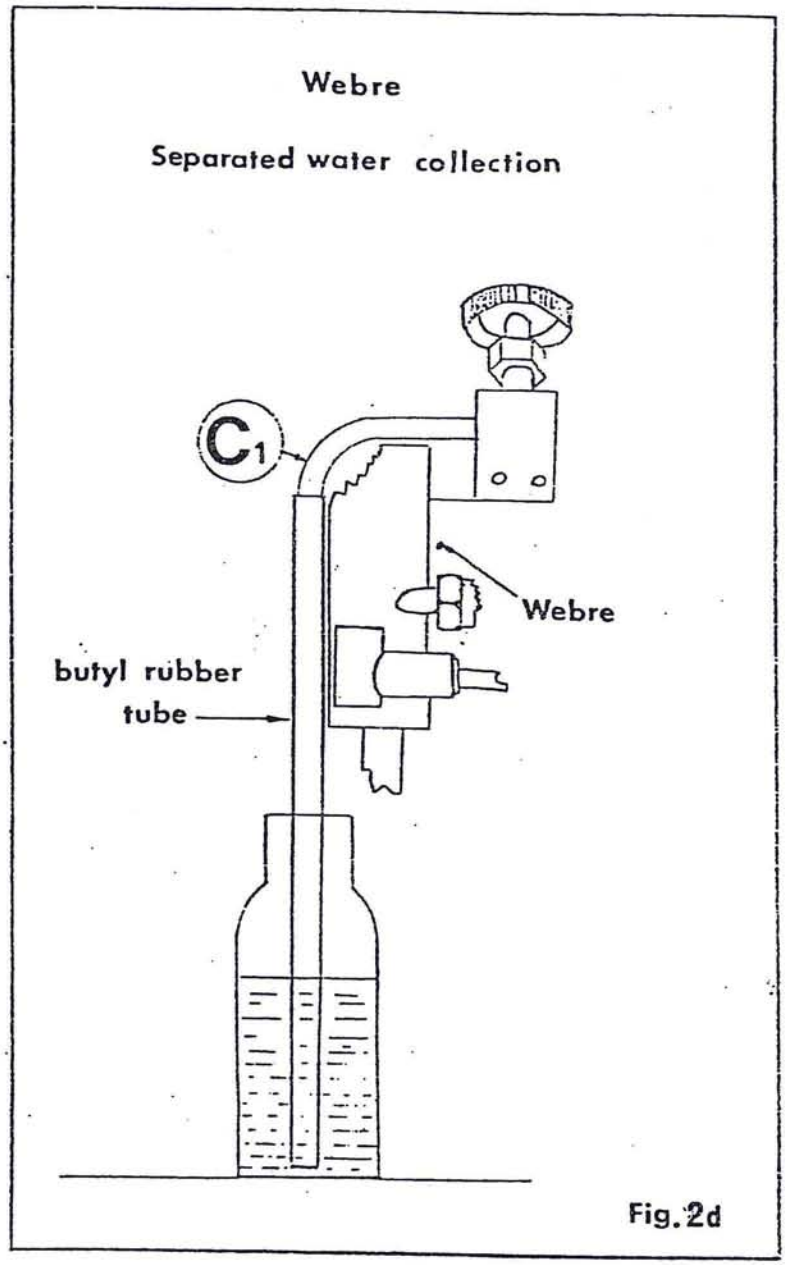

Webre
Separated water collection
C1
Webre
butyl rubber
tube

Fig. 2d

HIGH PRESSURE HOT WATER COOLER

Function

To cool separated, high pressure, geothermal hot water to a temperature at which it may be extracted without evaporation. This device duplicates one of the Webre Separator functions but is more readily adaptable to the location of most hot water sampling points.

It may, if required, perform also as a simple high-pressure condenser.

Use

(i) For the collection of separated, high pressure geothermal hot water samples,

(ii) For the collection of dry steam condensates in conjunction with a dry steam source.

Description (refer Figs. 3 and 3a)

Separated, high pressure, hot water enters the stainless steel tube (A) upon opening the sample point valve. Cooling water flows freely through the water jacket (B) which encloses the pressure tube (A). Cooled sample water may be collected at atmospheric pressure from (C).

Method

(i) The cooler is connected to a sampling point on a separated hot water line. Cooling water is fed into the water jacket (B). Appropriate adjustment of the valve at (C) will give sample water at a temperature, say 30 °C, at which significant evaporation cannot occur.

(ii) Dry steam condensation is achieved by connecting the cooler downstream from, and in series with, a dry steam source; e.g. Webre Separator.

Operation for high pressure hot water collection (refer Figs. 3 and 3a)

1. Attach the cooler to a sample point with a mac union nipple assembly.

2. Mount and secure cooler in an inclined attitude with the sample outlet end highest by approximately 10 cm.

3. Shut the valve at (C).

4. Attach sufficient 12 mm OD x 6 mm ID butyl rubber tube to the discharge port at (C) to reach the bottom of the sample vessel..

5. Apply cooling water to the lower water jacket connection.

6. Crack sample point valve and check for leaks.

7. If system is leakage free, completely open the valve at (C) and purge cooler pressure tube until steam appears.

8. Shut valve at (C).

9. Fully open sample point valve.

10. Note sample point pressure on gauge at (C).

11. Open valve at (C) until a small, cool, discharge flows from the butyl rubber hose.

12. Allow to run for two minutes then check temperature of flow.

13. If the flow remains cool allow a further 350 mls of discharge and begin sample collection with the butyl rubber tube located close to the bottom of a transparent collection vessel. If the temperature rises above 30°C reduce the discharge rate until temperature decreases before sample collection begins. NB: Always precede sample collection by twice washing out the sample vessel with sample water.

14. Ensure that no bubbles are emitted from the butyl rubber delivery tube during sample collection. Bubbling may be an indication of insufficient cooling and/or too rapid a collection rate. If bubbling occurs even when discharge remains cool it will be attributable to excess steam and/or gas entering the separated hot water line, and should be carefully recorded and reported to the section supervisor.

15. Sample volume may be dictated by analytical requirements but usually 250-500 mls is sufficient.

Operation for dry steam condensate collection and steam and condensate free gas collection (refer Figs. 3 and 3a)

1. Secure a short length of 21 mm OD x 7 mm ID butyl rubber tube to the upstream end of the cooler's mac union nipple assembly.

2. Attach a hose to the dry steam source per a tee-piece (Figs 4 and 4a) or, where applicable, set the Webre separator up for optimum separation discharge.

3. Connect the dry steam discharge hose to the cooler's mac union nipple assembly per the butyl rubber extension.

4. Apply cooling water to the cooler's lower water jacket connection.

5. For dry steam condensate collection proceed according to the hot water sampling instructions. Distinguish between unacceptable steam bubbles and normally attendant gas bubbles by observing strict control of discharge temperature.

6. (refer fig. 3b) For steam and condensate free gas collection separate the condensed fraction by means of a trap (D) interposed between the cooler and the gas collection vessel.

7. Sample volume may be dictated by analytical requirements but usually 250-500 mls is sufficient.

Routine Maintenance

1. Flush out pressure tube (A) with clean tap water.

2. Check pressure gauge and recalibrate where necessary.

Specimen Field Notes

Well No:

Separated Water Sample Bottle No.

Date

WHP	(Wellhead pressure)	bar gauge
CP	(Wellhead Cyclone pressure)	bar gauge
SPP	(Sample point pressure)	bar gauge
SP	(Sampling pressure)	bar gauge

Separated, high pressure, hot water collection

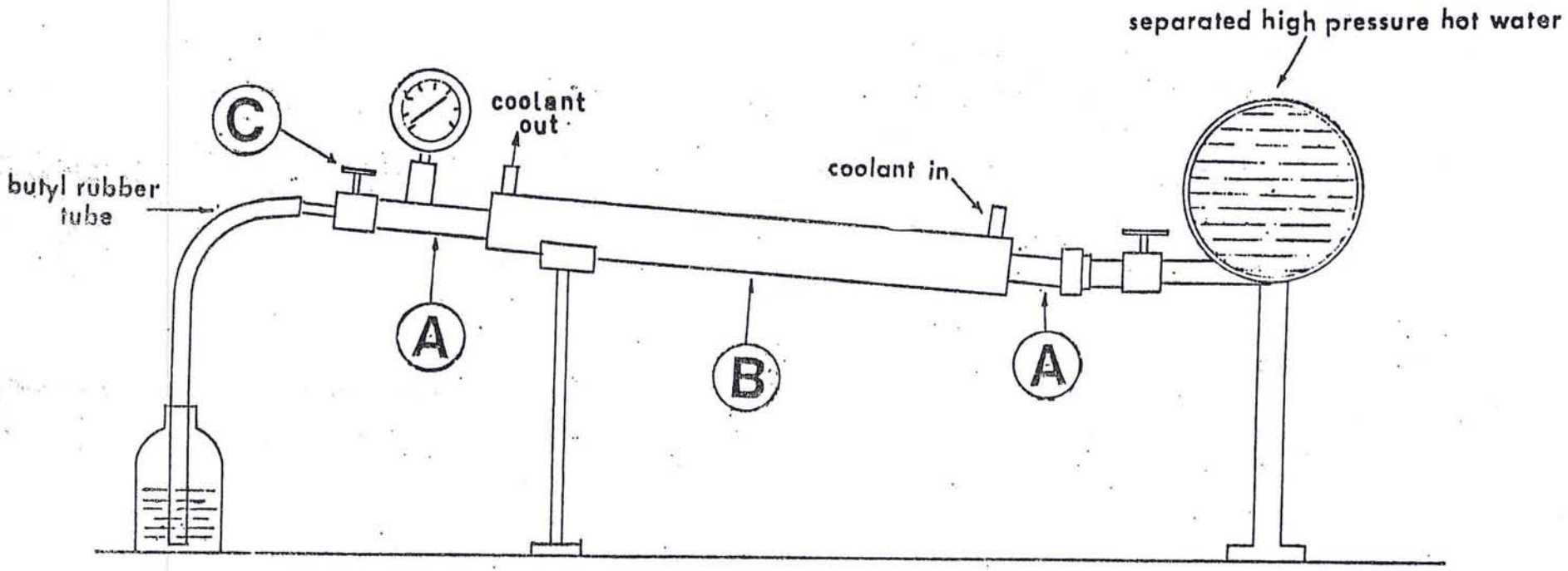


Fig.3

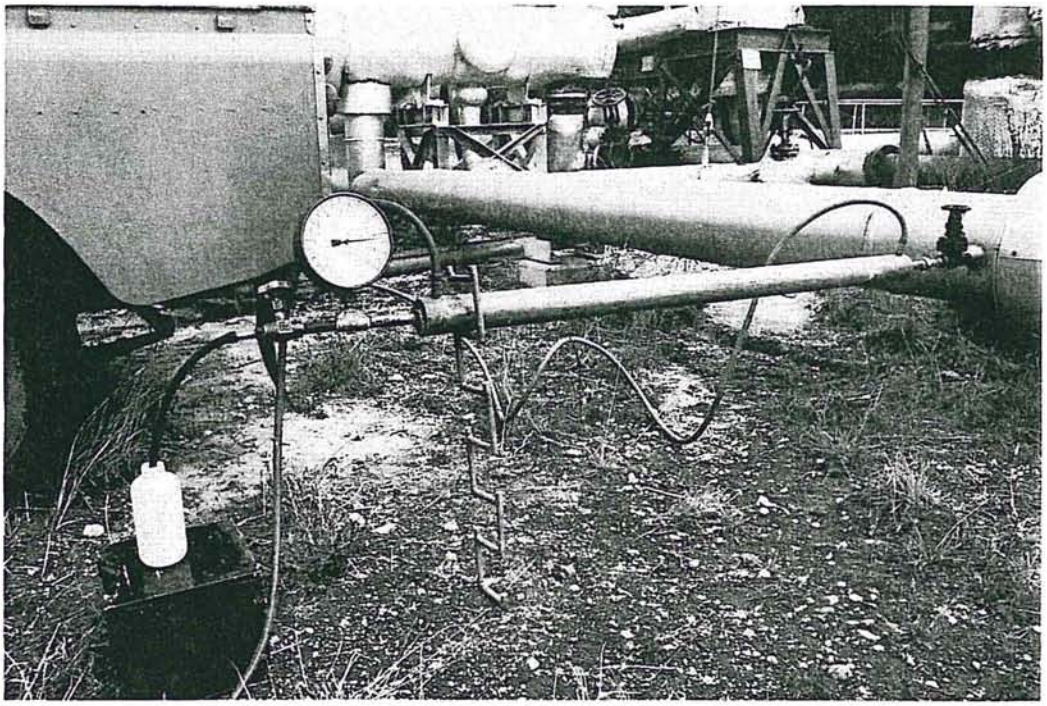


Figure 3a

Separated, steam free, gas collection

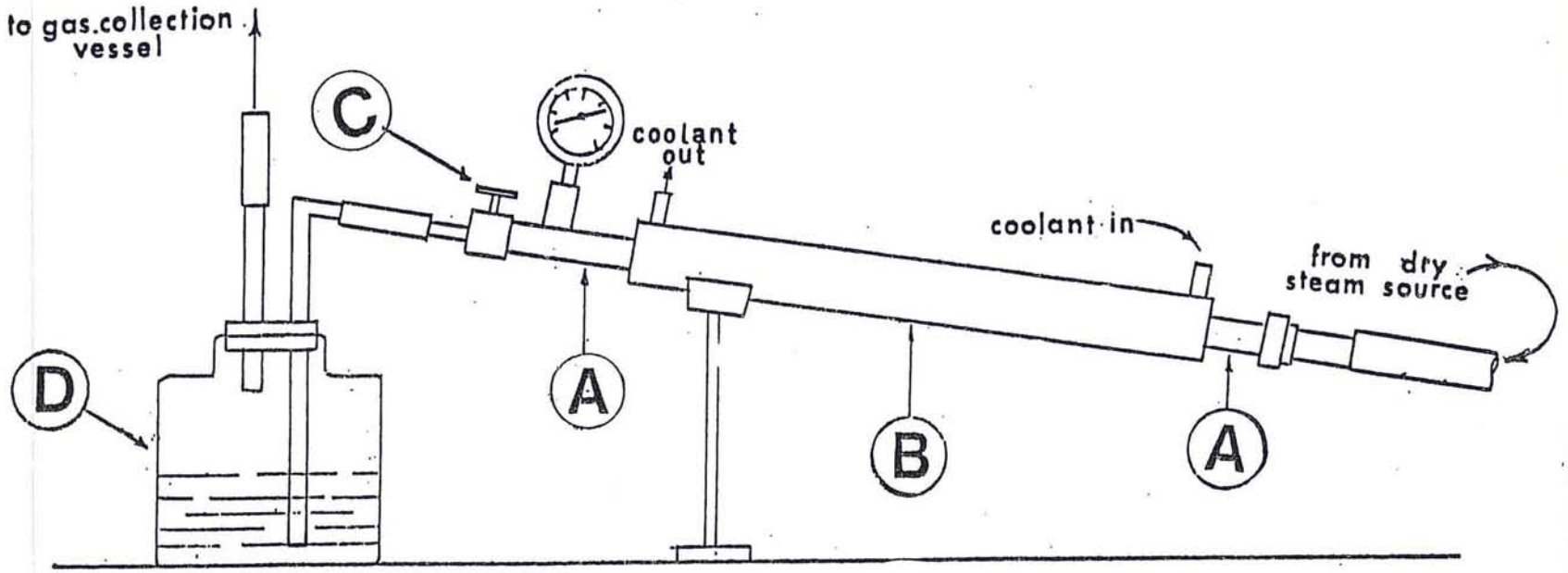


Fig.3b

GAS SAMPLING TEE PIECE

Function

To provide a suitable sampling adapter for separated steam line sample points.

Use

For the collection of gas samples from separated steam lines.

Description (refer Fig. 4 and 4a)

A separated, dry-steam and gas flow entering the tee-piece at (A) is regulated by the valve at (B) before exiting through the two tee ports at (C). From one of the ports a hose delivers dry steam and gas for collection into an evacuated pyrex flask, whilst the second port provides pressure relief.

Method (refer Fig. 4 and 4a)

The tee-piece is screwed into a sampling point on a separated steam line. Gas and steam are fed through a butyl rubber hose into a water cooled, evacuated, pyrex flask - usually of 5 litre volume - containing a measured quantity of 70% sodium hydroxide (NaOH) i.e. 70 g NaOH dissolved in 100 mls H_2O. This solution normally is further diluted, preventing the precipitation of $NaCO_3$, and providing a less viscous and more easily dispensed fluid. Solution quantities and dilutions are dictated by local field gas concentrations. NaOH solutions in 5 litre collection flasks for typical New Zealand conditions are:

Field	mmoles CO_2/100 moles in separated steam	mls 70% NaOH	mls H_2O
Wairakei	50	20	80
Broadlands	1300	100	100
Ngawha	4000	300	200

As gas and steam bubble through the sodium hydroxide, hydrogen sulphide and carbon dioxide are taken into solution. Cold water applied to the exterior of the collection flask promotes the condensation of the dry steam whilst retaining a negative interior pressure and, thus, the continued entry of gases. 'Rotoflo' type flasks of 0.3 litre volume may be used with an advantage of reduced sampling times and volumes but incurring, also, the possible disadvantage of a smaller amount of noncondensible gases.

Operation

1. Screw the tee-piece into a sample point on a separated steam line.
2. Shut the valve at (B)

3. Attach a sufficient length of 21 mm OD x 7 mm ID butyl rubber hose to one of the exit ports. This, preferably, should be the right-angled port if a sufficient flow can be maintained, thus enhancing the ejection of unwanted superfluous water through the in-line port.

4. Wear protective eye-glasses from here on until sampling is completed.

5. Crack the sample point valve and check for leaks.

6. If the system is leakage free, completely open the sample point valve.

7. Note the pressure on the gauge at (B).

8. Open the valve at (B) until a vapour plume of approximately 1 metre is attained. Note sampling pressure.

9. Securely connect the discharge hose to a prepared collection flask after purging all intermediate connections.

10. Clamp flask input hose downstream of the flask sealing clip using self-locking artery forceps.

11. Position flask so that sample input will bubble through the NaOH solution thus eliminating the need for continuous manual shaking.

12. Fully release the flask sealing clip.

13. Carefully release artery forceps whilst observing that the tee discharge plume is maintained at all times throughout the sampling period. If sample discharge into the evacuated flask is too fast internal pressure at the tee discharge point could be sufficiently reduced to allow atmospheric entry. Should this occur the sample is immediately contaminated and must be discarded.

14. Continue to control the flask input by manipulation of the forceps until manual control may safely be abandoned without loss of the tee discharge plume.

15. Apply cooling water to the walls of the collection flask whilst ensuring that the resultant pressure drop does not induce atmospheric contamination as in 13 above.

16. Exercise a close supervision throughout sampling period to ensure that tee discharge plume is maintained.

17. If the sample is required only for H_2S and/or CO_2 determinations sampling may be terminated upon the collection of not less than 1 litre of total liquid (i.e., NaOH solution plus condensate) where standard 5 litre flasks are used. But check with analyst as to what volume is required. If the sample is required for non-condensible gas, and/or CH_4 and CO_2 isotope, determinations allow sample collection to continue until input bubbling has almost ceased. Where stable isotope determinations such as ^{18}O and D are required, collect not less than 50 mls of sample into a cooled, evacuated, one litre flask without NaOH solution.

For NH_3 determinations collect not less than 100 mls into a cooled, one litre flask, without NaOH solution. Upon completion of sampling retighten sealing clip with flask in sampling position and with continued cooling until flask is fully sealed.

18. Where H_2S collection takes place in standard 5 litre flasks fitted with butyl rubber hoses analysis should be undertaken without delay. If collection is into teflon sealed 'Rotoflo' type flasks haste is unnecessary. But be sure always to gently retighten valves after about one hour following completion of sampling.

