(e)	Residual Chlorine	5%
(f)	Total Chromium	5%
(g)	Copper	5%
(h)	Total Cyanide	5%
(i)	Lead	5%
(j)	Mercury	5%
(k)	Nickel	5%
(l)	Total Phosphate	5%
(m)	Zink	5%
(n)	Dissolved Oxygen	5%

B — 4 Biological Pollutants

	(Pollutants)	(Guidelines at edge of mixing zone)
(a)	Total Coliform	70 most probable number per 100 ML (average for 30 day period).

13. Performance Standards for Direct Discharge

A — Purpose: Performance standards for direct discharge are intended to require waste water source to adopt best practical controls.

B — Scope: Performance standards for direct discharge apply to sanitary sewage, surface runoff (including fire control waters), cooling water discharges, boiler water conditioning blowdown, process wastewaters, and any other wastewater.

C — General Performance Standards: Wastewaters of different character shall be segregated to the maximum extent possible. Uncontaminated surface runoff and once-through cooling waters may be discharged to receiving waters without treatment.

D — Specific Performance Standards: The following performance standards apply to wastewaters at the end of the outfall and before discharge to coastal waters or to any channel of wastewater.

D — 1 Physio-Chemical Pollutants

	(Pollutants)	(Allowable effluent Level)
(a)	Floatables	None
(b)	PH	6-9 pH units
(c)	Total Suspended solids (TSS)	15 mg/1 (max.)

(d)	Temperature	MEPA determines the thermal properties of discharged water to fit the properties of receiving water and such properties are determined on a case by case basis.
(e)	Turbidity	75 NTU (max.)

D — 2 Organic Pollutants

	(Pollutants)	(Allowable Effluent Level)
(a)	Biochemical Oxygen Demand	25 mg/1
(b)	Chemical Oxygen Demand	150 mg/1
(c)	Total Organic Carbon (TOÇ)	50 mg/1
(d)	Total kjeldahl nitrogen (TKN)	5 mg/1
(e)	Total Chlorinated Hydrocarbons	0.1 mg/1
(f)	Oil and Grease	8 mg/1 (not to exceed 15 mg/1 in any individual discharge)
(g)	Phenols	0.1 mg/1

D — 3 Non-organic Pollutants

	(Pollutants)	(Allowable Effluent Level 30-day Average)
(a)	Ammonia (as nitrogen)	1.0 mg/1
(b)	Arsenic	0.1 mg/1
(c)	Cadmium	0.02 mg/1
(d)	Chlorine (residual)	0.5 mg/1
(e)	Chromium (total)	0.1 mg/1
(f)	Copper	0.2 mg/1
(g)	Cyanide	0.05 mg/1
(h)	Lead	0.1 mg/1
(i)	Mercury	0.001 mg/1
(j)	Nickel	0.2 mg/1
(k)	Phosphate (Total) (as Phosphorous)	1.0 mg/1
(l)	Zinc	1.0 mg/1

D — 4 Biological Pollutants

(Pollutant)		(Allowable Effluent Level — 30-day Average)
(a)	Total Coliform	1000 MPN per 100 ml

E — Mixing Zone

Each direct discharge shall be adequately dispersed and mixed with the receiving waters. A mixing zone shall be designed to minimize adverse effects to designated beneficial uses. Adequacy of the mixing zone shall be determined on a case-by-case basis.

14. Pretreatment Guidelines for Discharge to General Treatment Facilities.

A — Purpose: Pretreatment guidelines are intended to provide guidance for the removal of substances that significantly effect the performance of the central treatment facilities, and substances that are not adequately controlled at central treatment facilities.

B — Scope: Pretreatment guidelines and standards apply to all facilities and modifications covered by the environmental standards which discharge to a central industrial or municipal wastewater treatment facility.

C — General Pretreatment Guidelines: Wastewaters of different character shall be segregated to the maximum extent possible. Sanitary wastes may be sent to a central treatment facility without pretreatment. Contaminated wastewaters other than sanitary wastes shall be treated on-site to meet applicable pretreatment requirements.

D — Specific Pretreatment Guidelines: The following pretreatment guidelines apply to wastewater before discharge to a central treatment facility. The pretreatment guidelines provide a range for allowable levels of pollution in the effluent.

D — 1 Physio-chemical Pollutants

	(Pollutants)	(Guidelines)
(a)	Total suspended Solids (TSS)	2,000 mg/1 (max.)
(b)	pH	5-10 pH units
(c)	Temperature	60° C (max.)

D — 2 Organic Pollutants

	(Pollutants)	(Guidelines)
(a)	Chemical Oxygen Demand	1,500 mg/1
(b)	Total organic carbon	1,000 mg/1
(c)	Oil and Grease	120 mg/1
(d)	Phenols	150 mg/1

(e)	Total chlorinated Hydrocarbons	0.5 mg/1

D — 3 Non-organic Pollutants

	(Pollutants)	(Guidelines)
(a)	Arsenic	1.0 mg/1
(b)	Cadmium	0.5 mg/1
(c)	Chromium (Total)	2.0 mg/1
(d)	Copper	1.0 mg/1
(e)	Cyanide (Total)	1.0 mg/1
(f)	Lead	1.0 mg/1
(g)	Mercury	0.01 mg/1
(h)	Nickel	2.0 mg/1
(i)	Zinc	10.0 mg/1

15. Implementation Obligations

1 — It shall be the duty and obligation of the owners, planners and operators of new facilities and modification to existing facilities to ensure that such facilities are located, designed and operated in accordance with these standards.

2 — It shall be the duty and obligation of owners and operators of existing facilities to ensure that such facilities are operated in accordance with these standards.

3 — Subject to other official requirements, owners and operators proposing to build a new facility must contact MEPA and provide specific required data to MEPA including relevant planning and design details indicating the pollution control measures to be.taken. MEPA shall review such data and grant written permit within a period not exceeding 3 months after the date of receiving such data from other departments and facilities, prior to execution of such facilities.

4 — Owners and operators of existing facilities are required to supply specific required data to MEPA following notification by MEPA. MEPA may request the carrying out of tests, investigations or analysis to insure compliance with the standards in any existing facility. The owners and operators of existing facilities shall be deemed responsible for submitting data relating to the existing facilities even if they don't receive notification by MEPA requesting such information.

16. Enforcement

1 — It shall be the responsibility of MEPA to ensure that compliance with these standards is enforced.

2 — Every application for a license to construct a new facility or introduce a major modification to an existing facility which is submitted to the competent authority must enclose a certificate stating that MEPA has evaluated the existing facility or the plans for the new facility and ascertained that the subject facility complies with these standards.

3 — In case where MEPA finds that the design of a planned new facility does not incorporate adequate control measures to comply with the standards, MEPA shall so inform the applicable licensing authority and request that a license not be issued to the facility until it rectifies the specific defects cited by MEPA. The facility owners shall also be informed.

4 — In case where MEPA finds that an existing facility is contravening these standards, MEPA shall so inform that facility and request that it be rectified according to a designated schedule. If the contravention continues, MEPA may address a final warning to the facility. If the warning fails to produce positive results, MEPA shall inform the licensing authority concerned and request that the license of the facility be suspended or withdrawn.

5 — MEPA shall carry out spot inspection of any facility to assess compliance with these standards without prior notice or warning.

7．R6 添付資料（ハイブリッド型逆浸透法における膜の選択実験）

ファウリング膜の解析方法

１９９２．１月６日
日東電工株式会社
メンブレン事業ユニット

１．　適用範囲

本文は、脱塩用途の逆浸透（ＲＯ）システムなどに用いられる、スパイラル型のＲＯ膜モジュールがファウリングなどにより性能低下を生じた場合の原因究明の手段として、ファウリング膜の準備とそれに関する分析方法について述べる。

２．　サンプリング方法

（２－１）外観観察

（１）ＲＯモジュールからエレメントを取り出す。
（２）エレメントのロット番号を控える。
（３）それがＲＯユニット内のどこの位置に在ったのかを記録する。
（４）取り出したエレメントの外観、特に、原水の上流側端面に異物の付着が有るかどうかをよく観察する。　もし有れば、付着の程度を記録し、さらに写真撮影しておくとよい。　異物をサンプリングしておく。

（２－２）エレメントの解体

（１）工具等として、つぎのものを準備する。
　電動丸のこ精密切断機
　（使用丸鋸刃：FRP切断用で300mm直径以上が望ましい）
　アングル・グラインダー（使用砥石外形100mm程度のもの）
　カッター・ナイフ
　洗浄用純水および容器
　サンプリング用プラスチック袋
（２）エレメントの端面より約１０ｃｍの両端を電動丸のこ精密切断機を用いて切断する。
（３）アングル・グラインダーにてエレメントのFRP製外側面部分に、ほぼ一直線状に約２ｃｍの深さで、ほぼ１８０度の位置となるように２カ所に切り込みを入る。
（４）それから、FRPの外装を手で引っ張りながら剥離させると、膜リーフ部分および原水スペーサーが露出してくる。
（５）通常の８インチエレメントは１０枚以上のリーフより構成されているので、エレメントを巻き戻すようにすると、１リーフ毎の平膜に展開される。
（６）２つのリーフの間に挟まれた原水スペーサーを取り除くと膜面を全体を観察出来る。　膜面全体に亘りファウリングの片寄りが有るかどうか目視にて膜面の色調分布など異常の有無を観察する。

（２－３）平膜サンプル

（１）ＲＯテストセルのサンプルがとれるだけの十分大きな寸法の平膜を採取する。　このときにサンプル番号がリーフ上のサンプル位置と照合できるように記録しておく。　なほ、サンプル枚数は、ＲＯ性能テストの実施（最低３枚／テスト回数）、洗浄テスト（洗浄テスト条件の３倍数）に応じ所定数量準備する。

（２）ＲＯ性能測定用平膜サンプルは純水にて、異物を除くために、穏やかに短時間、浸漬洗浄した後、所定のテストセルの寸法に切り出して、プラスチック袋に封入する。　テストのときまで冷蔵庫にて保存する。