Routine Maintenance

1. Flush out with distilled water.

2. Check pressure gauge and recalibrate where necessary.

Specimen Field Notes

Steam line gas sample per Tee-piece. Well No:

Flask No: Date

NaOH mls. WHP (Wellhead pressure) bar gauge

H_2O mls. CP (Cyclone pressure) bar gauge

SPP (Sample point pressure) bar gauge

SP (Sample pressure) bar gauge

BM (Baily Meter i.e., Dry Steam Flow) tonne/hr.

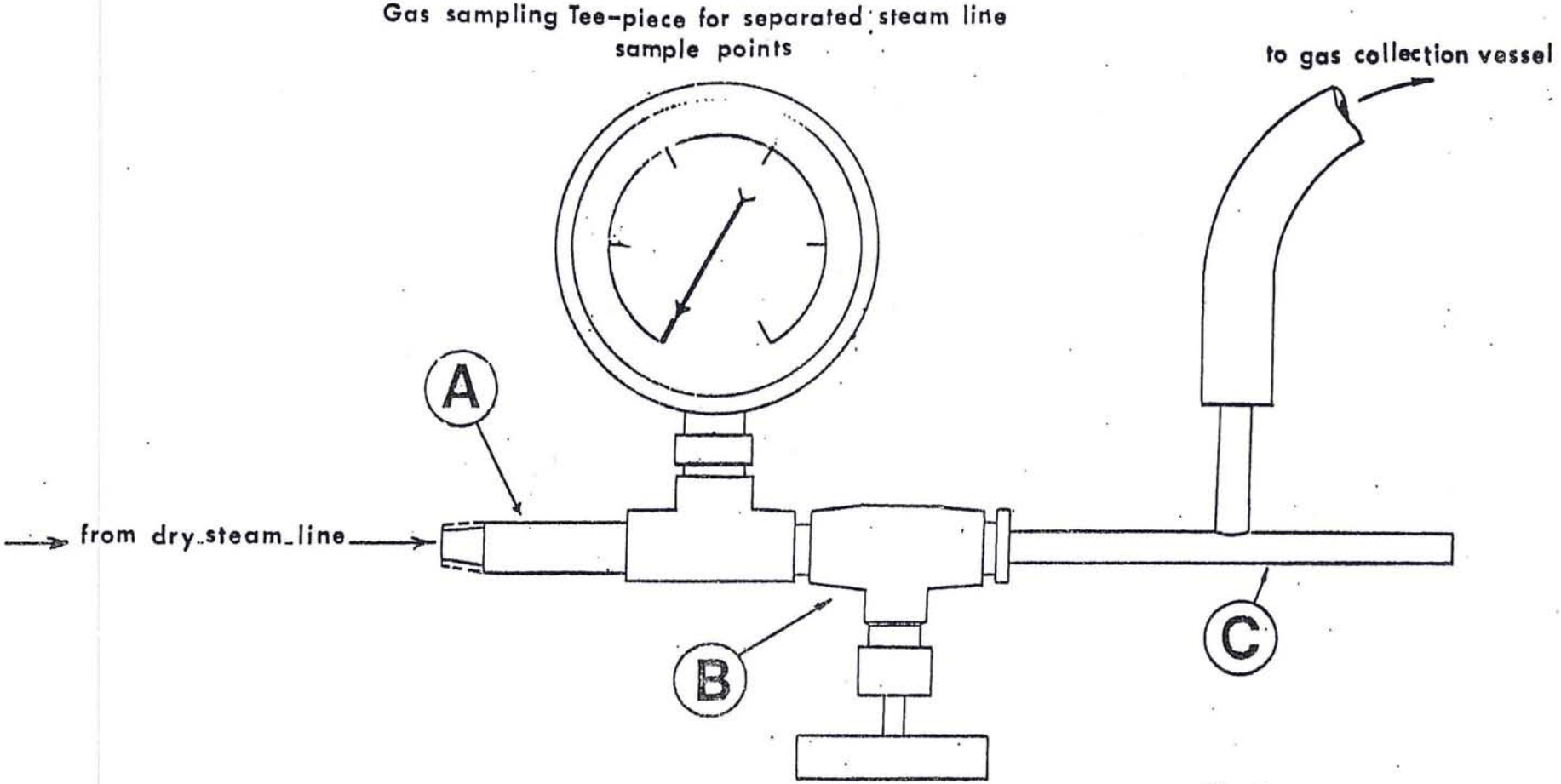

Gas sampling Tee-piece for separated steam line sample points
to gas collection vessel
A
from dry steam line
B
C

Fig. 4

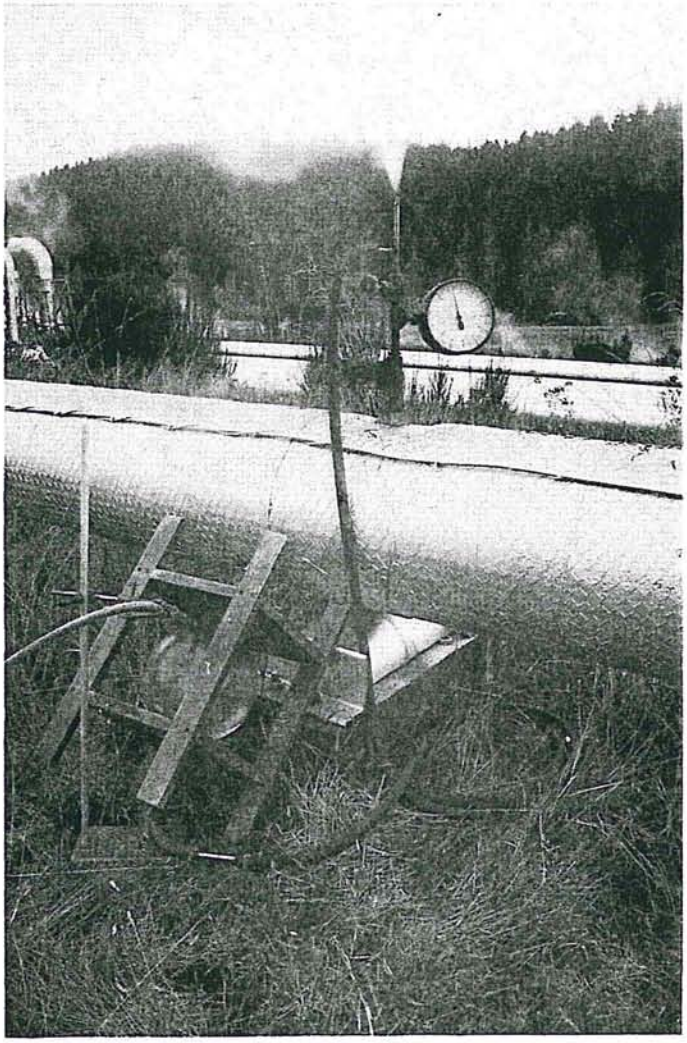


Figure 4a

MISCELLANEOUS SAMPLING OF GEOTHERMAL WELLS

Weirbox Water Sampling

(i) Weirbox water is collected by means of a simple baler constructed from non-corrosible materials, e.g. plastic beaker attached to a wooden pole.

(ii) Measure weirbox temperature at time of sampling.

Atmospheric Water Sampling of a Horizontal Steam/Water Discharge*

NB. Observe caution throughout methods A & B below.

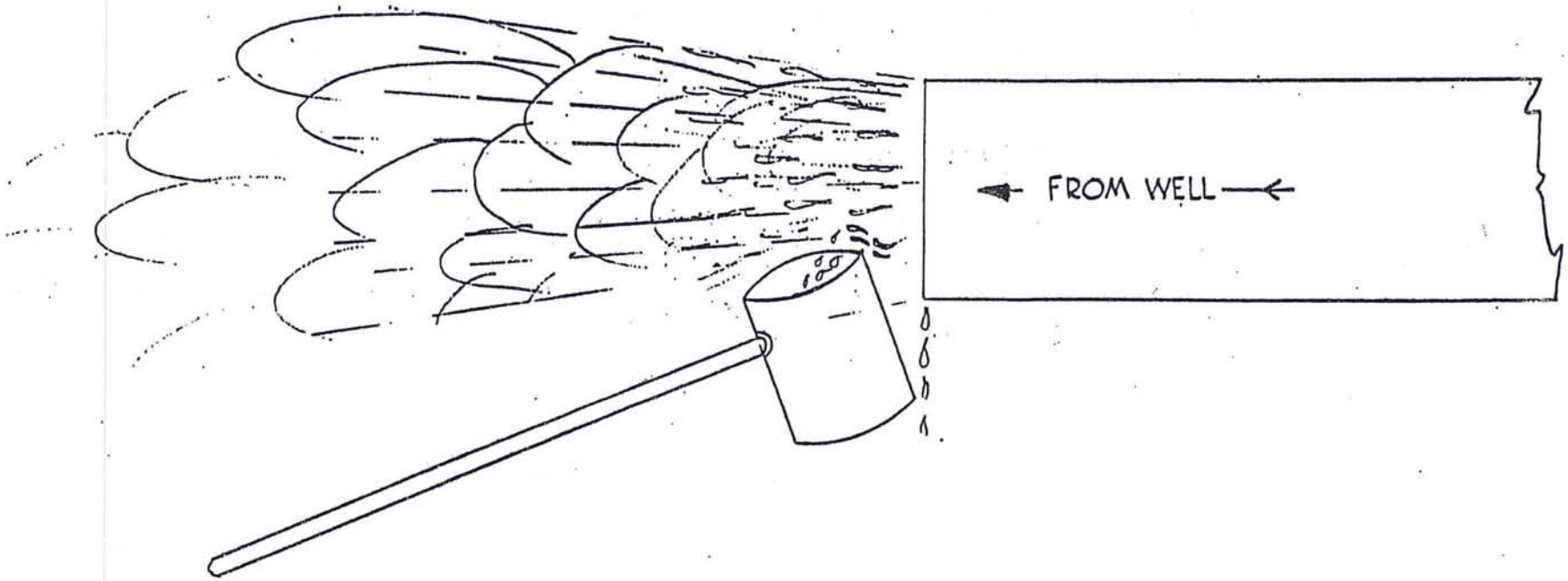
Method A: (refer Fig. 5)

A stainless-steel, 4 litre, beaker secured to a steel pole is inserted into the lower edge of the horizontal discharge plume. The water fraction of the discharge will separate across the lip of, and be retained by, the beaker. Record temperature where possible.

Method B: (refer Fig. 5a)

A lagged, stainless-steel tube fitted with a handle is located within the lower lip of the horizontal by-pass pipe. Entrapped water will be directed through the tube into the collection vessel. Record temperature where possible.

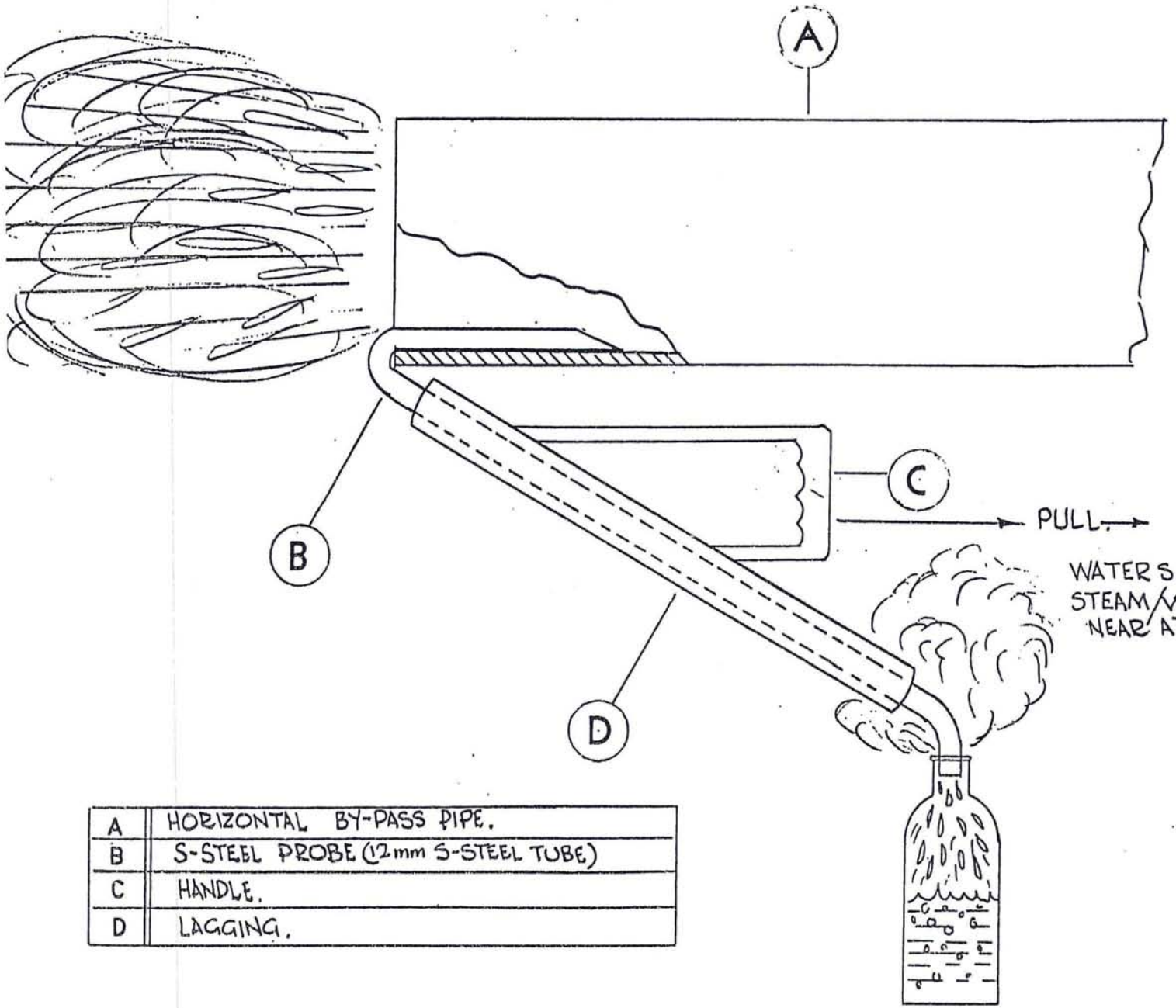
* The horizontal blowing of geothermal wells has been largely discontinued in N.Z. Samples collected from such discharges generally were unsatisfactory due to uncertainties arising from variable evaporation.



WATER SAMPLING FROM A HORIZONTAL STEAM/WATER DISCHARGE AT ATMOSPHERIC PRESSURES.

METHOD A.

Fig 5



WATER SAMPLER FOR HORIZONTAL STEAM/WATER DISCHARGE AT NEAR ATMOSPHERIC PRESSURES.

METHOD B

A	HORIZONTAL BY-PASS PIPE.
B	S-STEEL PROBE (12mm S-STEEL TUBE)
C	HANDLE.
D	LAGGING.

Fig 5a

'THROW-IN' SAMPLE VESSEL

Function

A vessel for the collection and temperature measurement of surface feature water samples.

Use

For the collection and temperature measurement of water samples where close approach is denied by natural hazard and/or access difficulty, e.g. overhung or precipitously banked hot springs and rivers.

Description and Method (refer Figs. 6 and 6a)

The sampler is attached to a length of nylon cord and thrown into the feature from which samples are required. It is necessary that there be sufficient depth of water to receive the sampler without damage. Inlet ports at (A1) admit water to the submerged vessel. A maximum thermometer contained in the pocket (C) is in direct contact with exterior temperatures through the holes at the lower end (C). Sample contamination from the debris disturbed during retrieval is eliminated by the rising slope of the inlet ports in conjunction with the surrounding partial skirt. The upper design of the sampler assists in vessel recovery whenever the nylon cord cuts into the edge, or bank from which sampling is conducted. Samples are extracted upon unscrewing the nose-piece (B) until the port (A2) communicates with the vessel's interior.

Operation

1. Unscrew nose-piece (B) from (A).
2. Select an appropriate maximum indicating thermometer and shake mercury down to minimum reading.
3. Insert thermometer into pocket (C) and cap with rubber stopper.
4. Screw (B), hand tight, into (A).
5. Avoid all sharp impacts on sampler from here on.
6. Pay out sufficient length of nylon cord to reach the sample source.
7. Throw sampler into the sample source.
8. In the event of little, or no, ebullition withdraw the sampler after one minute of immersion; or after five minutes in the presence of vigorous ebullition.
9. With suitably gloved hands unscrew the nose-piece (B) only until the port (A2) discharges sample water which may be collected directly into clean, or sample washed storage bottles.
10. Remove maximum thermometer and allow to cool before noting temperature.

Routine Maintenance

1. Flush out with clean tap water.
2. Lubricate thread with molybdenum-di-sulphide grease.
3. Check nylon cord for abrasion.

Specimen Field Notes

Feature name, number or location Date

(If previously unrecorded in N.Z. enter details on sheet SIR Y25/g-5c)*

Temp. = ^{o}C Sample location within feature:

Bottle No.

* Specimen sheet on page 88.