（２－４）ＦＴ－ＩＲ、ＥＤＸ（別称ＸＭＡ）分析用サンプル

まず、自然乾燥を行う。　後述の分析方法にしたがって、サンプルを調製する。

３．ファウリング膜の分析方法

（３－１）ＦＴ－ＩＲ分析

（１）ＫＢｒ法

ＲＯ膜に付着したファウリング物質が、掻き取れる場合に単離し、常法によりＫＢｒと混合し分析用サンプルを作る。

（２）ＡＴＲ法

ＡＴＲ（多重反射法：Attenual Total Reflection）法により膜面のスペクトルをとる。　最近　ＭＩＲ（Multiple Internal Reflection）法が主として用いられる。

この分析条件は次のとうり。

＊反射板：ＫＲＳ－５（臭化タリウム／ヨウ化タリウム
=42/58）

＊反射角：４５°

（KRS-5は　400 ～4000cm^{-1}までの広いスペクトルを可能にする。）

＊スキャン回数：装置のメーカーに依存し、相違する。

（例）　ニコレー製SX-60の場合128回
パーキンエルマー製1750の場合30回（干渉器の精度高い為）

スキャン回数を振ってみて、ノイズ成分の無いきれいなスペクトルが得られる最適回数を探す。

（３）備考：

＊新膜のスペクトルデータをファイルしておき、
ファウリング膜との差スペクトルをとる。　そうすると、表面のファウリング成分のスペクトルが残る。
ファウリング成分のスペクトルは、ほぼパターン化してくるので、標準スペクトル集や標準サンプルのスペクトルのライブラリーより同定できるように解析の情報・技能レベルを向上させる。

＊洗浄後の膜面分析はファウリング膜の洗浄効果の確認として有効な手段を提供するであろう。

（３－２）ＳＥＭ・ＥＤＸ

（１）サンプル作成

風乾の後、Φ15～25mmのSEM用ホルダーに両面テープで固定し、導電性塗料でホルダーと試料を導通させ、蒸着を下記の条件で行う。

使途	ＳＥＭサンプル	ＥＤＸサンプル
試料ホルダー	アルミ製	カーボン製（Φ15mm用が主流）
導電性塗料	銀ペースト	カーボンペースト
イオンコーター	Au-Pdコーター Auコーター	カーボンコーター
特徴	微細（x20,000～50,000） 観察が可能	分解能　x4000位が上限、それ以上では鮮明な像が得られにくい。 ただし、オールカーボンのため、ＥＤＸ分析時の余分なピーク無し

筆者らの方法では、高倍率の観察も兼ねるため上記のＳＥＭサンプルの方法でＥＤＸ分析も実施している。　この場合にＥＤＸの分析時にAuのピークが出るが、近接のＰ,Ｓのピークとは識別できる。

（２）分析上の特記事項

＊　ＳＥＭとＥＤＸでは設定モードを変える。詳細は各ＳＥＭの説明書に記載されているので、それを参考にする。

下表にSEM：日立S-570，EDX：堀場製作所EMAX-1770の場合の主な相違点を示す。

機種	ＳＥＭ	ＥＤＸ
加速電圧	１０ＫＶ	２０ＫＶ
ワーキング・ディスタンス（対物レンズ／試料間距離）	１～２　mm 注）	２０　mm
特徴	膜の最表面の情報が得られる。 試料のダメージ少	EDX検出器、エネルギーに依存する。 試料のダメージ大

注）　ＳＥＭの機種によってはこの値まで近ずけることが不可能なことあり。　取説を参考にして最良の像が得られるよう設定する。

＊観察の方法は、まず低倍率（x200～800）で全体の様子を把握する。　ファウリングの程度の著しい部分と、そうでない所など特徴的な部分をx4000で観察する。そしてこれらのEDX分析を行う。

＊倍率を種々変えると異なるサンプル間の比較が困難になるのでなるべく一定の倍率で観察・分析を行うのが好ましい。

下記に典型的な倍率と識別例を示す。

倍率	識別の程度
x200～800	全体の汚れ状態が良く分かる 糸状菌（カビ）、微生物の汚染が分かる
x4000	細菌、スケールの状態が良く分かる

（なお、x4000以上の倍率はＥＤＸ分析に不向きである）

NITTO
TECHNICAL
DATA SHEET

Analysis of the NTR-759HR-S8 Element

No. R-1949

DATE: OCT 23, 1991
Reported by Nitto Denko Corporation
Product Development, Membrane Business Unit

1. Preface

This report covers the analysis of the returned spiral wound RO element, NTR-759HR-S8, used in so-and-so Plant in Japan.

2. Sample Element

* NTR-759HR-S8 : Total 4 elements

Serial No.	Position
8070004	Inlet place of the vessel at the first bank
8070007	Inlet place of the vessel at the first bank
8070009	Outlet place of the vessel at the third bank
8070040	Outlet place of the vessel at the third bank

* Start operation : July 1988
* Returned : August 1991 (Operated about 3 years)

3. Items Analyzed / Tested

(1) General appearance

(2) Rejection and flux measurement of elements (under the test condition specified in the inspection procedure)

(3) SEM and EDX(or XMA) (as to observation of membrane surface and inorganic analysis of the foulant deposited on the membrane)

(4) FT-IR (organic analysis of the foulant)

Note: SEM is the abbreviation of Scanning Electron Microscopy EDX (or, XMA) is the abbreviation of Energy Dispersive X-ray Microanalyzer.

4. Results

(1) General appearance

There was no deformation, breakage or leakage of the element.