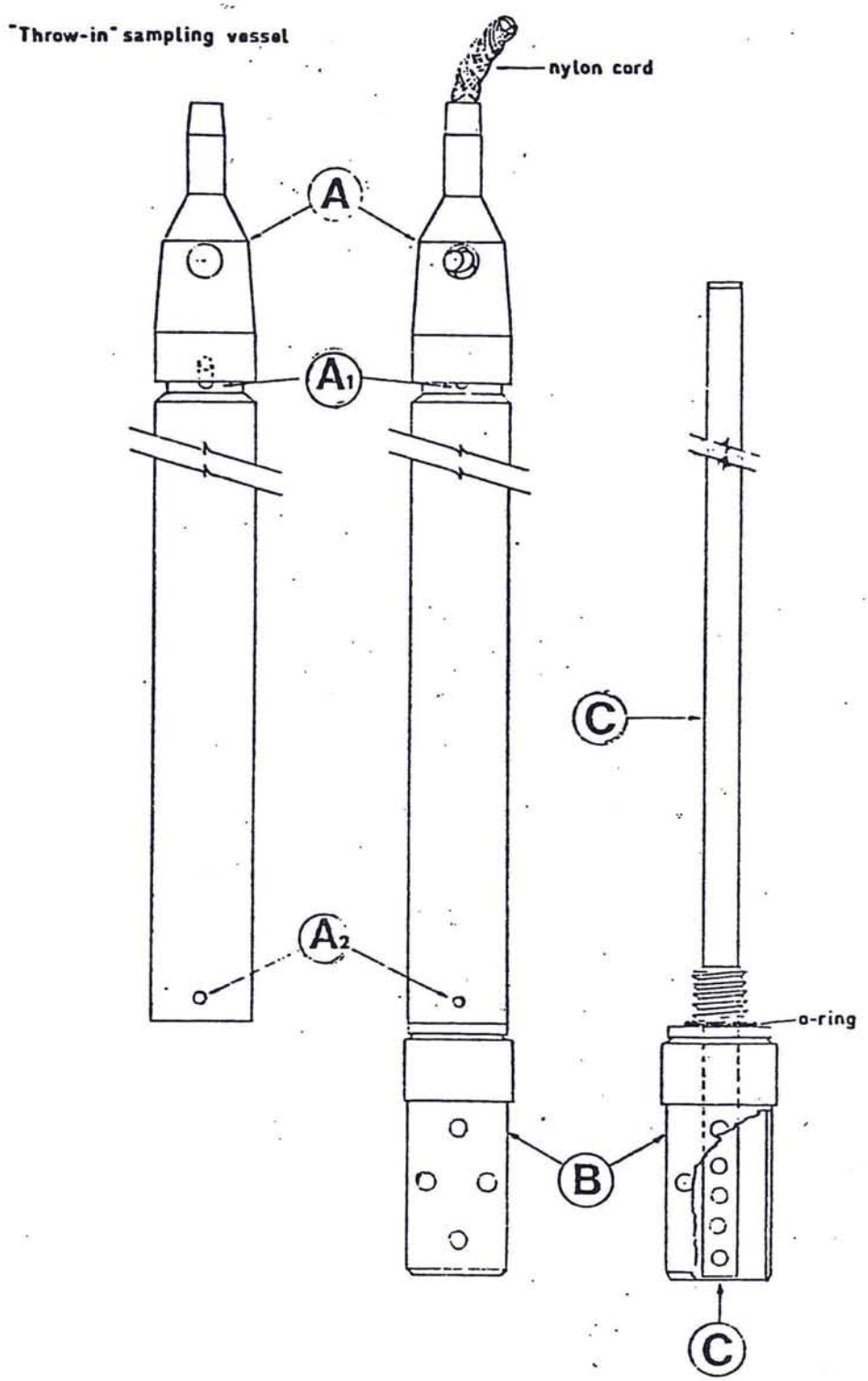


Fig 6

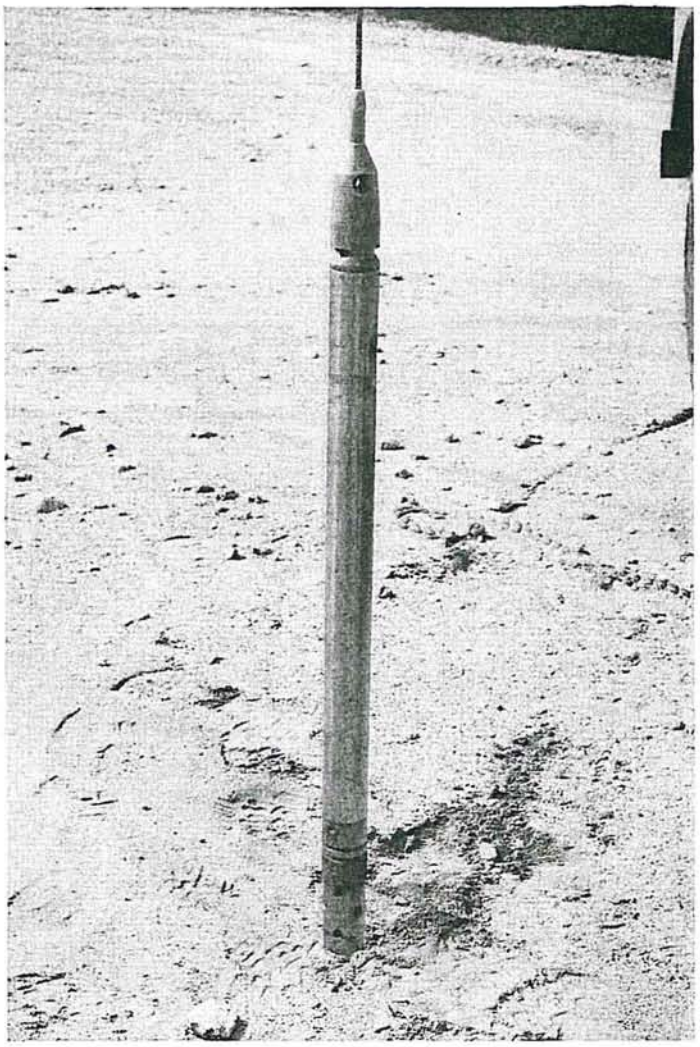


Figure 6a

DRÄGER GAS DETECTOR*

Function

To detect and measure concentrations of selected gases.

Use

To provide a portable means for the immediate detection and approximate measurement of selected gases.

Description

Gases are drawn, by means of a small hand bellows, through glass tubes containing visually indicating materials normally sensitive to one specified gas. Determinations are read by comparing the length of interior tube discolouration against an exterior engraved scale.

For Method, Operation and Routine Maintenance

Proceed strictly in accordance with the manufacturer's instructions included in each detector tube pack.

Specimen Field Notes

Site location and description: Date

Gas detected: Gas concentration:

(Seal, identify and retain all detector tubes)

CAUTION

Ensure ready access to a gas mask fitted with appropriate filters when working in confined spaces.

* Manufactured by Drägerwerk, AG,
Lubeck,
FEDERAL REPUBLIC OF GERMANY

KLYEN SUB-SURFACE SAMPLER Mk 1*

NZ PATENT 173058

US PATENT 3986553

Function

To collect sub-surface fluids

Use

For the collection of water and gas samples at selected depths in wells at temperatures up to 300°C and pressures up to 22400 k/Pa.

Description (refer Figs. 7 and 7a)

A sample vessel (J) is fitted at the lower end with a sample release valve (L) and an inward flow, non-return valve (F) at the upper end. A pyrex glass break-off tube (B) is located above, and in series, with the non-return valve. A guided, spring suspended weight, fitted at its lower end with a break-off tube striker, comprises the inertia mechanism (A), and is mounted directly above the break-off tube.

Upon activating the inertia mechanism the break-off tube is shattered and the non-return valve exposed thereby to external pressure opens and allows the well fluids to enter the sample chamber. When interior pressure together with the non-return valve spring pressure exceeds the exterior pressure the non-return valve closes and seals the sampler.

Method and Operation (refer Fig. 7; 7a; 7b and 7c - 7h, 7j)

Preparation:

With the sampler firmly clamped remove bottom cap (M) with the longer tommy-bar provided and close valve (L) with the spanner provided. Do not use excessive force. (See below for alternative gas sampling procedure). Apply grease** to thread and, with copper seal-ring (K) seated, screw bottom cap onto the lower thread of sample vessel (J) tightening firmly with the tommy-bar. The function of the copper seal ring (K) is to provide a back up seal in the event of valve (L) failure when the sample would otherwise be lost. Should valve (L) failure occur the bottom cap would contain fluid under pressure. A longitudinal groove cut across the lower thread of the sample vessel allows safe discharge of entrapped fluid when unscrewing the bottom cap.

* Manufactured by 'Prodelco' Engineering Ltd. Box 40433, Upper Hutt, New Zealand.
Marketed by 'Forgan Jones' Ltd., Box 9197, Newmarket, Auckland, New Zealand.

** Apply molybdenum disulphide grease liberally in all references to greasing.

Remove the non-return valve body (F) together with items (B) (remains of break-off tube from previous run), (C), (D), (E), (G) and (H). Disassemble valve assembly (F) and clean all parts. Examine spring (F2) and o-ring (F3) for deterioration; replace with new components where necessary. Install neoprene or 'Nitrile' o-rings for temperatures up to 230°C and 'Viton' for temperatures up to 300°C. Grease threads and the dynamic seal area of valve (F) and reassemble. Screw (F) into upper thread of sample vessel (J) and down onto copper seal ring (G). Tighten with the wrench provided against the firmly clamped assembly (J) (M). Continue tightening until index marks at lower (M) and upper (J) are within ± 4 mm of alignment. If indices advance beyond this limit replace seal ring (G). If indices fail to reach the limit continue tightening. Failure to observe this tolerance will result in misalignment of the break-off tube and striker axis. Examine and wash, where necessary, the stainless steel gauze filters (E). Replace in (F) with the coarse filter supporting the finer.

Examine, and replace if hardened, the o-ring (D) which, it should be noted, serves as a cushion for (B) and not as a seal.

Examine o-rings (C1) and (C2) located in gland nut (C) and renew where necessary (observing temperature rating as defined earlier). Clean and grease upper seat in (C) and locate o-ring by using tool provided through (C) to immediately below seat and then pressing o-ring into position with second part from above. Lightly grease exterior lower half of break-off tube (B) and gently press tapered end into and through upper seal of gland nut (C) until it protrudes approximately 5 mm below (C). Grease the lower 45° seat of (C) and locate o-ring around break-off tube. Grease thread of gland nut (C) and commence screwing into the upper thread of valve (F). Continue screwing, supporting bend of break-off tube with the fingers, whilst maintaining a slight downwards pressure, until the break-off tube is located between the wings of the support and the gland nut is firmly finger tight. Do not allow the break-off tube to ride up and out of the 45° seal of the gland nut during screwing, neither use any more force than finger pressure for final tightening. Finally ensure that the break-off tube is pressed firmly onto cushion (D). With experience the support may be discarded.

For gas sampling proceed as above with the following two exceptions:

(i) the bottom cap (M) is left unattached and

(ii) the valve (L) remains open.

With preparation of the main assembly complete, screw the nozzle provided into the side port of valve (L) and connect to vacuum source. When vessel is evacuated close valve (L) and remove nozzle and vacuum connections. Screw bottom cap onto greased lower thread of vessel (J).

Notes on preparation:

Although the foregoing preparations are carried out more easily where workshop facilities are available, no great difficulty should be encountered when implementing the same procedures in the field. With experience five to ten minutes is normally adequate

to ready the sampler for use. For ease of handling and transportation the sampler is best left as two units in the carrying case provided.

Sample Collection:

Check inertia mechanism (A) and ensure movement freedom by jerking vertically. Screw (A) onto greased thread of clamped vessel (J). Care must be taken not to damage break-off tube (B) at this stage. With the wrench provided tighten (A) down onto copper spacing ring (H) until index marks are within $\pm$ 4 mm of alignment. Discard and replace ring (H) if indices advance beyond stated tolerance. Shackle the assembled sampler to wireline and lower into well avoiding erratic movements and sudden changes of velocity which may prematurely activate the inertia mechanism. Lower vessel at a rate of approximately 70 m/min. Upon arrival at the sampling depth collection is achieved in the following manner.

Depths up to 750 m (refer Figs. 7c and 7d)

(i) With gloved hands 50 cm apart grasp wireline approximately 4 m from wireline winch.

(ii) Hand closest to well, palm uppermost.

(iii) Hand furthest from well moves downward and forward.

(iv) Hand closest from well moves upward and rearward.

(v) Halt movement when hands are one above the other and 50 cms apart.

(vi) Quickly return hands to starting position retaining loose grip on wireline.

(vii) Repeat five times.

Depths from 750 - 1050 m (refer Figs. 7e and 7f)

(i) With gloved hands 50 cms apart grasp wireline approximately 1.5 m from wellhead.

(ii) Pull wireline down to waist height.

(iii) In one quick action depress wireline to knee height, inclining towards well-head, and return to starting position.

(iv) Repeat five times.

Depths below 1050 m (refer Figs. 7g and 7h).

(i) With gloved hands fully extended above head and 30 cms apart grasp wireline approximately 1.5 m from wellhead whilst facing towards wireline winch.

(ii) In one quick action pull wireline down to shoulder height and return to starting position.

(iii) Repeat five times.

Allow sampler to remain at sampling station for five minutes and then retrieve. Ascent rates should not exceed 100 m/min. When the sampler is recovered hot it should be cooled to prevent the sample from vapourizing when released to atmosphere. When cooled (to less than 30°C), clamp sampler horizontally and remove cap (M) and inertia mechanism (A). Tilt vessel (J) with valve (L) uppermost and vent any residual internal pressure through valve (L). Close valve (L) and loosen valve (F). Stand vessel vertically, Valve (F) uppermost and remove valve (F). Cap top of vessel (J) with suitable container - (e.g. 1000 ml measuring cylinder) and invert both together. Open valve (L) to release sample into cylinder.

Notes on operation

Sample volumes may vary from well to well and from different depths in individual wells due to the variations in temperatures and pressures at the sampling stations. At certain depths in some wells the hot water vapour plus gas pressure may be equal, or close, to the hydrostatic pressure. When the sampler is operated under such conditions only small quantities of fluid are collected due to the water boiling upon entering the relatively low pressure interior of the sample vessel, most of which volume the resulting vapour will occupy. Apart from vapour resulting from boiling, air previously present in the vessel together with the pressure exerted by the non-return valve spring, will prevent a liquid phase from filling the sample vessel to capacity.

Before downhole sampling is undertaken, the temperature and pressure characteristics of the well should be consulted together with Table 1 so that sampling is not undertaken where boiling may occur and to ensure a successful programme. Similarly, a sounding run to determine the clear depth of the well and to locate obstructions such as liner hangers, casing fractures, etc. should be carried out before committing the sampler to the possibility of unknown downhole hazards.

Locations of deep sampling interest include: permeable zones, zones of drilling fluid loss and areas of cold water intrusion.

Summary of Operating Instructions (refer Figs. 7; 7a; 7b and 7c-h; 7j

1. Remove bottom cap (M).
2. Close valve (L).
3. Replace bottom cap (M).
4. Remove valve (F).
5. Check valve (F) - components (F1, (F2), (F3) and (F4).
6. Reassemble valve (F).
7. Relocate valve (F).
8. Check index alignment (F), (J).

9. Check filters (E).
10. Relocate filters (E).
11. Check o-ring (D).
12. Relocate o-ring (D).
13. Check gland nut (C) seats.
14. Check o-rings (C1 and C2).
15. Relocate o-ring (C1).
16. Insert break-off tube (B) in (C).
17. Relocate o-ring (C2).
18. Install (B) and (C) in valve (F).
19. Attach inertia mechanism (A) to sample vessel assembly.
20. Shackle assembled sampler to wireline.
21. Run sampler into well to required depth.
22. Activate sampler by jerking wireline.
23. Retrieve sampler after five minutes.
24. Cool sampler where necessary.
25. Clamp sampler horizontally.
26. Remove bottom cap (M).
27. Remove inertia mechanism (A).
28. Tilt sample vessel, valve (L) uppermost.
29. Vent residual pressure through valve (L).
30. Close valve (L).
31. Loosen valve (F).
32. Stand sample vessel vertically, valve (F) uppermost; remove valve (F).
33. Cap top of sample vessel with 1000 ml measuring cylinder.
34. Invert sample vessel and cylinder together.
35. Open valve (L).

--

Maintenance (refer Figs. 7 and 7a).

General

When dismantling the sampler wash components in grease solvent paying special attention to threads and seal seats which should also be scoured with a stiff bristle or non-ferrous brush. The sample vessel (J) should be additionally flushed with distilled water injected through the evacuation nozzle with the valve (F) assembly removed. Dry all parts requiring lubrication with tissues or a soft cloth. NB: Unless all stainless steel threads are kept scrupulously clean, frequently and liberally greased, there could be a risk of thread seizure.

With the exception of the inertia mechanism much maintenance is inherent in the preparation procedure. Frequency of component inspection will depend largely upon the rigours of downhole exposure, nevertheless a thorough overhaul after every six downhole trips would be advisable, or monthly if the sampler is used less frequently.

It should be noted that, with the exception of screw threads, the inertia mechanism (A) operates without lubrication.

The foregoing, together with the following detailed instructions, should be incorporated into a schedule of regular maintenance consistent with local usage and downhole environment.

Specific

1. Sample release valve (L): Little attention required, packing nut should be snug without excessive tightness, check occasionally.

2. Copper seal ring (K): Check and anneal or renew if necessary after every third downhole trip. NB: Remove with edge, not tip, of thin blade.

3. Copper spacing ring (H): Discard and replace with new ring when alignment of (R) (J) indices advance beyond $\pm$ 4 mm tolerance. Check before each downhole trip.

4. Copper seal ring (G): Discard and replace with new ring when alignment of (J) (F) indices advance beyond $\pm$ 4 mm tolerance. Check before each downhole trip.

5. Non-return valve (F): (i) Check spring (F2) for corrosion and relaxation. Spring rate should lie between 1.5 and 3N/mm; free length should be approximately 15 mm. Restretching may restore spring for further use. Replace with new spring where necessary. Check after every downhole trip. (ii) Check for and remove any scale deposition from piston (F1) after every six downhole trips. Note that sealing is obtained from both the o-ring (F3) and the conical valve face (where a metal to metal seal with (F) is achieved. (iii) Check 0086-24 o-ring* (F3) and replace with new ring at least sign of deterioration, i.e. hardening, deformation, etc. Check before each downhole trip.

6. Stainless steel gauze filters (E): check and clean, where necessary.

7. Cushion 0051-16 o-ring (D): Check for hardening only. Replace with new ring when resilience has faded and/or after every sixth downhole trip.

8. Gland nut (C): Clean, with special attention to the upper o-ring seat and the lower 45° o-ring seat, whenever o-rings are replaced and/or every sixth downhole trip. Check 011-BS o-rings (C1) and C2)* for deterioration, hardening, etc., after every downhole trip and replace with new rings where necessary.

9. Inertia mechanism (A): Check prior to each downhole trip the tightness of the eight exterior screws. Check for freedom of mechanism movement before each downhole trip by jerking vertically. After every sixth downhole trip remove the eight exterior screws and withdraw inner assembly. Remove and check spring (A2) for corrosion and relaxation, replacing with new spring where necessary. To install new springs: remove tether bolt (A4): remove top block (A1) together with suspension hook (A5) and remove top block (A1) together with suspension hook (A5) and old spring. Drop new spring into top cavity of weight (A3) and secure with tether bolt (A4) through lower spring loop. Engage upper spring loop with a hooked wire and withdraw onto suspension hook (A5). Relocate block (A1) together with hook (A5) and secure. Although the mechanism is designed to be unresponsive to movement other than intentional activation damping adjustment is provided by the setting of the suspension hook (A5) which may be locked at any point along its thread shank.

Fault Finding (refer Figs. 7 and 7a)

No Sample

(i) Check that break-off tube (B) is broken; if not, inspect (A) (J) and (F) (J) index alignments and inertia mechanism freedom.

(ii) Check seals (K), (L), (G) and (F3).

(iii) Check filters (E).

(iv) Check spring (F2).

(v) Check that sampling station is below water level in well.

(vi) Check that valve (L) is open to release otherwise air-locked sample according to instruction No. 35, p. .

* For temperatures up to 230°C use neoprene or 'Nitrile' o-rings; for temperatures up to 300°C 'Viton' o-rings. Although these temperatures exceed the manufacturer's ratings the relatively short exposure time permits satisfactory performance for at least one sampling run.

Small Sample

(i) Check seals (K), (L), (G) and (F3).

(ii) Check filters (E).

(iii) Check that at sampling depth water plus gas vapour pressure/hydrostatic pressure is favourable to sampling as discussed under "Notes on Operation".

Contaminated Sample

(i) Check seals (K), (L), (G) and (F3).

(ii) Check that premature striking is not occurring due to downhole turbulence, downhole obstruction, rough handling or erratic descent velocity.

(iii) If sampler is subjected to prolonged downhole exposure at significantly lower temperatures than that at which sampling took place subsequent lowering of internal pressure relative to external hydrostatic pressure may result in the opening of valve (F). It is unlikely that this situation will be encountered under most operation conditions and times of exposure. The exceptional conditions under which this will arise require a substantial negative temperature inversion together with sufficient hydrostatic head to overcome both the return spring (F2) pressure and whatever internal pressure remains in the sample vessel. Even so, at the ascent rates recommended, the sampler should retain sufficient heat to prevent internal pressure collapse whilst passing through any zone of anomalous low temperature.

Field Check List

Item	Quantity
Fully made up sample vessel, comprising (B), (C), (D), (E), (F), (G), (H), (J), (K), (L), (M).	1
Fully made up inertia mechanism (A)	1
Spare inertia mechanism spring (A2)	1
Spare non-return valve spring (F2)	1
Spare break-off tubes (C)	Dictated by programme
Spare filters (E)	1 pr
Spare 'Neoprene', 'Nitrile' or 'Viton' 011-BS o-rings (C1) and (C2)	Dictated by programme
Spare 'Neoprene', 'Nitrile' or 'Viton' 0051-16 o-rings (D)	Dictated by programme

Specimen Field Notes

Well No. Date

Depth of Sample: Sample Volume

Ancillary Equipment (refer Fig. 7b)

1. Wireline winch fitted with hydraulic descent control (essential) and depthometer, preferably, motorized, as supplied by the Kuster Co., Box 7038, Long Beach, California, 90807, U.S.A.

2. Single strand stainless steel wireline of 400 kg breaking strain to reach desired sampling depths (include wastage) also available from the Kuster organisation, together with shackles, thimbles, etc.

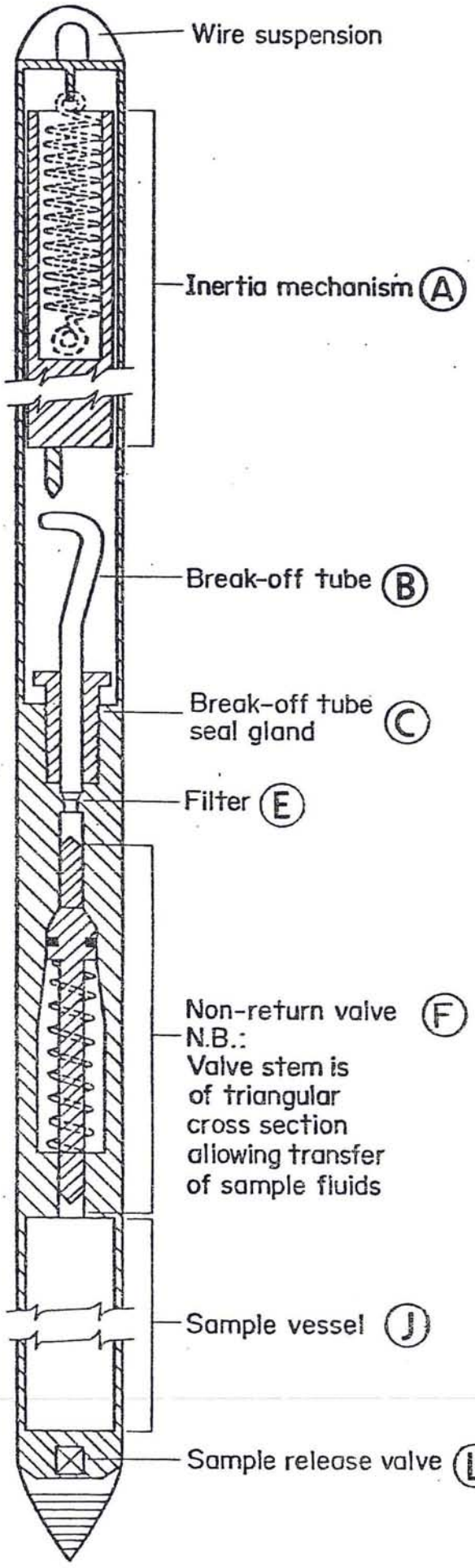
3. A suitably mounted flanged wheel to convey the wireline from the winch into well.

4. An instrument recovery spool fitted with pressure exhaust valve and wireline sealing gland are necessary for wells exhibiting wellhead pressure.

Part No. List (refer Fig. 7i)

Part No.	Qty.	Description
1	1	Inertial Mechanism casing
2	1	Sample chamber
3	1	Bottom cap
4	1	Top support plate
5	2	Guide rod nut
6	2	Guide rod
7	1	Upper compression spring
8	1	Upper compression spring support
9	2	Spring support hook nut
10	1	Support hook
11	1	Spring support screw
12	1	Tension spring
13	2	Grub screw, striker rod
14	1	Inertia weight
15	1	Lower compression spring
16	1	Weight guide
17	1	Bottom support plate
18	1	Striker Arm
19	8	Inertial mechanism retaining screws
20	1	'o' ring valve 'Viton'
21	1	Compression spring non return valve
22	1	Non return valve piston
23	1	Break-off tube
24	2	Copper seal ring
25	1	'O' ring upper seal
26	1	Gland nut
27	2	Raised csk slotted head screw
28	1	'O' ring lower
29	1	Break-off tube support
30	1	'O' ring cushion
31	1	Wire gauze filter
32	1	Wire gauze filter support
33	1	Valve body
34	1	Copper seal ring
35	1	Sample removal nozzle
36	1	Needle valve body
37	1	Copper washer

Part No.	Qty.	Description
38	1	Teflon packing
39	1	Gland, brass
40	1	Valve stem
42	1	Valve key
43	1	Bar for removal bottom cap
44	1	Spanner casing body 'Rigid'
45	2	Casing clamp
46	1	Carrying case
47	1	Pyrex tube profile board
48	1	'O' ring insertion tool



Klyen sub-surface sampler, Mk I

Fig 7

Klyen Sub-surface Sampler, MkI.

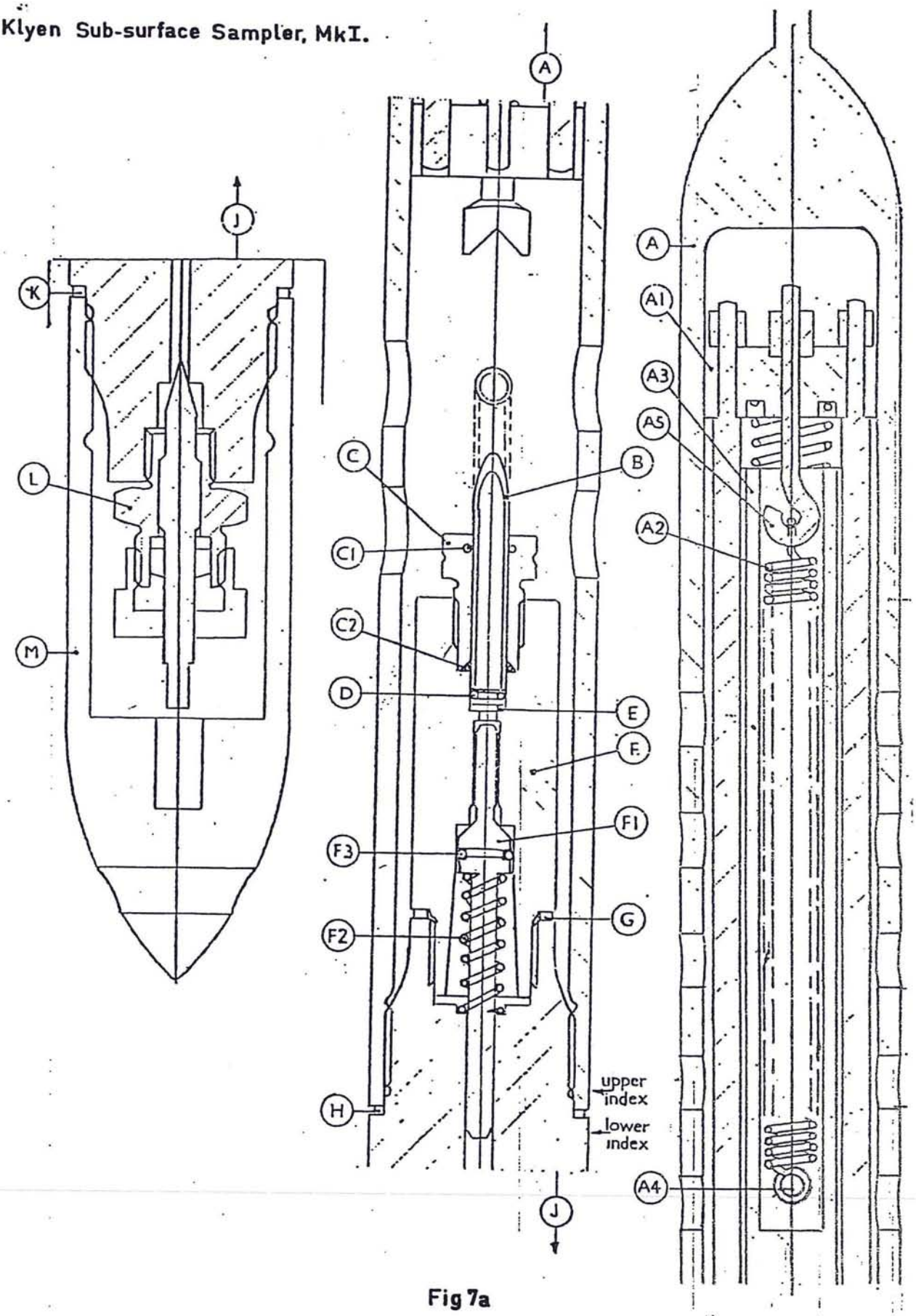
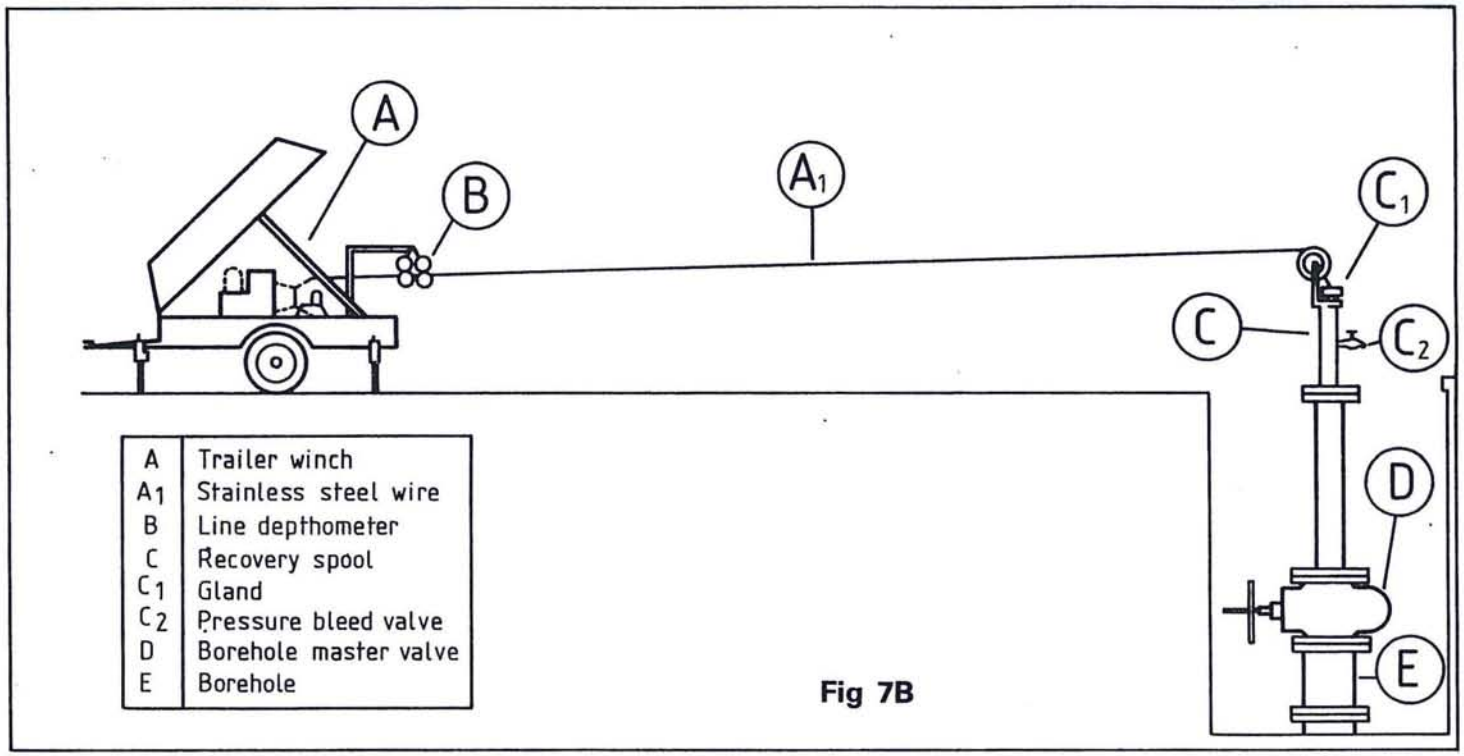


Fig 7a



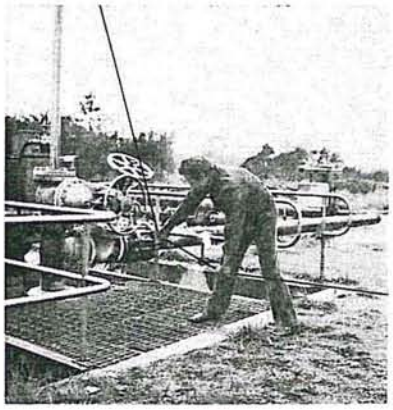
A	Trailer winch
A_1	Stainless steel wire
B	Line depthometer
C	Recovery spool
C_1	Gland
C_2	Pressure bleed valve
D	Borehole master valve
E	Borehole

Fig 7B

7c

7d

7e



7f

7g

7h

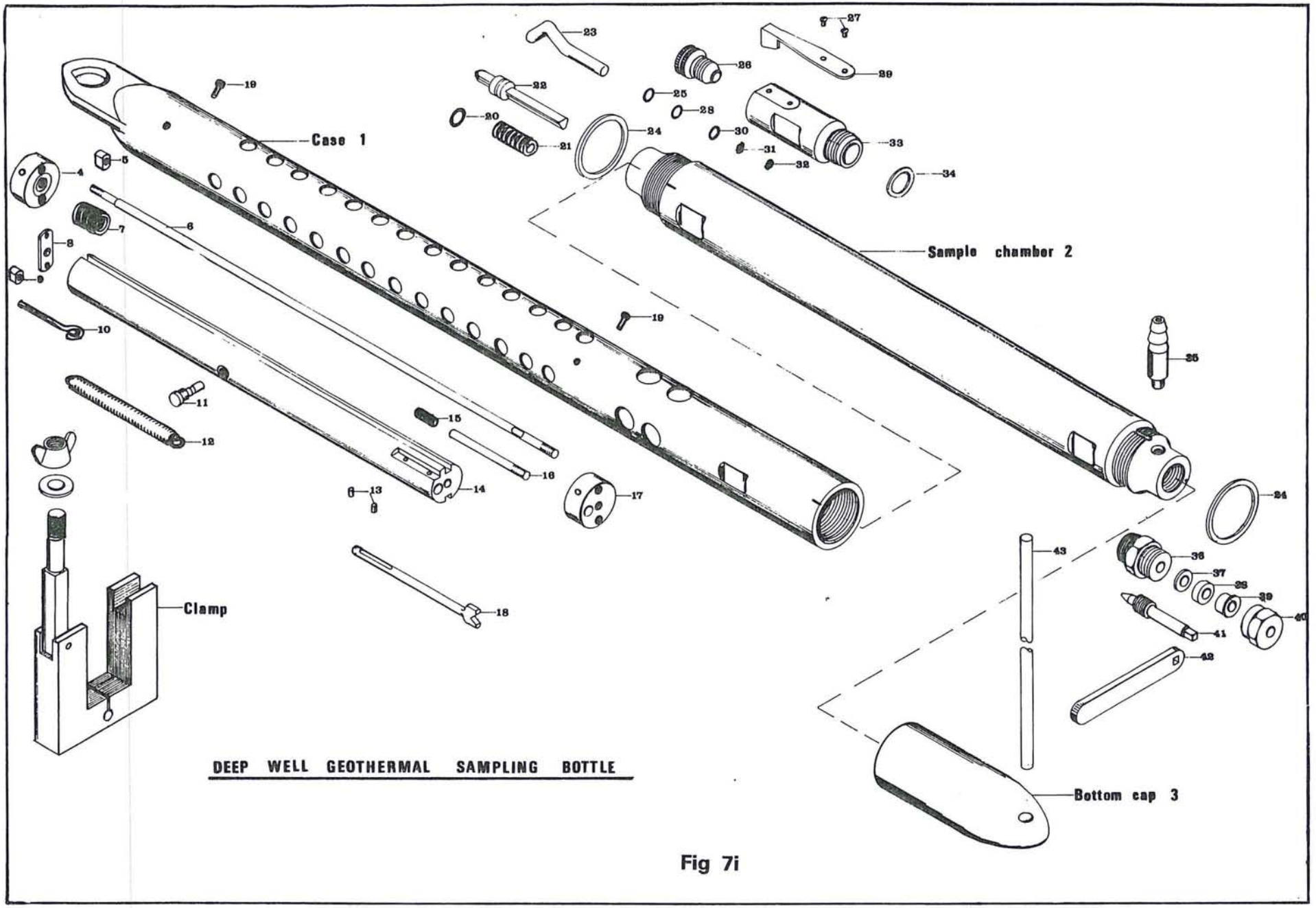

Case 1
Sample chamber 2
Clamp
Bottom cap 3
DEEP WELL GEOTHERMAL SAMPLING BOTTLE

Fig 7i

Method of wire-line attachment.

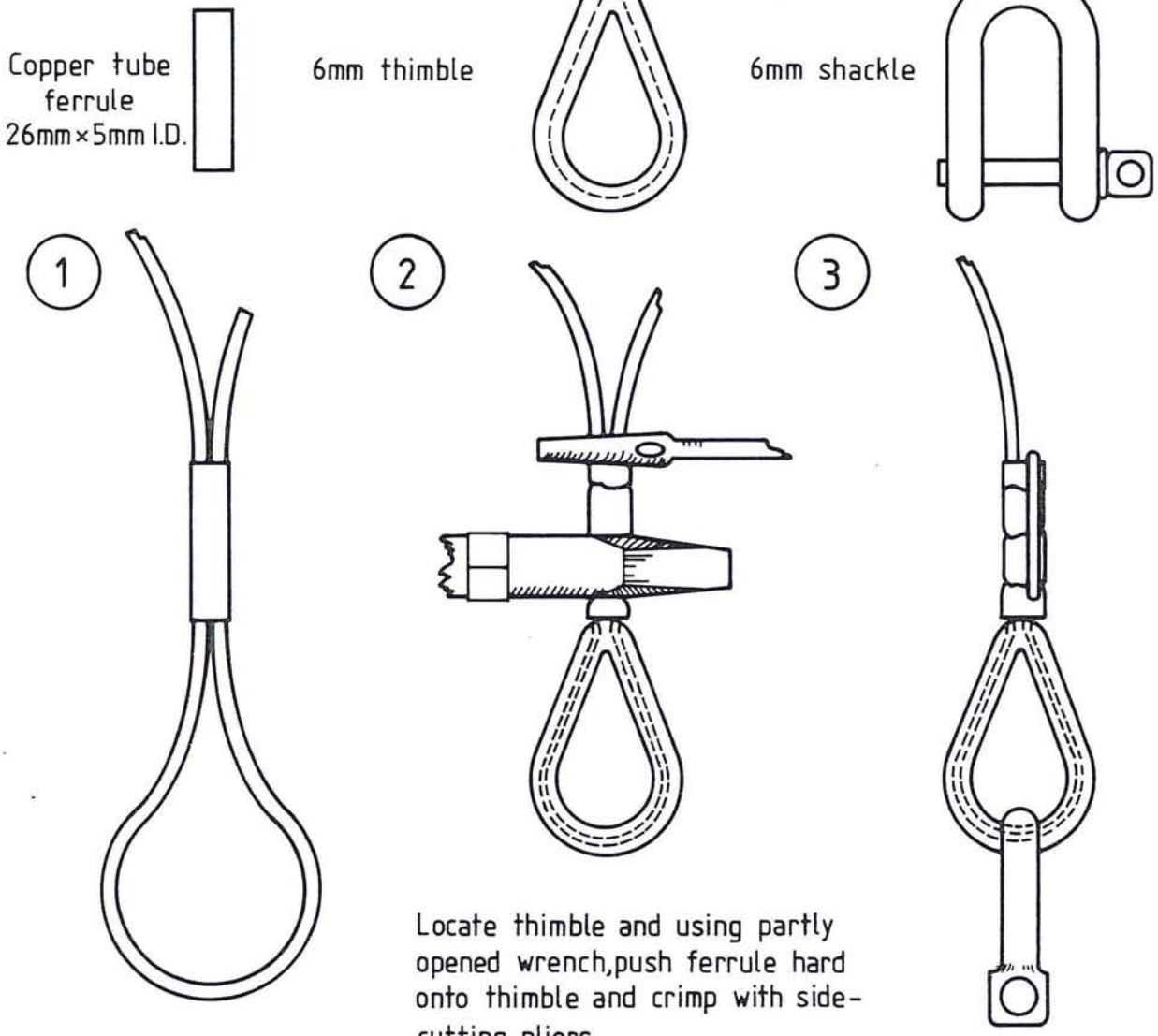


Fig 7j

KLYEN SUB-SURFACE SAMPLER MK II*

NZ PATENT 173058

US PATENT 3986553

Function

To collect sub-surface fluids.