(2) Rejection and flux measurement of elements

In Figure 1., the test results were shown. Although the all elements showed the permeate flux decline by about 15 to 30% compared with the out-going test results, there was no change in the rejection performance. The pressure drops of feed inlet and outlet within the elements were increased by about 10 to 30 %.

The above mentioned changes were more remarkably observed in the third bank elements which were located at the down stream, accordingly the phenomena of the membrane fouling are presumed.

For your reference, the data of RO pure water flux versus pressure were also shown in Fig. 1. All elements showed that the permeate fluxes proportionally were increased by the operation pressures.

(3) & (4) SEM , EDX(or, XMA) and FT-IR

The two elements of No.8070004(at inlet place of vessel in the first bank) and No.8070009(at outlet place of vessel in third bank) were disassembled and the sample membranes of which were analyzed.

In the table 2, results are shown. In particular, the down stream elements have large amounts of deposits which are grey and brownish foulants on the membrane surface. The foulants were identified as slime, bacteria and particles by the analysis of using SEM, EDX and FT-IR059. The particles consist of either silicates (coexisting with Al and Fe) or organic compound as the main component.

Among absorptions in FT-IR, amide compounds, ether bonding (-O-), methylene($-CH_2-$), hydroxyl(-OH) functional groups are presumed to be associated with bacteria and slime (also decomposed dead bacteria, metabolized, etc.,)

These analysis results are very similar to the former results (which was reported on December 28, 1990 by the technical paper R-0623).

5. Summary

(1) all elements showed the permeate flux decline by about 15 to 30 % compared with the out-going test results, there was no change in the rejection of NaCl test performance.

The pressure drops of feed inlet and outlet within the elements were increased by about 10 to 30 %.

As a conclusion, the changes more remarkably observed on the third bank elements were affected by the membrane fouling.

(2) On the membrane surface in particular, of the down stream elements, grey and brownish foulants were much accumulated.

The foulants were identified as slime, bacteria and particles. There are two types of particles which consist of either silicates (coexisting with Al and Fe) or organic compound as the main component.

(3) Since the actual operational flux data seemed to have had no pressure dependance in the RO plant, we examined the

pressure dependance on element flux with RO pure water as feed.

All elements have linear relationship between pressure and water flux.

We would like to suggest that the actual net driving pressure in the current RO plant should be checked if there are abnormal pressure gauges or the permeate-side pressures are significant.

(4) These analysis results are very similar to the former results (cf. the technical paper R-0623, reported on December 28, 1990).

Table 1. Element Performance of Rejection and Flux

Element Location	1st Bank,inlet	1st Bank,inlet
Lot No.	8070004	8070007
<u>Out-going Test</u>		
Rejection (%)	*99.6	*99.5
Flux(m^3/d), at 25°C	*31.2	*30.1
Pressure drop(kgf/cm^2)	0.2 to 0.3	0.2 to 0.3
Pure water Flux(m^3/d), at 25°C	34.6	34.5
<u>Returned Element Test</u>		
Rejection (%)	*99.4	*99.4
Flux(m^3/d), at 25°C	*26.8	*24.9
Pressure drop(kgf/cm^2)	0.33	0.30
Pure water Flux(m^3/d), at 25°C	29.6	28.2

Element Location	1st Bank,inlet	1st Bank,inlet
Lot No.	8070009	8070040
<u>Out-going Test</u>		
Rejection (%)	*99.6	*99.6
Flux(m^3/d), at 25°C	*32.1	*29.8
Pressure drop(kgf/cm^2)	0.2 to 0.3	0.2 to 0.3
Pure water Flux(m^3/d), at 25°C	32.4	31.5
<u>Returned Element Test</u>		
Rejection (%)	*99.5	*99.3
Flux(m^3/d), at 25°C	*21.2	*24.0
Pressure drop(kgf/cm^2)	0.38	0.35
Pure water Flux(m^3/d), at 25°C	23.6	27.3

Measuring conditions:
0.15% NaCl solution (pH 6.5),
Pressure = 15 kgf/cm^2, Concentrate flow rate = 90 liter/min
* Note: The out-going tests with NaCl solution were done by sampling several from the product for inspection, no data was taken, so typical RO performance which is close to the above lot number is listed.