Use

For the collection of water and gas samples at selected depths in wells at temperature up to 350°C and pressures up to 22400 k/Pa.

Description (refer Figs. 8 and 8a)

A sample vessel (C) is fitted at the lower end with a sample release valve (D) and an inward flow non-return valve (B) at the upper end. A mild steel shim puncture-seal (B2) is located above, and in series with the non-return valve. A spring suspended weight fitted at its lower end with a shim-seal spear, comprising the inertia mechanism (A), is mounted directly above the shim-seal.

Method and Operation (refer Fig. 8; 81; 8b; 8c-8h and 8j)

Preparation:

With the sampler firmly clamped remove nose cap (E) with the tommy-bar provided and close valve (D) with the dwang provided. Do not use excessive force. (See below for alternative gas sampling procedure). Apply grease** to threads and, with copper seal-ring (E1) seated, screw nose cap onto the lower thread of sample vessel (C) tightening firmly with the tommy-bar.

NOTE: The function of the copper seal ring (E1) is to provide a back up seal in the event of valve (D) failure when the sample would otherwise be lost. Should valve (D) failure occur the nose cap could contain fluid under pressure. A longitudinal groove cut across the lower thread of the sample vessel allows for the safe discharge of entrapped fluid when unscrewing the nose cap.

Remove next the non-return valve assembly (B). Disassemble and clean parts (B1), (B3), (B4), (B5) and B6) discard (B2). Examine spring (B6) for deterioration and replace where necessary. Examine lapped conical seal of (B5) and refurbish where required. Assemble items (B3), (B5), (B6) and grease lower threads of (B3). Locate copper seal-ring (B4) and screw valve assembly into upper thread of sample vessel (C). Tighten with the wrench provided against the firmly clamped assembly (C). Apply a light smear of

* Manufactured by 'Prodelco' Eng. Ltd., Box 40433, Upper Hutt, N.Z.
Marketed by 'Forgan Jones' Ltd., Box 9197, Newmarket, Auckland N.Z.

** Apply molybdenum Di-sulphide grease liberally in all references

grease to the seal face of (B3) and carefully locate shim seal (B2). Grease upper thread of (B3) and screw on shim compression cap (B1) using the wrench provided.

For gas sampling proceed as above with the following two exceptions:

(i) the nose cap (E) is left unattached and,

(ii) the valve (D) remains open.

With preparation of the main assembly complete screw the nozzle (G) provided into the side port of vessel (C) and connect to vacuum source. When vessel is evacuated close valve (D) and remove nozzle. Screw nose cap (E) together with ring (E1) onto the greased lower thread of vessel (C).

Although the foregoing preparations are more easily carried out where workshop facilities are available, no great difficulty should be encountered when carrying out the same procedures in the field. With experience five to ten minutes is normally adequate to ready the sampler for use. For ease of handling and transportation the sampler is best left as two units in the carrying case provided.

Sample Collection:

Check inertia mechanism (A) and ensure movement freedom by jerking vertically. Screw (A) onto greased upper male thread of clamped vessel (C). With the wrench provided tighten (A) down onto copper cushion-ring (C1). Do not use excessive force. Shackle the assembled sampler to wire and lower into well avoiding erratic changes of descent velocity. Lower vessel at a rate of approximately 70 m/min. Upon arrival at sampling depth collection is achieved in the following manner:

Depths up to 750 m (refer Figs. 8c and 8d)

(i) With gloved hands 50 cms apart grasp wireline approximately 4 m from wireline winch.

(ii) Hand closest to well, palm uppermost,

(iii) Hand furthest from well, palm downwards,

(iv) Hand furthest from well moves downward and forward,

(v) Hand closest from well moves upward and rearward,

(vi) Halt movement when hands are one above the other and 50 cms apart,

(vii) Quickly return hands to starting position retaining loose grip on wireline.

(viii) Repeat five times.

Depths from 750 - 1050 m (refer Figs. 8e and 8f)

(i) With gloved hands 50 cms apart grasp wireline approximately 1.5 m from wellhead.

(ii) Pull wireline down to waist height.

(iii) In one quick action depress wireline to knee height inclining towards wellhead, and return to starting position.

(iv) Repeat five times.

Depths below 1050 m (refer Figs. 8g & 8h)

(i) With gloved hands fully extended above head and 30 cms apart grasp wireline approximately 1.5 m from wellhead whilst facing towards wireline winch.

(ii) In one quick action pull wireline down to shoulder height and return to starting position.

(iii) Repeat five times.

Allow sampler to remain at sampling station for a minimum time of five minutes and then retrieve. Ascent rates should not exceed 100 m/minute. When the sampler is recovered hot it should be immediately cooled to prevent the sample from vapourising when released to atmosphere. When cooled (to less than 30°C), clamp sampler horizontally and remove nose cap (E) and inertia mechanism (A). Tilt vessel (C) with valve (D) uppermost and vent any residual pressure through valve (D). Close valve (D) and loosen valve (B). Stand vessel vertically, valve (B) uppermost, and remove valve (B). Cap top of vessel (C) with suitable container (e.g. 1000 ml measuring cylinder) and invert both together. Open valve (D) to release sample into measuring cylinder.

Sample volumes may vary from well to well, and from different depths within individual wells, due to the variations in temperature and pressure existing between the sampling stations. At certain depths in some wells the hot water vapour plus gas pressure may be equal, or close, to the hydrostatic pressure. If the sampler is operated under such conditions only small quantities of liquid will be collected. This results from the boiling of the sample upon entering the relatively low pressure interior of the sample vessel and thereby filling most of its volume with vapour. Air previously present in the sample vessel together with the pressure exerted by the non-return valve spring also will prevent a liquid phase from filling completely the vessel.

Before downhole sampling is undertaken the temperature and pressure characteristics of the well should be consulted so that sampling is not undertaken where boiling may occur and to ensure an advantageous programme. Similarly a sounding run to measure the clear depths of a well and to locate obstructions

such as liner hangers, casing fractures etc., should be carried out before committing the sampler to any unknown downhole hazard. Locations of deep sampling interest include: permeable zones, zones of drilling fluid loss and areas of cold water intrusion.

SUMMARY OF OPERATING INSTRUCTIONS

(refer Figs. 8; 8a; 8b; 8c-8h and 8j)

1. Remove nose cap (E).
2. Close valve (D).
3. Replace nose cap (E).
4. Remove valve assembly (B).
5. Check parts (B1), (B3), (B4), (B5) and (B6).
6. Reassemble parts (B3), (B4), (B5) and (B6).
7. Mount on vessel (C) parts (B3), (B4) and (B6).
8. Lightly grease seal face of (B3).
9. Locate shim seal (B2).
10. Screw on compression cap (B1).
11. Attach inertia mechanism (A).
12. Shackle assembled sampler to wireline.
13. Run sampler into well to required depth.
14. Activate inertia mechanism by jerking wireline.
15. Retrieve sampler after five minutes.
16. Cool sampler where necessary.
17. Clamp sampler horizontally.
18. Remove nose cap (E).
19. Remove inertia mechanism (A).
20. Tilt vessel, valve (D), uppermost.
21. Vent residual pressure through valve (D).
22. Close valve (D).
23. Loosen valve (B).
24. Stand vessel (C) vertically, valve (B) uppermost.
25. Remove valve (B).
26. Cap top of vessel (C) with 1000 ml measuring cylinder.
27. Invert vessel (C) and measuring cylinder together.
28. Open valve (D).
29. Receive sample in cylinder.

Maintenance (refer Figs. 8 and 8a)

General:

When dismantling the sampler wash components in grease solvent paying special attention to threads and seal seats. These should also be scoured with a stiff bristle or non-ferrous brush. The sample vessel (C) should be flushed with distilled water injected through the evacuation nozzle with the valve (B) assembly removed. Dry all parts requiring lubrication with tissues or a soft cloth.

NB: Unless the stainless steel threads are kept scrupulously clean, frequently and liberally greased, there is every likelihood of thread seizure.

With the exception of the inertia mechanism (A) much maintenance is inherent in the normal preparation procedure. Frequency of component inspection will depend largely upon the rigours of downhole exposure; nevertheless, a thorough overhaul after every six trips would be advisable, or monthly if the sampler is used less often.

It should be noted that, with the exception of the screw threads, the inertia mechanism (A) operates without lubrication.

The foregoing, together with the following detailed instructions, should be incorporated into a schedule of regular maintenance consistent with local usage and downhole environment.

Specific:

1. Sample release valve (D): Little attention required; check packing nut (D5) occasionally.

2. Copper seal ring (E1): Check and anneal, or renew, if necessary after every sixth downhole trip.

3. Copper cushion ring (C1): Little attention required, check occasionally that stainless steel mating threads of (A) and (C) do not bottom due to ring wear.

4. Copper seal ring (B4): Check and anneal, or renew if necessary after every sixth downhole trip.

5. (i) Non-return valve (B): Check spring (B6) for deterioration and relaxation. Unstressed length of spring should be 35 mm. Re-stretching may restore spring for further use. Replace with new spring where necessary. Check after each downhole trip.

   (ii) Check for and remove any scale deposition from conical seal face of piston with a non-ferrous brush (B5): Check with lens for pitting or other deterioration of lapped conical seal face of piston (B5). Refurbish with fine grade grinding paste, five or six strokes are normally sufficient to restore full sealing area. check after every sixth downhole trip.

6. Shim seal lower seat of (B3). Wipe clean and remove any scale deposition with a non-ferrous brush. Check after every sixth downhole trip.

7. Shim seal upper seat of (B1) as for 6 above.

8. (i) Inertia mechanism (A). Check prior to each downhole trip the tightness of the eight exterior screws. Check freedom of mechanism movement before each downhole trip by jerking vertically.

   (ii) After every sixth downhole trip release mechanism by first screwing IN the securing allen screw (A4) and then unscrewing the suspension cap (A2) before withdrawal together with mechanism. Check for any entrapped well debris. Check for spring (A12) deterioration and/or relaxation; replace where necessary. Similar for spring (A6).

   (iii) Although the mechanism is designed to be unresponsive to movement other than intentional activation further damping adjustment is provided by the setting of the inertia adjustment nut (A5).

Fault Check List (refer Fig. 8 and 8a)

No Sample:

   (i) Check that shim seal (B2) is punctured; if not inspect inertia mechanism freedom.

   (ii) Check seals (B1), (B3) and (B5).

   (iii) Check spring (B6).

   (iv) Check that sampling station is below water level in well.

   (v) Check that valve (D) is open to release otherwise airlocked sample according to instruction No. 18, p. .

Small Sample:

   (i) Check seals (B1), (B3) and (B5).

   (ii) Check that sampler was not prematurely activated in steam/gas column.

   (iii) Check that at sampling depth water plus gas vapour pressure/hydrostatic pressure is favourable to sampling as discussed on p. 58.

Contaminated Sample:

   (i) Check seals (B1), (B3) and (B5).

   (ii) Check that premature activation is not occurring due to downhole turbulence, downhole obstruction, rough handling or erratic descent velocity.

(iii) If sampler is subjected to prolonged downhole exposure at significantly lower temperatures than those at which sampling took place subsequent lowering of internal pressure, relative to external hydrostatic pressure, may result in the opening of valve (B). It is unlikely that this situation will be encountered under most operating conditions and times of exposure. The exceptional conditions under which this will arise require a substantial negative temperature inversion together with sufficient hydrostatic head to overcome both the return spring (B6) pressure and whatever internal pressure remains in the sample vessel. Even so, at the ascent rates recommended, the sampler should retain sufficient heat to prevent internal pressure collapse whilst passing through any zone of anomalous low temperature.

Field Check List

Item	Qty
Fully made up Sample Vessel	1
Fully made up Inertia Mech.	1
Spare Inertia Mechanism Spring (A6)	1
Spare Inertia Mechanism Spring (A12)	1
Spare non-return Valve Spring (B6)	1
Spare Shim Seals (B2)	Dictated by programme
Spare Copper Ring (B4)	2
Spare Copper Ring (A1)	1
Spare Copper Ring (C1)	1
Spare Copper Ring (E1)	1
Tools	As provided
Molybdenum Di-sulphide grease	Dictated by programme
6 mm Shackles	2
6 mm Thimbles	2
26 mm x 5 mm ID copper furrules	10
Sample Containers	Dictated by programme
1000 ml Plastic Measuring Cylinder	1
Borehole Data	Dictated by programme
Field Book	Dictated by programme
Instruction Manual	1

Ancillary Equipment (refer Fig. 8b)

1. Motorized wireline winch, fitted with hydraulic descent control and depthometer, e.g. as supplied by the Kuster Co., Box 7038, Long Beach, California, 90807, U.S.A.

2. Single strand stainless-steel wireline of 400 kg breaking strain to reach desired sampling depths (include wastage) supplied by the Kuster organisation, together with shackles, Thimbles etc.

3. A suitably mounted flanged wheel to convey the wireline from the winch into well.

4. An instrument recovery spool fitted with pressure exhaust valve and wireline sealing gland are necessary for wells exhibiting wellhead pressure.

Part No. List (refer Fig. 8i)

Inertia Mechanism assembly	A
Copper ring	A1 (C1/E1)
Suspension cap	A2
Casing	A3
Securing screw	A4
Adjustment nut	A5
Buffer spring	A6
Guide rod nut	A7
Guide rod nut washer	A8
Weight	A9
Piercing spike washer	A10
Piercing spike	A11
Compression spring	A12
Support rod	A13
Guide nut	A14
Non-return Valve Assembly	B
Shim compression cap	B1
Shim seal	B2
Valve body	B3
Seal ring	B4
Piston	B5
Spring	B6
Sample Vessel Assembly	C
Copper ring	C1 (A1/E1)

Sample Release Valve Assembly	D
Valve body	D1
Seal ring	D2
Packing	D3
Gland	D4
Packing nut	D5
Valve stem	D6
Nose Cap Assembly	E
Copper ring	E1 (Al/Cl)
Casing Clamp	F
Nozzle	G
Tommy Bar	H
Dwang	I
Allen Key	J
Casing Wrench	K
Adjustable Spanner 225 mm	L
Side Cutting Pliers 225 mm	M
Molybdenum Di-sulphide Grease Tube	N
Shackles	O
Thimbles	P
Copper Ferrules	Q
Grinding paste	R

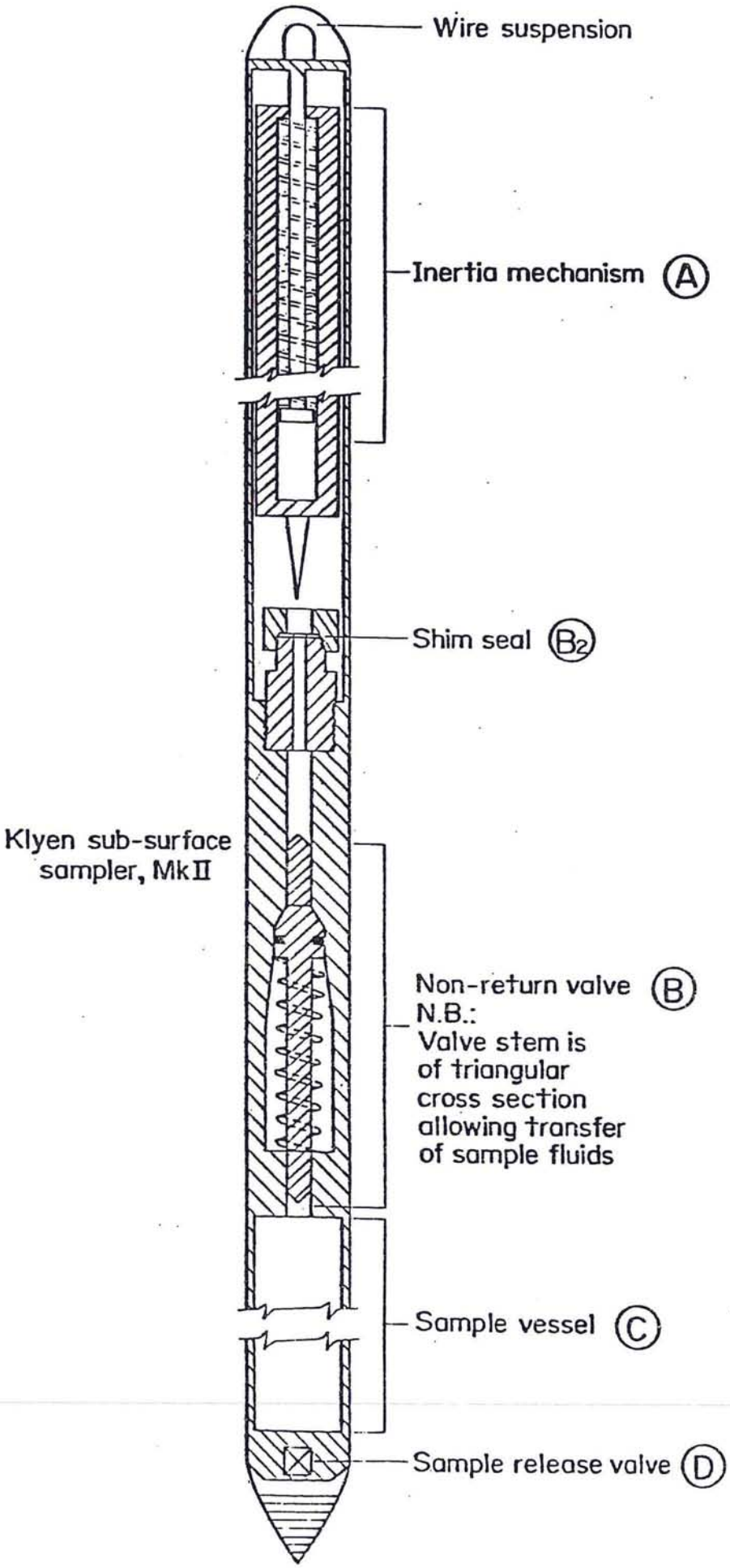

Wire suspension
Inertia mechanism (A)
Shim seal (B2)
Klyen sub-surface sampler, Mk II
Non-return valve (B)
N.B.:
Valve stem is of triangular cross section allowing transfer of sample fluids
Sample vessel (C)
Sample release valve (D)

Fig 8

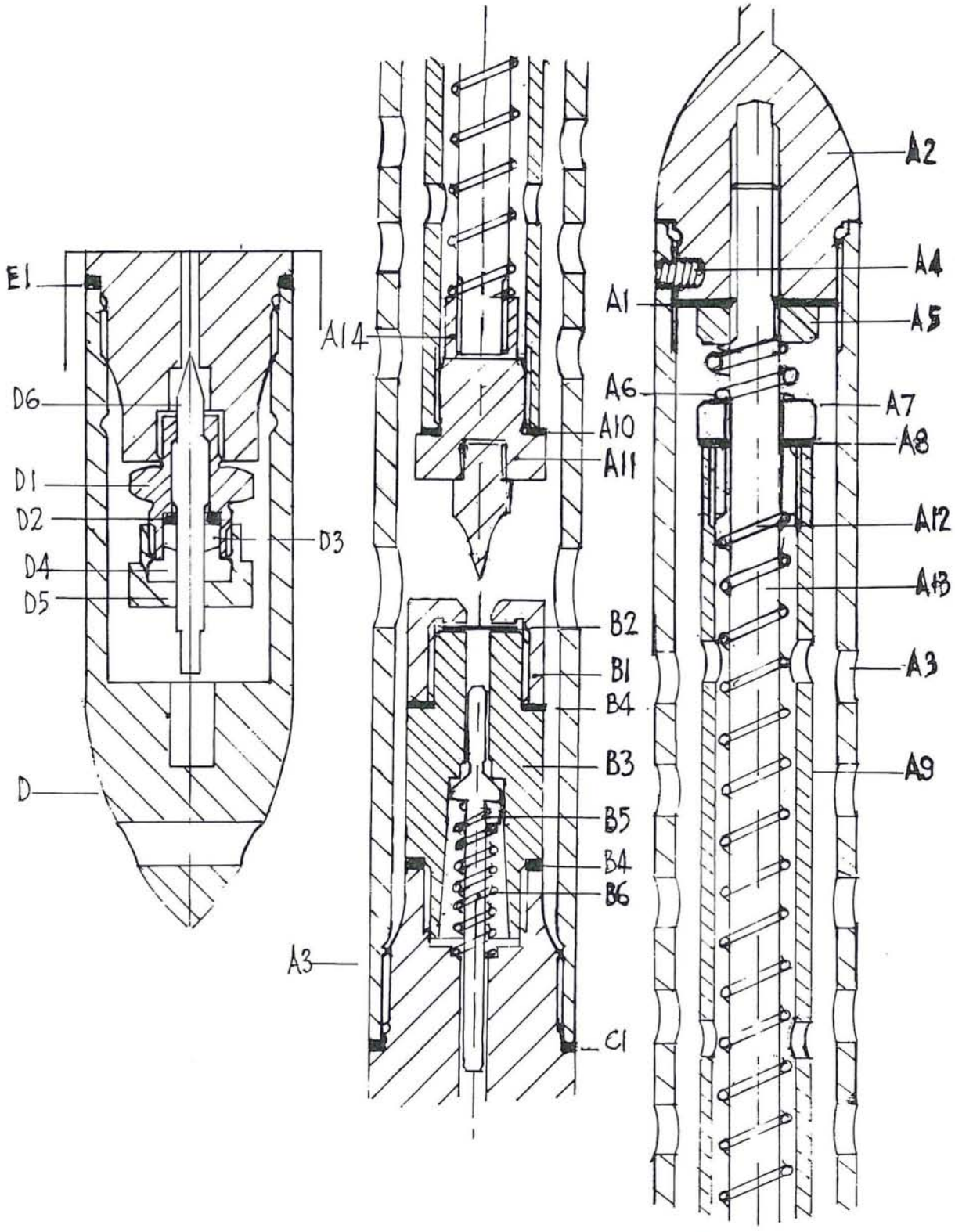
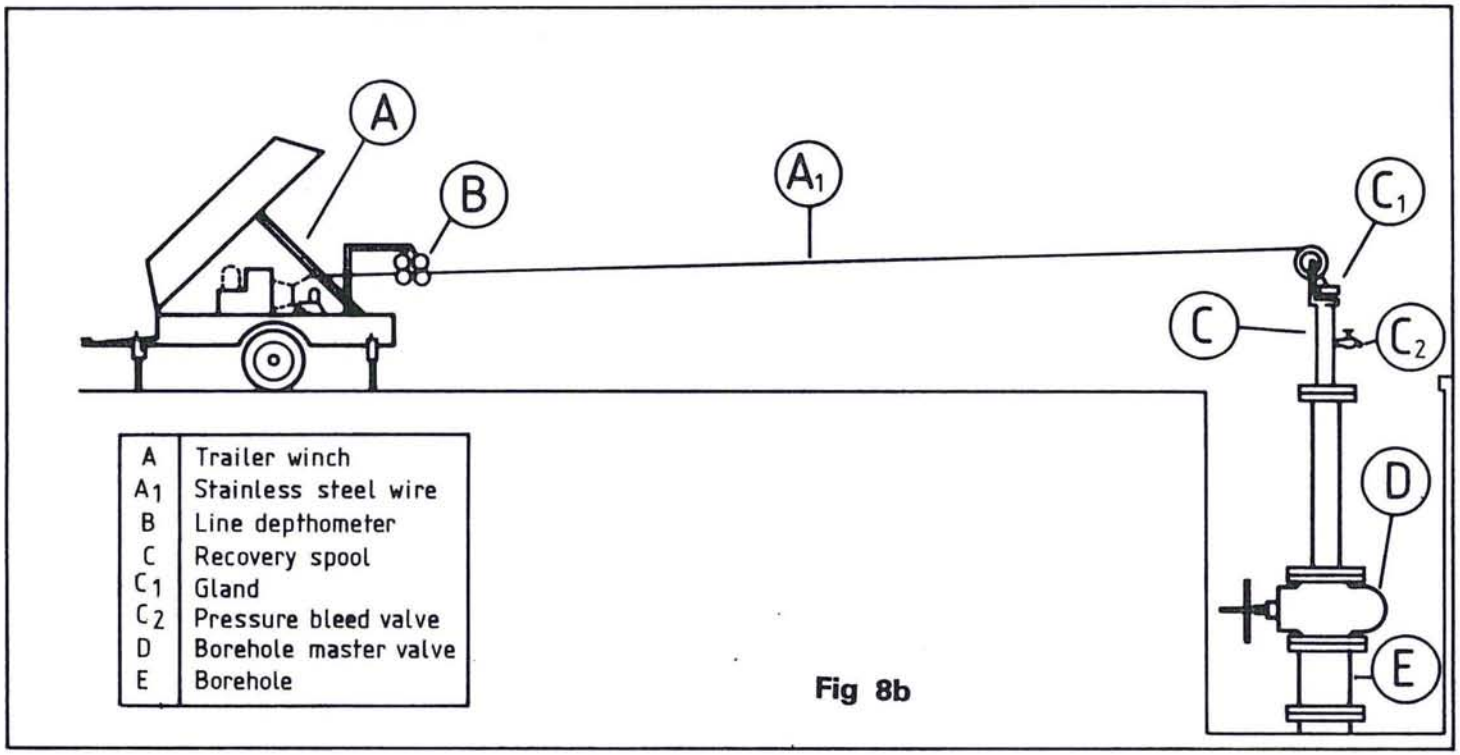

E1
A14
D6
D1
D2
D4
D5
D3
D
A3
B2
B1
B4
B3
B5
B4
B6
C1
A2
A4
A1
A5
A6
A7
A10
A8
A11
A12
A13
A3
A9

Fig 8a



A	Trailer winch
A_1	Stainless steel wire
B	Line depthometer
C	Recovery spool
C_1	Gland
C_2	Pressure bleed valve
D	Borehole master valve
E	Borehole

Fig 8b

8c

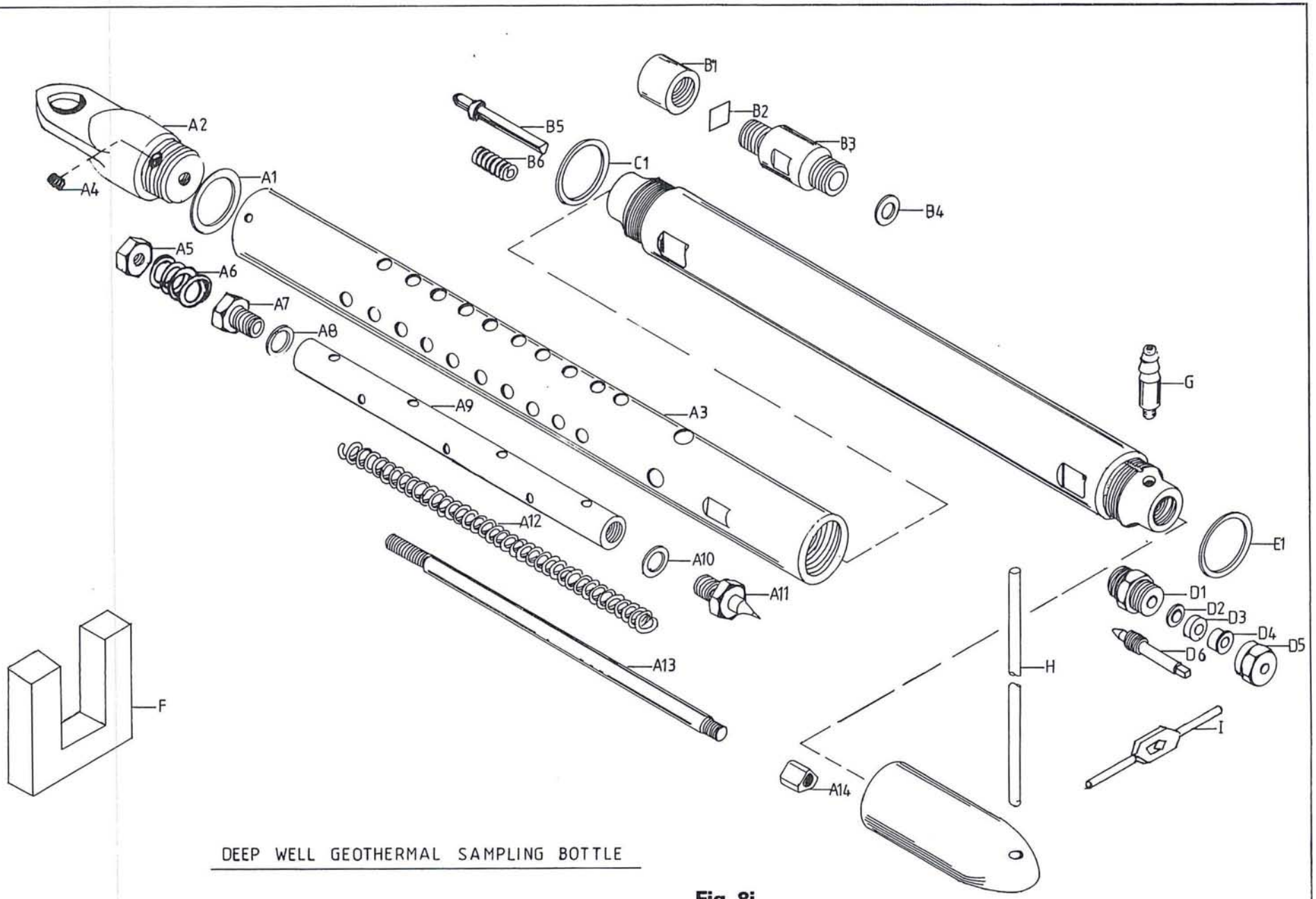
8d

8e

8f

8g

8h



DEEP WELL GEOTHERMAL SAMPLING BOTTLE

Fig 8i

Method of wire-line attachment.

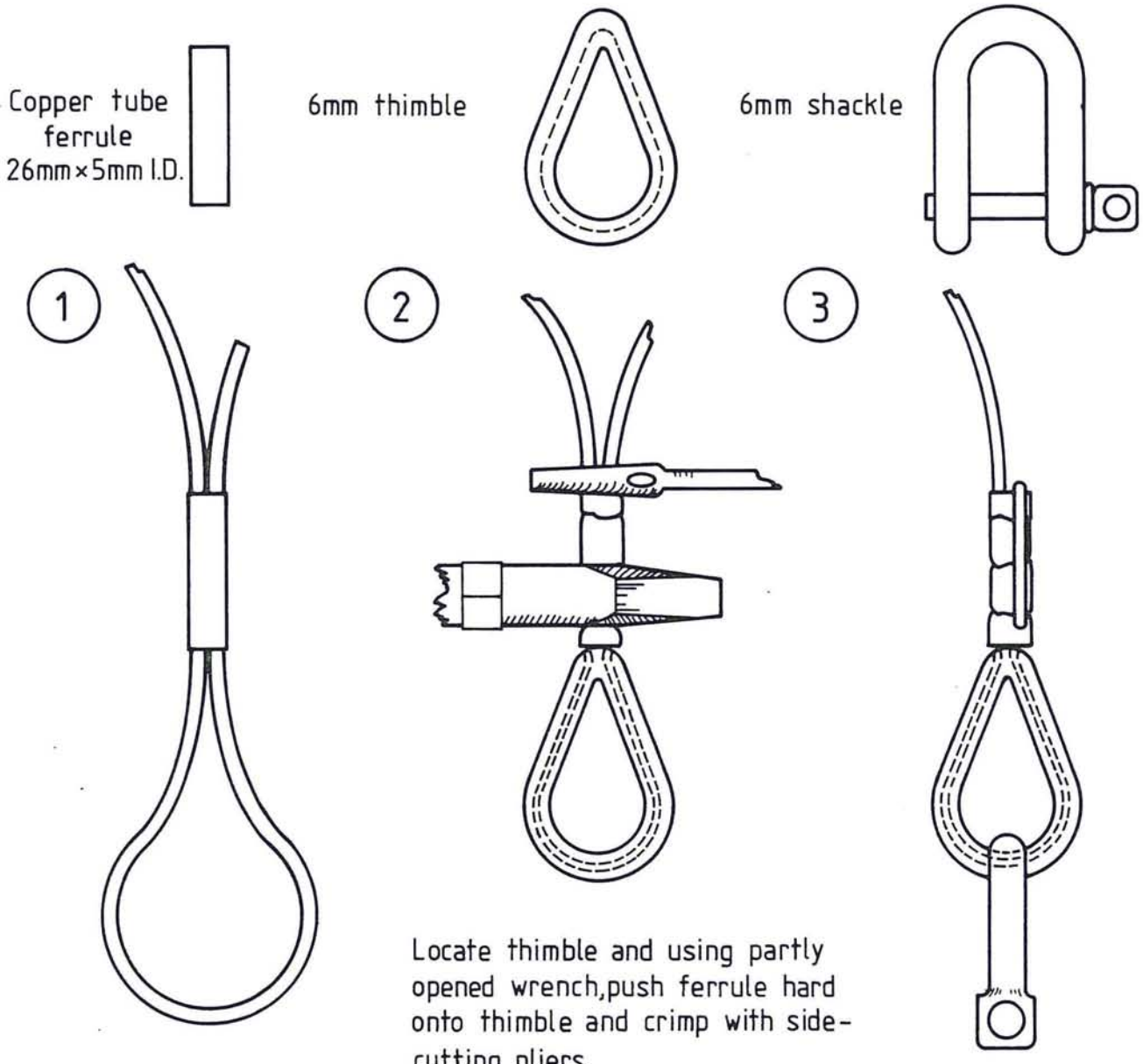


Fig 8j

FUMAROLE SAMPLING DOME

Function

To confine and direct naturally dispersing fumarolic gases.

Use

For the collection of steam and gas samples from fumaroles and steaming ground.

Description (refer Figs. 9 and 9a)

Fumarolic gases are confined beneath a stainless-steel dome (A) from which the atmosphere is excluded. Fumarole discharge escapes through the tube (B) and may be sampled at the tee-piece (C).

Method (refer Figs. 9 and 9a)

The lower edge of the dome (A) is pressed firmly into the ground around the fumarole. Earth shovelled over the dome insulates against undue heat loss leading to condensation, seals against atmospheric intrusion and/or excessive gas leakage and provides weight to overcome pressure displacement of the dome. Gas is extracted from the tee-piece at (C) and is collected through a butyl rubber hose into a (ideally) water cooled evacuated pyrex flask. The presence, quantity and dilution of sodium hydroxide will be determined by the Section Supervisor. The procedure from here on is similar to previous gas collection instructions.

Air condensers or unaided atmospheric cooling of sample input may be called for where the locality renders impracticable the transport of cooling water.

Fumarole sample pressures are frequently low and demand careful control of collection flask input to prevent atmospheric intrusion into the port at B.

Operation (refer Figs. 9 and 9a)

CAUTION: Fumaroles are commonly located in hazardous terrain, e.g. hot mud or cavities concealed beneath a fragile crust. Investigate and define a safe approach before moving personnel and equipment into the sampling area. Exercise vigilance at all times.

1. Clear the immediate area of the fumarolic vent of all obstructions likely to impede lodgement of the dome.

2. Grasp the dome assembly by the upper pipe (B). Approach the vent with the nearer edge of the dome close to the ground level thus deflecting steam and hot mud away from self before covering discharge.

3. Press lower edge of dome firmly into the ground and cover with shovelled earth.

4. Consolidate earth cover, sealing all internal gas leakages and, in the event of weak discharges, atmospheric intrusions.

5. Establish optimum gas flow from the tee-piece extension hose. Weak discharges may require initial pump extraction but, once achieved, are usually self maintaining. Throttling of the port at upper (B) will often enhance flow at (C). Do not diminish through-put to quench point.

6. Allow the tee-piece extension hose to follow a continuous down-hill path to an evacuated collection flask located below the level point (C).

7. The demand for, and specifications of, sodium hydroxide will depend on sample source and current requirement; seek instructions from the Section Supervisor.

8. In some regions it may be impracticable to supply cooling water and resort may have to be made to air condensers or even, unaided atmospheric sample cooling.

9. The low pressure of some gas emissions calls for careful control of sample extraction to prevent atmospheric intrusion into the port at (B) and subsequent sample contamination. Artery forceps, or a screw tube clamp, are useful in this context.

Routine Maintenance

Hose down with clean tap water.

Specimen Field Notes

Feature name, number or location: Date:

(if previously unrecorded in N.Z., enter details on sheet SIR Y25/G-5c)*

Temp = ^{o}C Sample location within feature

Flask No.:

* Specimen sheet on page 88.