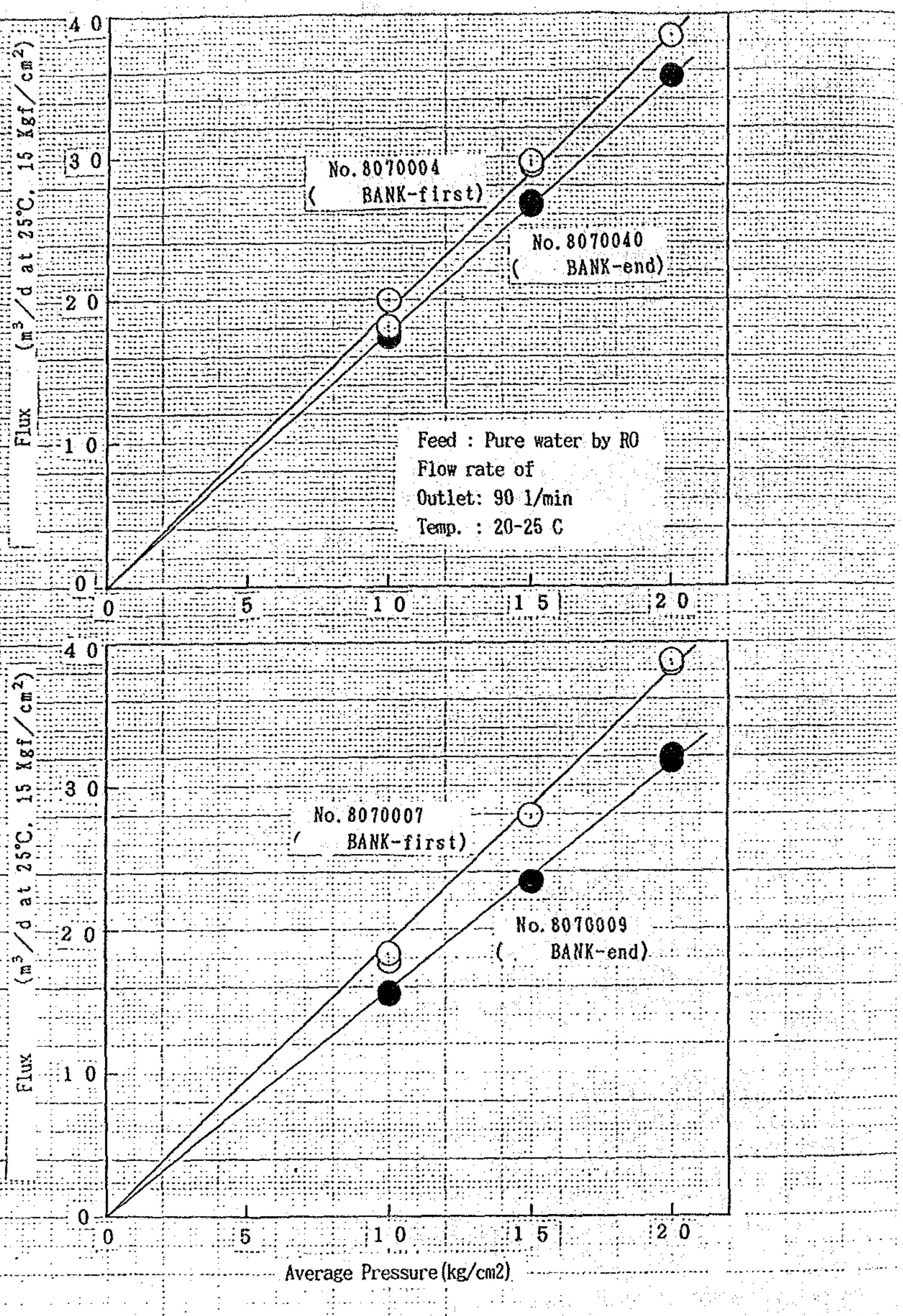


Fig. 1 Results of Flux Mesurement
(NTR759HR-S8)

Table 2-1 (Element Serial No.8070004, No.8070009)

	RESULT OF ANALYSIS	REFERENCE
Observation of disassembled element	(Sample No.8070004 at 1st Bank, inlet) Small amount of deposit of brownish foulant exists on membrane surface. (Photo 2 is a magnification of photo 1) (Sample No.8070009 at 3rd Bank, outlet) Large amounts of deposit of brownish and grey color foulant exists on the entire membrane surface. (Photo 4 is a magnification of photo 3)	Photo 1 through Photo 4
SEM	(Sample No.8070004) SEM 1, SEM 2 – Magnification of photo 2 show deposit of particles on the membrane surface. SEM 3, 4 & 5 – Magnification of SEM 1 & 2 show that foulant consists of particle and slime. (Sample No.8070009) SEM 6, SEM 7 – Magnification of photo 4 show the entire membrane surface was covered with deposit of particles, bacteria and slime. SEM 8, 9 & 10 – Magnification of SEM 6 & 7 show that the entire membrane surface was covered with deposit of large amounts of particle and slime. (Brownish portion of sample No.8070009) SEM 13,14 & 15 – Magnification of SEM 11 & 12 show that the entire membrane surface was covered with deposit of large amounts of particle and slime.	SEM1 through SEM15
EDX (XMA)	(Sample No.8070004 at 1st Bank, inlet) XMA 1 – Surface analysis of SEM 1 shows that inorganics are less than the detectable limits. (The particles are organics) XMA 2 – Analysis of spot 1 on the SEM 3 shows that: Particle 1 & 4: inorganics as Fe Spot 2, Particle 3 & 4: inorganics is less than the detectable limits. (The particles are organics.) XMA 3 – Analysis of particle 6 on the SEM 4 shows that: Particle 6: inorganics as Si Particle 7 & 8: inorganics are less than the detectable limits.	XMA 1 through XMA 12

(The particles are organics)
Particle 9: inorganics as Fe
Particle 10: inorganics as Fe and Si

XMA 4 - Analysis of particle 11 on the SEM 5 shows that:
Particle 11: inorganics as Si,Al,Fe and Ca
Particle 12: inorganics as Si and Al
Particle 13: inorganics as Si
Particle 14: inorganics are less than the detectable limits.
(The particles are organics)
Particle 15: inorganics as Si and Fe.