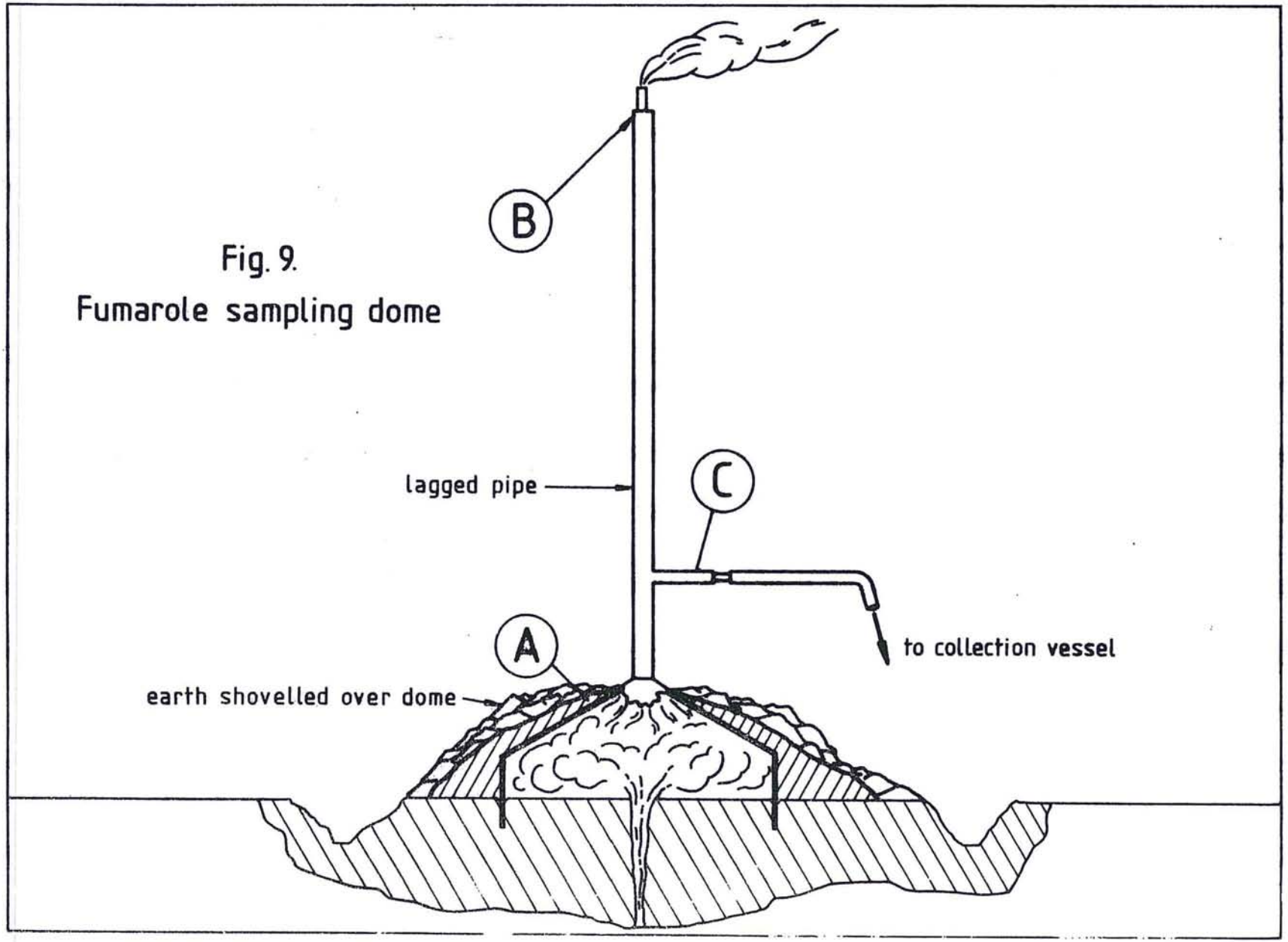


Fig. 9.
Fumarole sampling dome

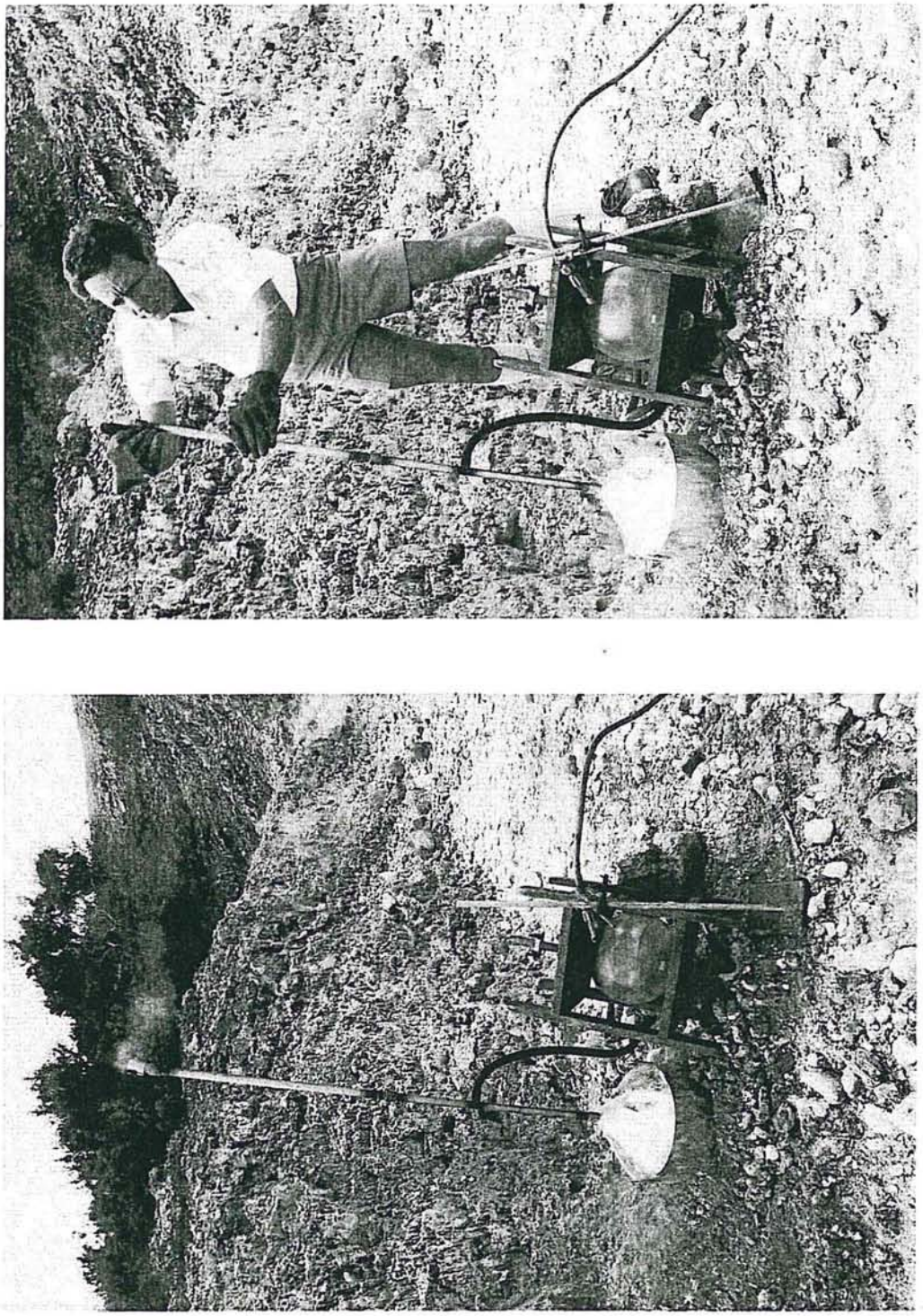


Figure 9a

FUMAROLE SAMPLING WITH TITANIUM TUBES

Function

To confine and direct naturally dispersing fumarolic gases.

Use

For the collection of steam and gas samples from fumaroles which, for reasons of their excessively corrosive nature, high temperature, size and/or location, the dome is unsuitable.

Method

Similar to dome usage.

Operation (refer Fig. 10)

Observe caution as for dome usage.

1. For vertical vents insert the shorter end of the tube (A) into the emission exit. For horizontal vents use straight tube (A).
2. Seal and cover (A) with shovelled earth, leaving sufficient of the downstream end exposed for connection purposes.
3. Allow the longer end of the tube (A), together with any extensions and hoses to follow a continuous down-hill path to an evacuated flask located below the gas vent level.
4. Weak emissions may require initial extraction pumping to establish gas flow.

Routine Maintenance

Hose out with clean tap water.

Specimen Field Notes

Feature, name, numbers or location: Date:

Temp = ^{o}C Sample location within feature:

Flask No.:

(If previously unrecorded in N.Z. enter details on sheet SIR Y25/G-5c)*.

* Specimen sheet on page

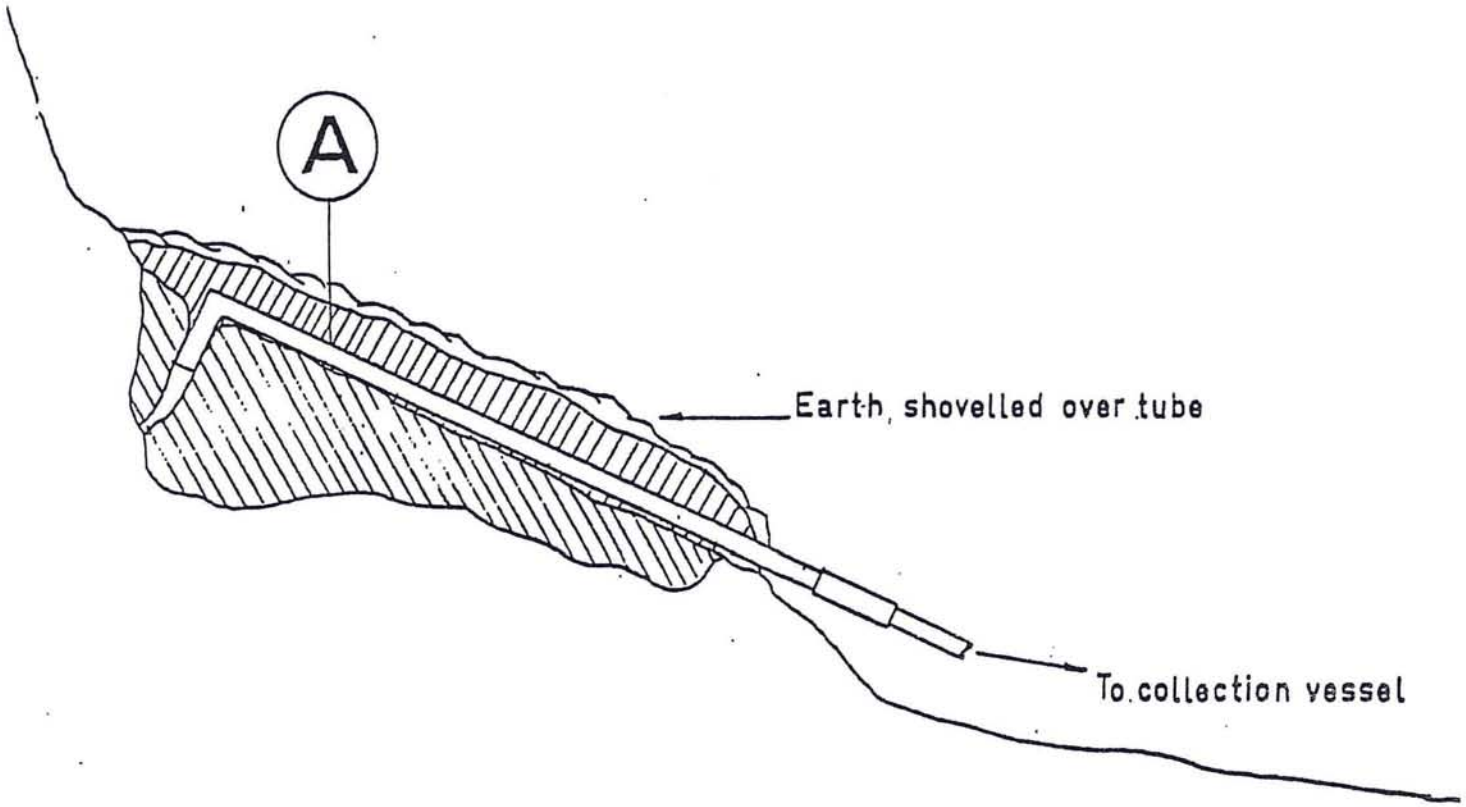


FIGURE 10. Fumerole sampling (titanium) tube

SURFACE FEATURE WATER SAMPLING

CAUTION: Approach all hot springs and seepages with extreme care; even minor flows are often located in unstable terrain. Before attempting sample collection closely scrutinize the feature's surrounds noting hazardous overhangs and the direction of any air-borne hot discharge. When sampling, work as far from the spring edge as practicable thus leaving a safety margin in the event of a momentary overbalance or stumble.

Method

1. Strive to sample hot springs at the point of upflow wherever possible or, failing this, at the outflow. Where temperatures are too high for direct bottle collection use the plastic dipper. Shallow discharges are best sampled with a hand held plastic scoop thus avoiding undue disturbance of bed sediment. (If adequate access is denied refer to 'Throw-in Sample Vessel' p. 32). Recommended sample volumes are:

   (i) 500 mls in a clean, or sample washed, plastic vessel for main constituent determinations.

   (ii) 500 mls in a clean, or sample washed, glass, gas-tight, sealed vessel for H_2S, sulphate and carbonate species determinations.

   (iii) 100 mls in a clean plastic vessel pre-spiked with 1 ml of 1:1 HNO_3 for SiO_2 determinations.

   (iv) 10 mls in a clean plastic vessel containing 90 mls of a solution of 0.1 molar NaOH + 1000 ppm Na EDTA for SiO_2, K, Ca, Cs and etc., determinations.

2. Record temperature fo collection zone.

3. Record and measure spring outflow in decametre units thus:

$$\frac{\text{Channel length x Channel width x Channel depth}}{\text{Velocity through channel length in seconds}} \times 0.7^{*} = \text{l/sec}$$

Where necessary, modify the outflow channel to procure a consistent cross section.

Specimen Field Notes

Feature number, name or location and position within feature:

Date:

Bottle Nos.

Temp = ^{o}C

Outflow: Litre/sec.

(If previously unrecorded in N.Z. enter details on sheet SIR Y25/G-5c.**

* Typical bed roughness factor
** Specimen sheet on page .

SUBMERGED-GAS SAMPLER

Function

To collect and direct rising gas bubbles in surface features.

Use

For the collection of gas samples from submerged vents.

Description (refer Figs. 11 and 11b)

A vessel (A), fitted with a valve (A1) (commonly a 'Rotoflo' type flask) is connected to the funnel (B). The assembly (A), (A1) and (B) may be rigidly clamped and attached to a handling pole. Alternatively, where rising bubbles are beyond reach the funnel (B), on extension poles, may be connected by a length of transparent hose to the flask (A) which remains conveniently on shore. A small, gas tight window let into the neck of the funnel (B) provides a check on unwanted spring water entering the vessel (A).

Method (refer Figs. 11 and 11b)

(i) With the valve (A1) open (A) and (B) are filled with water and then, with funnel (B) submerged, inverted over the gas stream. Rising bubbles collected by the funnel (B) are directed into the vessel (A) thus displacing the water contained therein. When sample collection is complete (A1) is closed whilst maintaining the water seal at (B).

(ii) Either an entirely evacuated vessel (A) is used or one prepared with the appropriate quantity of NaOH (sodium hydroxide) solution and then evacuated. With (A1) closed (B) is filled with water and submerged before inversion over the gas steam. With (A) exposed to atmosphere, rising bubbles collected by (B) are directed into (A) upon opening (A1). Where NaOH solution is present H_2S and CO_2 are absorbed into the NaOH solution while non-condensible gases collect in the space above. The sample is secured by closing (A1) before negative pressure subsides within (A) and with the water seal at (B) remaining intact.

(iii) Where gas emissions are only shallowly submerged the funnel (B) is detached from the remainder of the assembly, inverted over the gas stream and pressed firmly into the bed material. With the spout of (B) emerging above the spring water level gas is allowed to collect within (B) until a discernible gas flow is obtained upon which the vessel (A) is connected and sampling may proceed as under (i) and (ii).

(iv) The emissions from some submerged vents may, in rising, become too widely dispersed for sample collection. This may be dealt with by attaching stainless-steel, or titanium extension tubes to the funnel (B) and then proceding as described under (iii).

Operation (i) (refer Figs. 11 and 11b)

NB: Observe caution as instructed under Spring Sampling.

1. Detach (A) and evacuate.
2. Assemble sampler.
3. With (B) uppermost fill (B) with spring water.
4. Open (A1) to fill (A) with the water contained in (B).
5. Submerge sampler in spring with (B) uppermost and dislodge any adhering air bubbles.
6. Invert sampler over gas stream.
7. When all the water contained in (A) and (A1) is expelled close (A1) with (B) remaining sufficiently immersed to maintain a water seal against atmospheric intrusion.
8. Remove sampler from source.

Operation (ii) (refer Figs. 11 and 11b).

1. Detach (A) and evacuate.
2. If NaOH is to be used prepare (A) with the appropriate quantity of 70% NaOH solution re-evacuate air (guarding against inadvertent removal of NaOH solution) and record weight for analytical purposes.
3. Assemble sampler
4. Submerge sampler in spring with (B) uppermost and dislodge any adhering air bubbles.
5. Invert sampler over gas stream.
6. Raise sampler sufficiently to expose (A1).
7. Open (A1) cautiously, and only sufficiently, to admit gas to (A) being careful not to allow the entry of spring water.
8. Where NaOH solution is being used, regularly close (A1) and shake (A) to agitate NaOH solution. (This is made easier when a flexible connection between funnel (B) and flask (A) is employed). Cautiously open (A1) no more than necessary to admit gas, before continuing to sample.
10. Where NaOH solution is being used discontinue sampling before incoming bubbles completely cease entry into (A). In the absence of NaOH solution discontinue sampling when (A1) may be fully opened without the admittance of spring water.
11. With (B) immersed, to prevent atmospheric intrusion, close (A1) to secure sample.
12. Remove sampler from source.

Operation (iii)

1. Detach (A) and prepare for desired sampling mode.

2. Locate (B) over shallow vent and press firmly into bed material.

3. Allow gas to accumulate within (B).

4. Test for continuous gas flow from exposed spout of (B), e.g. a dampened finger tip will show bubbles of escaping gas.

5. In the presence of vigorous gas emission counter the buoyancy of (B) by maintaining hand pressure or weighing down with rocks.

6. Purge neck of (A1) and connect to (B).

7. Open (A1) cautiously, and only sufficiently, to admit gas to (A). Exercise care to prevent the entry of spring water into (A); observation of the window in the neck of (B) will give early warning of this.

8. Close (A1) upon sample completion.

9. Remove sampler from source.

Operation (iv) (refer Fig. 1/a)

1, Detach (A) and prepare for desired sampling mode.

2. Screw onto (B) sufficient extension tubing to reach vent.

3. Locate (B) over deep vent and press into bed material.

4. Counter undue buoyancy by hand pressure.

5. Proceed as described under (iii).

Specimen Field Notes

Feature number, name or location and position within feature: Date:

Flask No's. Temp ^{o}C

NaOH: mls Outflow litre/sec.

H_2O: "

If previously unrecorded enter details on sheet SIR Y25/G-5c*

* Specimen sheet on page .

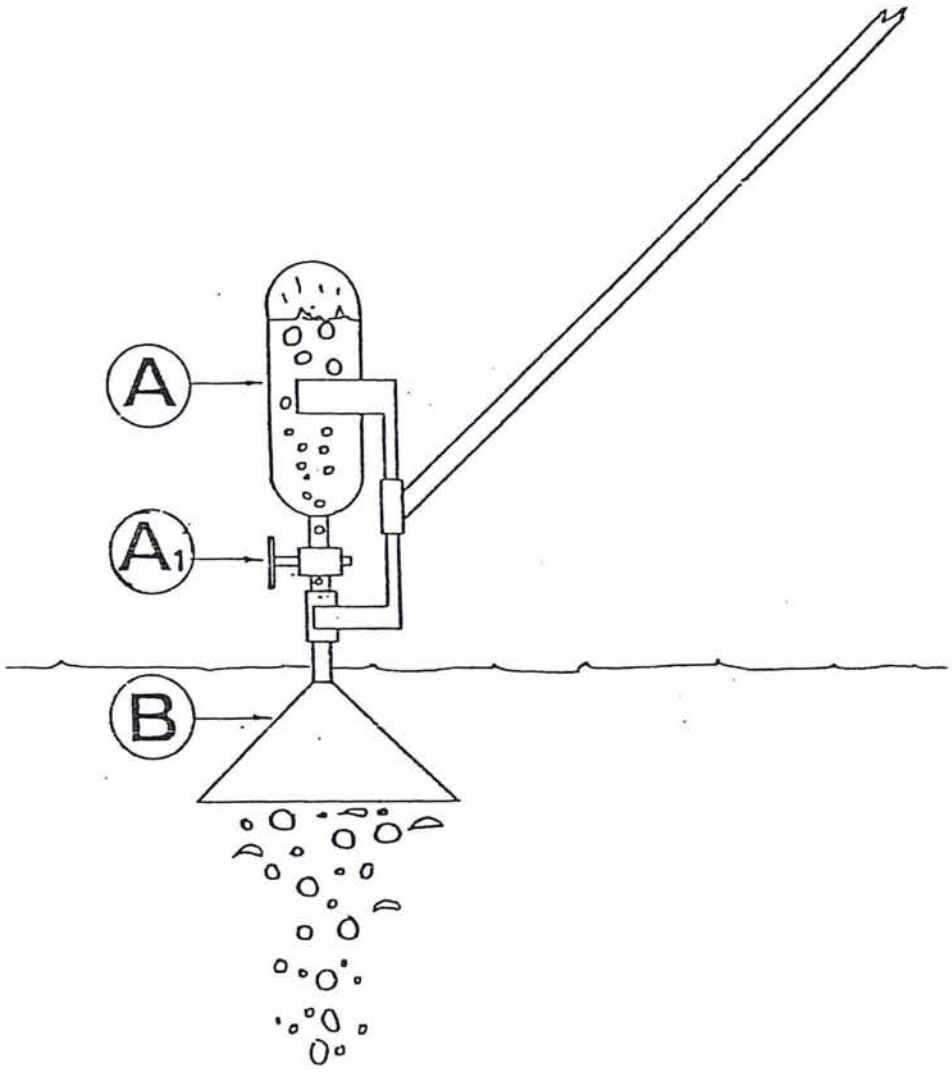


FIGURE 11. Spring gas sampling(i)