(Sample No.8070009 at 3rd Bank, outlet)
XMA 5 - Surface analysis of SEM 6 shows that inorganics are less than the detectable limits.
(The particles are organics)

XMA 6 - Analysis of particle 16 on the SEM 8 shows that:
Particle 16 &18: inorganics as Fe, Si and Al
Particle 17 & 21, Spot 20: inorganics are less than the detectable limits.
(The particles are organics)
Particle 19: inorganics as Fe and Si.

XMA 7 - Analysis of particle 22 on the SEM 9 shows that:
Particle 22: inorganics as Si,Al,K
Particle 23 & 25: inorganics are less than the detectable limits.
(The particles are organics)
Particle 24: inorganics as Si, AL, and Fe
Particle 26: inorganics as Si, Al, K and Fe.

XMA 8 - Analysis of particle 27 on the SEM 10 shows that:
Particle 27: inorganics as Si,Al,Ca
Particle 28: inorganics as Si, Al, K
Particle 29: inorganics as Si, Al, and Fe.
Particle 30: inorganics are less than the detectable limits.
(The particles are organics)
Particle 31: inorganics as Si

(Brownish portion of sample No.8070009)
XMA 9 - Surface analysis of SEM 11 shows that inorganics are less than the detectable limits. (The particles are organics)

XMA 10 - Analysis of particle 32 on the SEM 13 shows that:

Particle 32: inorganics as Si,Al, K
Particle 33: inorganics as Si,Al,Fe and K
Particle 34 & 35: inorganics are less than the detectable limits.
(The particles are organics)

XMA 11 - Analysis of particle 36 on the SEM 14 shows that:

Particle 36: inorganics as Si, Fe
Particle 37: inorganics as Si, Al
Particle 38: inorganics are less than the detectable limits.
(The particles are organics)
Particle 39: inorganics as Si,Al,K

XMA 12 - Analysis of Particle 40 on the SEM 15 shows that:

Particle 40: inorganics as Si, Fe, P
Particle 41: inorganics as Fe
Particle 42,44: inorganics as Si
Particle 43: inorganics as Si,Al,K,Fe
Particle 45: inorganics as Si,Al

FT-IR

(Sample No.8070004 at 1st Bank, inlet)
Fig 2 - The differential spectrum between the surface of photo 2 new membrane, which represents IR spectrum of the foulants on the membrane surface. Fig 2

(Sample No.8070009 at 3rd Bank, outlet)
Fig 3 - The differential spectrum between the surface of photo 4 new membrane, which represents IR spectrum of the foulants on the membrane surface. Fig 3

In the both Figures, the similar peaks are observed.
The peaks at 400 to 600 cm^{-1} are presumed to be the absorption of inorganics like Si and Fe compounds.
The following peaks are presumed to be:
at 1050 cm^{-1} for -O- group,
at 1550,1650 cm^{-1} for amide compounds, and
at 3300 to 3400 cm^{-1} for -OH group
respectively.

Note: On the EDX(or,XMA) the peak of S came from the support layer material of the polysulfon membrane and that of Au came from its vaporization on the samples.
They are not foulants.

(1-Inlet, No. 8070004)

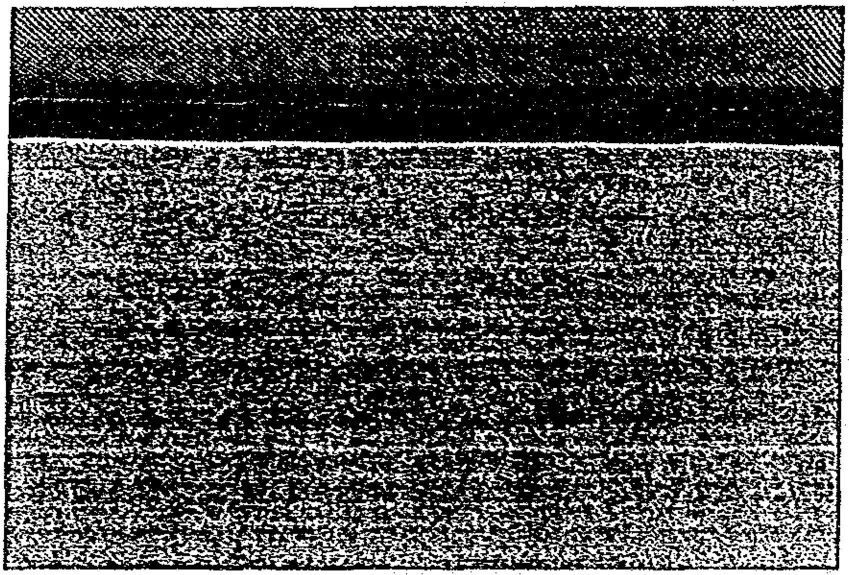


Photo. 1

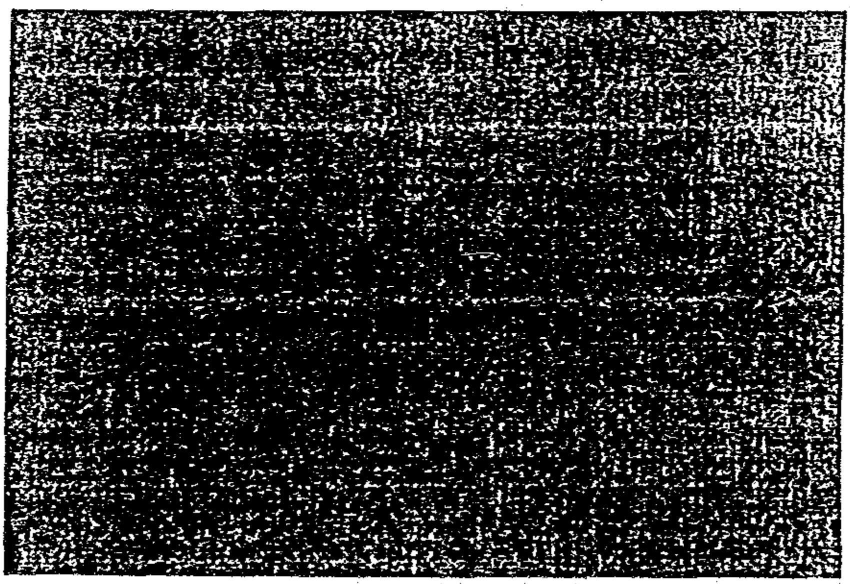


Photo. 2

(3-outlet, No. 8070009))