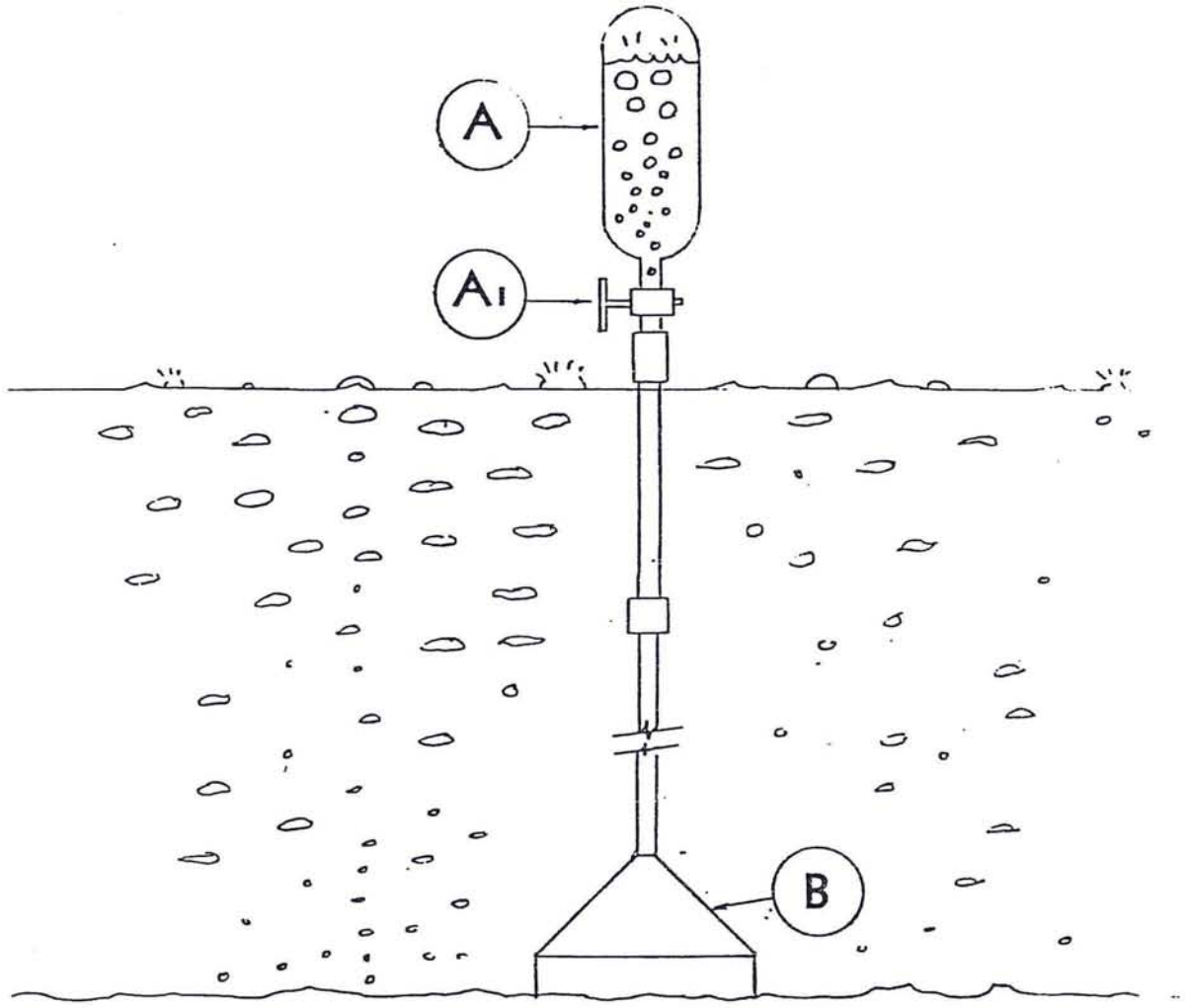


Figure 11a. Spring gas sampling (iv)

FIGURE 11b

GLOSSARY

ALLEN KEY — A driving tool, of hexagonal cross-section, designed to fit a socket in the head of an Allen screw.

ALLEN SCREW: — A screw possessing an hexagonal recess into which an Allen key is fitted for purposes of tightening and loosening.

BUTYL RUBBER: — A polymer less permeable than most rubbers to gas diffusion. Butyl rubber tubing of: 21 mm OD x 7 mm ID, is ideally suitable for gas collection flask connections and the dry steam hose of a Webre separator.

'CRACK' A VALVE: — To open a valve only the minimum amount necessary to allow the escape of a contained fluid.

CYCLONE SEPARATOR: — A vertical cylinder into which a fluid mixture is tangentially injected. The heavier fractions of the mixture, e.g. water, centrifugally separate and drain under gravity through a vent close to the base of the cylinder. The lighter components e.g. steam and gas escape through a vent communicating with the top of the cylinder. See Figs. 1a & 2.

DRY STEAM: — Unsuperheated, water free, steam.

DWANG: — A removable, usually adjustable, handle for imparting manual rotation to taps, dies, valve stems etc.

DYNAMIC SEAL: — A component, such as a piston-ring, which maintains its seal over a distance of travel unlike a gasket which seals only statically.

FLASH WATER: — The liquid phase remaining from the separation of steam derived from single-step pressure drop of high temperature water or steam/water mixture.

GLAND: — A device for sealing around cylindrical objects such as pump connecting rods, valve stems and, in the Klyen sub-surface sampler MkI, the glass break-off tubes.

GLAND NUT: — A component part of a gland by which the seal is secured and/or compressed.

HYDRAULIC DESCENT CONTROL OR HYDRAULIC DRAG: — A useful mechanism incorporated into many wireline winches where a variably throttled pump may be engaged at will to a ring-gear mounted on one of the wireline spool cheeks. As instrument and wireline is paid off downhole the resultant rotation of the spool drives the closed pumping system. Adjustment of the throttle provides a smooth, controllable and, therefore, safe descent. The use of this device is strongly recommended wherever wireline borehole logging is undertaken.

HYDROSTATIC PRESSURE: The pressure exerted by an overlying liquid. Ten metres depth of cold water equals approx. 1 kilogram per sq. centimeter, or 0.98 bar.

INERTIA MECHANISM: A device incorporated in Klyen sub-surface samplers where a guided, spring-suspended, mass when jerked punctures a pressure seal.

LOSS ZONE: A zone encountered during deep-well drilling where the fluids associated with drilling are lost into fissures and cavities in the immediate geological formations. Such zones often are the target of sub-surface sampling operations.

MAC-UNION: A pipe fitting normally consisting of a secured semi-ball and socket seal. It is a useful device providing an adjustable connection between the Webre separator and a sample point.

NON-RETURN VALVE: A valve admitting flow in one direction only. Such a valve allows the sample vessel in a Klyen sub-surface sampler to fill but prevents subsequent leakage.

O-RING: A seal ring of solid, circular, cross-section, often of polymeric material which, when correctly seated, provides a wide range of sealing applications both static and dynamic.

PERMEABLE ZONES: Geological formations through which fluids may move without undue restriction. Such zones often are the target of sub-surface sampling operations.

RECOVERY GEAR: (U.S. = LUBRICATOR) Normally a flanged pipe bearing at its upper end a removable gland. Its purpose is to provide access for downhole instruments into pressurized wells. This is accomplished when the recovery gear is secured to the wellhead with the wireline threaded through the gland and shackled to an instrument contained within the recovery gear at which point the master valve may safely be opened and the instrument lowered. Upon retrieval of the instrument the master valve is closed and pressure within the recovery gear is exhausted through a valve to atmosphere. The instrument may then be recovered upon removal of the upper gland or by releasing the recovery gear from the wellhead. See Fig. 8b.

'ROTOFLO' FLASKS: These derive their name from commercially available 'Rotoflo' teflon sealed, valves.

SAMPLE POINT PRESSURE: The pressure at the sample point in the absence of any discharge.

SAMPLE PRESSURE: The pressure at which sampling takes place.

STEAM FRACTION: The water vapour component of a steam/water two-phase flow.

SHIM: A thin metal plate such as those used as puncture seals in the Klyen sub-surface sampler MkII.

TWO-PHASE FLOW: Any simultaneous liquid and gas flow along a confined path: geothermally, a steam plus gas/water flow normally within a pipe.

TOMMY BAR: A lever designed to fit a matching recess.

THIMBLE: A peripherally grooved, tear-drop, shaped ring for forming eyelets at the ends of wires and ropes.

VAPOUR PRESS: The pressure of a vapour exerted either by itself or in a mixture of gases.

WATER FRACTION: The liquid water component of a steam/water two-phase flow.

WEBRE SEPARATOR: A miniature, twin-cyclone, separator. See 'cyclone separator'.

WEIRBOX: A compartment located at the base of a geothermal silencer. It contains a small dam over which flashed water from the silencer drains. Its known dimensions, together with other criteria, provide a ready means of enthalpy assessment. Useful water samples are collected from the weirbox.

WIRELINE: Normally a single strand, stainless-steel, wire from which some downhole logging and sampling instruments are suspended.

TABLE 1

STEAM TABLE EXTRACT (approx)

Pressure		Boiling Temp		Pressure		Boiling Temp	
PSIG	Bar g	°F	°C	PSIG	Bar g	°F	°C
100	6.9	338	170	675	46.5	501	261
125	8.6	353	178	700	48.3	505	263
150	10.3	366	185	725	50.0	509	265
175	12.0	377	192	750	51.7	513	267
200	13.8	387	197	775	53.4	517	269
225	15.5	397	203	800	55.2	520	271
250	17.2	406	208	825	56.9	523	273
275	19.0	414	212	850	58.6	527	275
300	20.7	422	217	875	60.3	530	277
325	22.4	429	220	900	62.1	534	279
350	24.1	436	224	925	63.8	537	281
375	25.9	442	228	950	65.5	540	282
400	27.6	448	231	975	67.2	543	284
425	29.3	454	234	1000	69.0	546	286
450	31.0	459	237	1025	70.7	549	287
475	32.8	463	239	1050	72.4	552	289
500	34.5	470	243	1075	74.1	555	291
525	36.2	475	246	1100	75.9	558	292
550	37.9	480	249	1125	77.6	561	293
575	39.7	484	251	1150	79.3	563	295
600	41.4	489	254	1175	81.0	566	297
625	43.1	493	256	1200	82.7	569	298
650	44.8	497	258	1225	84.4	571	299

TABLE 2

PRESSURE CONVERSION TABLE

kPa	Index	lb/in²	kPa	Index	lb/in²	kPa	Index	lb/in²
6.89	1	0.15	317.16	46	6.67	627.35	91	13.20
13.79	2	0.29	324.05	47	6.82	634.25	92	13.34
20.68	3	0.44	330.95	48	6.96	641.21	93	13.49
27.58	4	0.58	337.84	49	7.11	648.11	94	13.63
34.47	5	0.73	344.74	50	7.25	655.00	95	13.78
41.37	6	0.87	351.63	51	7.40	661.90	96	13.92
48.24	7	1.02	358.53	52	7.54	688.79	97	14.07
55.16	8	1.16	365.42	53	7.69	675.69	98	14.21
62.05	9	1.31	372.32	54	7.83	682.58	99	14.36
68.95	10	1.45	379.21	55	7.98	689.48	100	14.50
75.84	11	1.60	386.11	56	8.12	758.42	110	15.95
82.74	12	1.74	393.00	57	8.28	827.37	120	17.40
89.63	13	1.89	399.90	58	8.41	896.32	130	18.85
96.53	14	2.03	406.79	59	8.56	965.27	140	20.31
103.42	15	2.18	413.69	60	8.70	1034	150	21.76
110.32	16	2.32	420.58	61	8.85	1103	160	23.21
117.21	17	2.47	427.48	62	8.99	1172	170	24.66
124.11	18	2.61	434.37	63	9.14	1241	180	26.11
131.00	19	2.76	441.26	64	9.28	1310	190	27.56
137.90	20	2.90	448.16	65	9.43	1379	200	29.01
144.79	21	3.05	455.05	66	9.57	1724	250	36.26
151.68	22	3.19	441.95	67	9.72	2068	300	43.51
158.58	23	3.34	468.84	68	9.86	2578	400	58.02
165.47	24	3.48	475.74	69	10.01	3447	500	72.52
172.37	25	3.63	482.63	70	10.15	4137	600	87.02
179.26	26	3.77	489.53	71	10.30	4826	700	101.53
186.16	27	3.92	496.42	72	10.44	5516	800	116.03
193.05	28	4.06	503.32	73	10.59	6205	900	130.53
199.95	29	4.21	510.21	74	10.73	6895	1,000	145.04
206.84	30	4.35	517.11	75	10.88	11032	1,600	232.06
213.74	31	4.50	524.00	76	11.02	13790	2,000	290.08
220.63	32	4.64	530.90	77	11.17	17237	2,500	362.59
227.53	33	4.79	537.79	78	11.31	20685	3,000	435.11
234.42	34	4.93	544.69	79	11.46	27580	4,000	580.15
241.32	35	5.08	551.58	80	11.60	41370	6,000	870.23
248.21	36	5.22	558.48	81	11.75	55160	8,000	1160
255.11	37	5.37	565.37	82	11.89	68950	10,000	1450
262.00	38	5.51	572.26	83	12.04	110232	16,000	2321
268.90	39	5.66	579.14	84	12.18		25,000	3626
275.79	40	5.80	586.05	85	12.34		40,000	5802
282.69	41	5.95	592.94	86	12.47		60,000	8702
289.58	42	6.09	599.84	87	12.62		80,000	11603
296.47	43	6.24	606.73	88	12.76		100,000	14504
303.37	44	6.38	613.57	89	12.91			
310.26	45	6.53	620.53	90	13.05			

CONVERSION FACTORS

100 kPa	=	1 bAR
100 kPa	=	14.50 P.S.I.
1 kPa	=	.15 P.S.I.
100 kPa	=	1.09 kg/cm²
1 P.S.I.	=	6.89 kPa
1 FT.HD	=	.305 m.W.G.
1 m.W.G.	=	3.28 FT.HD.
100 kPa	=	10.2 m.W.G.

TABLE 3

TEMPERATURE CONVERSION TABLE

Cent	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.	Cent.	Fahr.
0	32	230	446	460	860	690	1274	920	1688	1150	2102	1380	2516
5	41	235	455	465	869	695	1283	925	1697	1155	2111	1385	2525
10	50	240	464	470	878	700	1292	930	1706	1160	2120	1390	2534
15	59	245	473	475	887	705	1301	935	1715	1165	2129	1395	2543
20	68	250	482	480	896	710	1310	940	1724	1170	2138	1400	2552
25	77	255	491	485	905	715	1319	945	1733	1175	2147	1405	2561
30	86	260	500	490	914	720	1328	950	1742	1180	2156	1410	2570
35	95	265	509	495	923	725	1337	955	1751	1185	2165	1415	2579
40	104	270	518	500	932	730	1346	960	1760	1190	2174	1420	2588
45	113	275	527	505	941	735	1355	965	1769	1195	2183	1425	2597
50	122	280	536	510	950	740	1364	970	1778	1200	2192	1430	2606
55	131	285	545	515	959	745	1373	975	1787	1205	2201	1435	2615
60	140	290	554	520	968	750	1382	980	1796	1210	2210	1440	2624
65	149	295	563	525	977	755	1391	985	1805	1215	2219	1445	2633
70	158	300	572	530	986	760	1400	990	1814	1220	2228	1450	2642
75	167	305	581	535	995	765	1409	995	1823	1225	2237	1455	2651
80	176	310	590	540	1004	770	1418	1000	1832	1230	2246	1460	2660
85	185	315	599	545	1013	775	1427	1005	1841	1235	2255	1465	2669
90	194	320	608	550	1022	780	1436	1010	1850	1240	2264	1470	2678
95	203	325	617	555	1031	785	1445	1015	1859	1245	2273	1475	2687
100	212	330	626	560	1040	690	1454	1020	1868	1250	2282	1480	2696
105	221	335	635	565	1049	795	1463	1025	1877	1255	2291	1485	2705
110	230	340	644	570	1058	800	1472	1030	1886	1260	2300	1490	2714
115	239	345	653	575	1067	805	1481	1035	1895	1265	2309	1495	2721
120	248	350	662	580	1076	810	1490	1040	1904	1270	2318	1500	2732
125	257	355	671	585	1085	815	1499	1045	1913	1275	2327	1505	2741
130	266	360	680	590	1094	820	1508	1050	1922	1280	2336	1510	2750
135	275	365	689	595	1103	825	1517	1055	1931	1285	2345	1515	2759
140	284	370	698	600	1112	830	1526	1060	1940	1290	2354	1520	2768
145	293	375	707	605	1121	835	1535	1065	1949	1295	2363	1525	2777
150	302	380	716	610	1130	840	1544	1070	1958	1300	2372	1530	2786
155	311	385	725	615	1139	845	1553	1075	1067	1305	2381	1535	2795
160	320	390	734	620	1148	850	1562	1080	1976	1310	2390	1540	2804
165	329	395	743	625	1157	855	1571	1085	1985	1315	2399	1545	2813
170	338	400	752	630	1166	860	1580	1090	1994	1320	2408	1550	2822
175	347	405	761	635	1175	865	1589	1095	2003	1325	2417	1555	2831
180	356	410	770	640	1184	870	1598	1100	2012	1330	2426	1560	2840
185	365	415	779	645	1193	875	1607	1105	2021	1335	2435	1565	2850
190	374	420	788	650	1202	880	1616	1110	2030	1340	2444	1570	2858
195	383	425	797	655	1211	885	1625	1115	2039	1345	2453	1575	2867
200	393	430	806	660	1220	890	1634	1120	2048	1350	2462	1580	2876
205	401	435	815	665	1229	895	1643	1125	2057	1355	2471	1585	2885
210	410	440	824	670	1238	900	1652	1130	2066	1360	2480	1590	2894
215	419	445	833	675	1247	905	1661	1135	2075	1365	2489	1595	2903
220	428	450	842	680	1256	910	1670	1140	2084	1370	2498	1600	2912
225	437	455	851	685	1265	915	1679	1145	2093	1375	2507	1605	2921

Degrees Centigrade × 1.8 + 32 = degrees Fahrenheit.

$\frac{\text{Degrees Fahrenheit} - 32}{1.8}$ = degrees Centigrade.

FIELD SURVEYS OF NATURAL HYDROTHERMAL FEATURES

NZMS 2 SHEET No. ..... GRID REF. ..... FEATURE No. .....

D.S.I.R. MAP No. ..... AREA ..... FEATURE NAME .....

MEASURED BY ..... DATE .....

DESCRIPTION (Include remarks on appearance of feature, geyser action, periodicity, etc.; nature, colour and appearance of the deposits; and surroundings.)

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TEMPERATURE, AND WHERE MEASURED ..... °C. .....

HEIGHT OF EBULLITION ..... cms / m OVERFLOW ..... litre/sec

WATER SAMPLE BOTTLE Nos. ..... GAS SAMPLE BOTTLE Nos. .....

GAS A. Constant / B. Intermittent — 1. Absent, 2. Small, 3. Moderate, 4. Strong .....

Any Particular Odour .....

DIAGRAM, DIMENSIONS AND PHOTOGRAPH (On diagram give dimensions of feature in cgs units, record depth, indicate with an "x" position where gas is evolved, show north point and direction that photograph was taken.)

PHOTOGRAPHER ..... DATE TAKEN .....

NEGATIVE No. ..... FILED AT .....

SAMPLED FOR CHEMICAL ANALYSIS BY .....

WATER SAMPLE BOTTLE Nos. ..... GAS SAMPLE BOTTLE Nos. .....