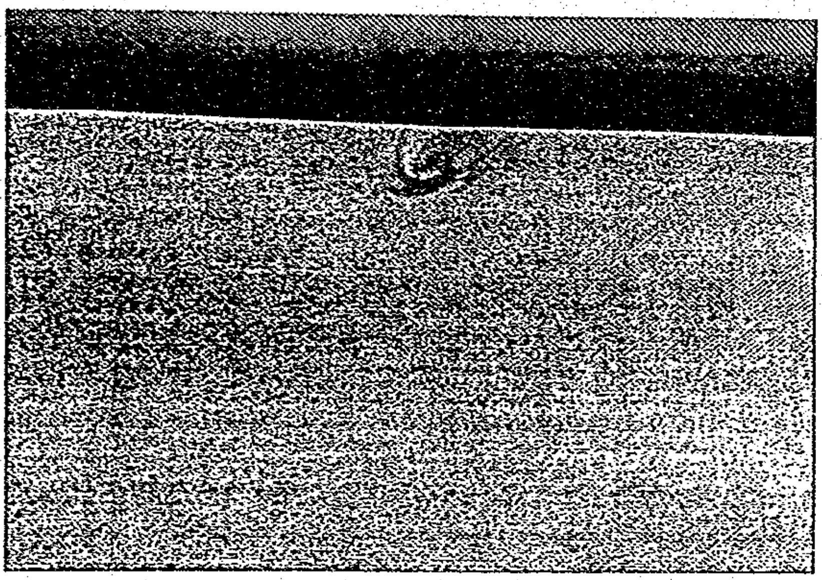


Photo. 3

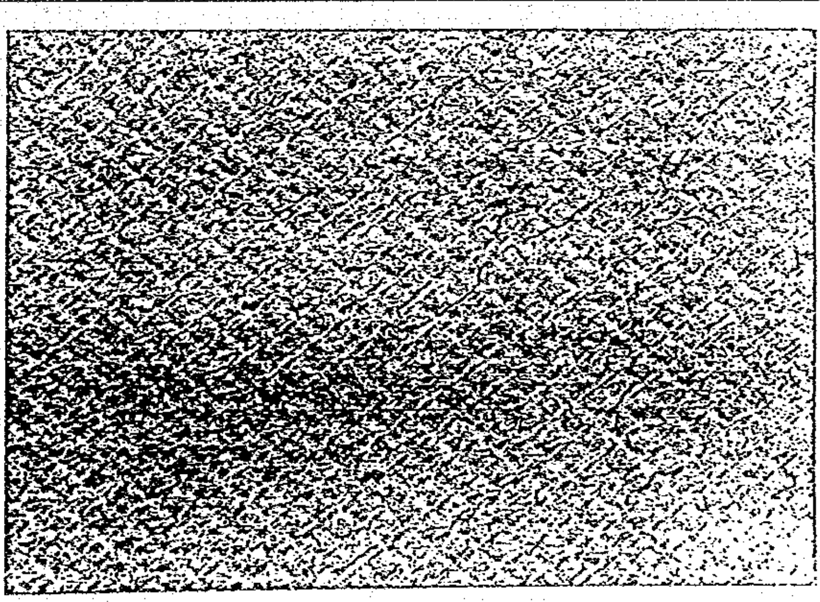
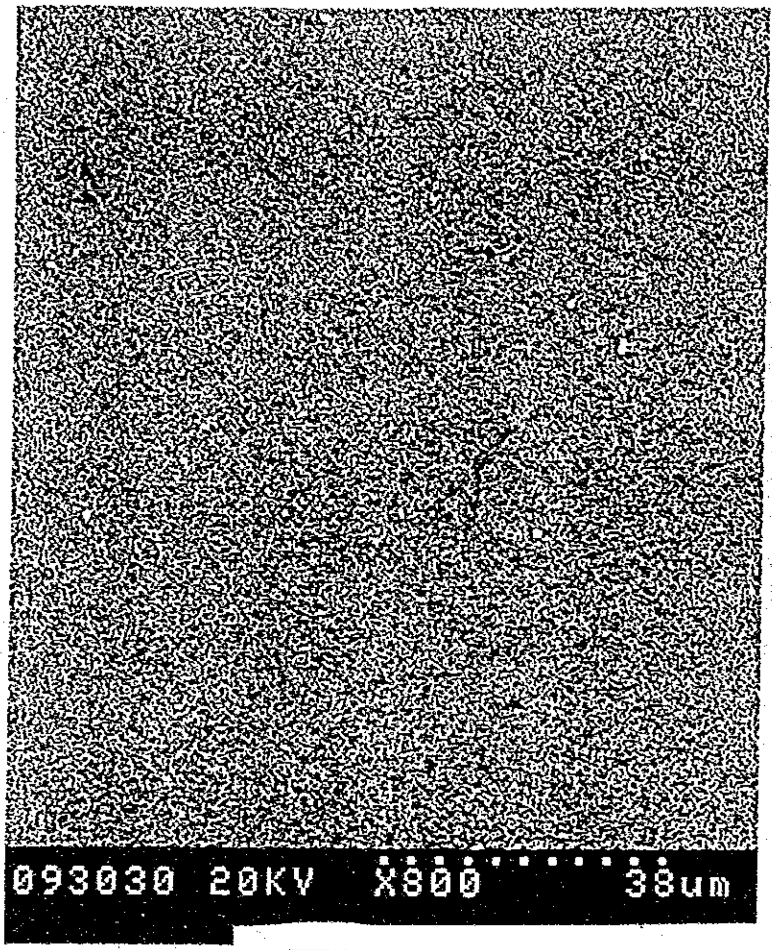
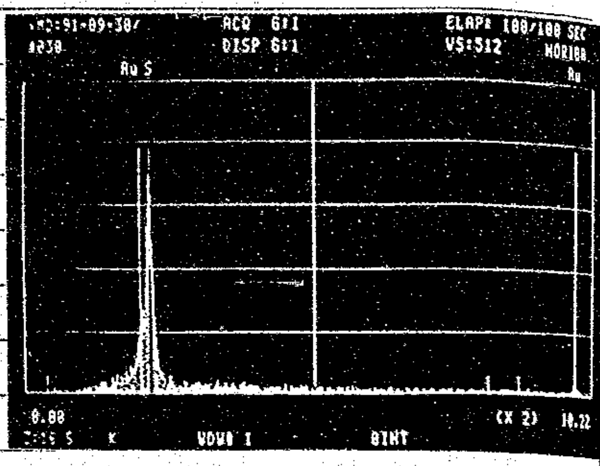


Photo. 4

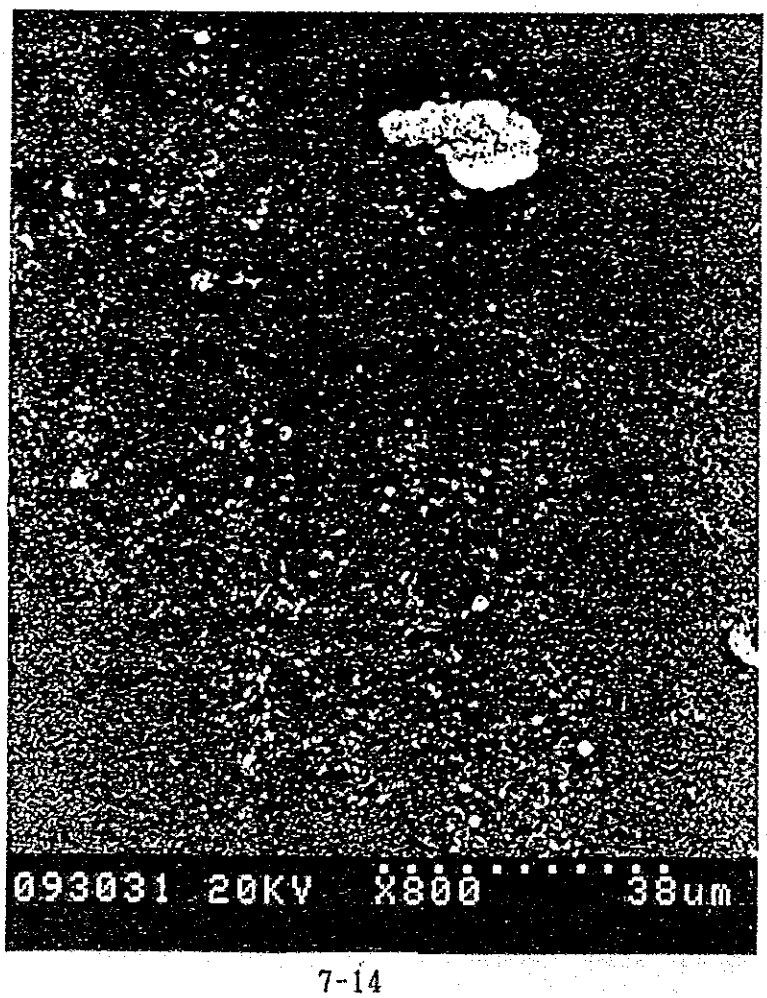
(1-Inlet, No. 8070004)



-SEM1

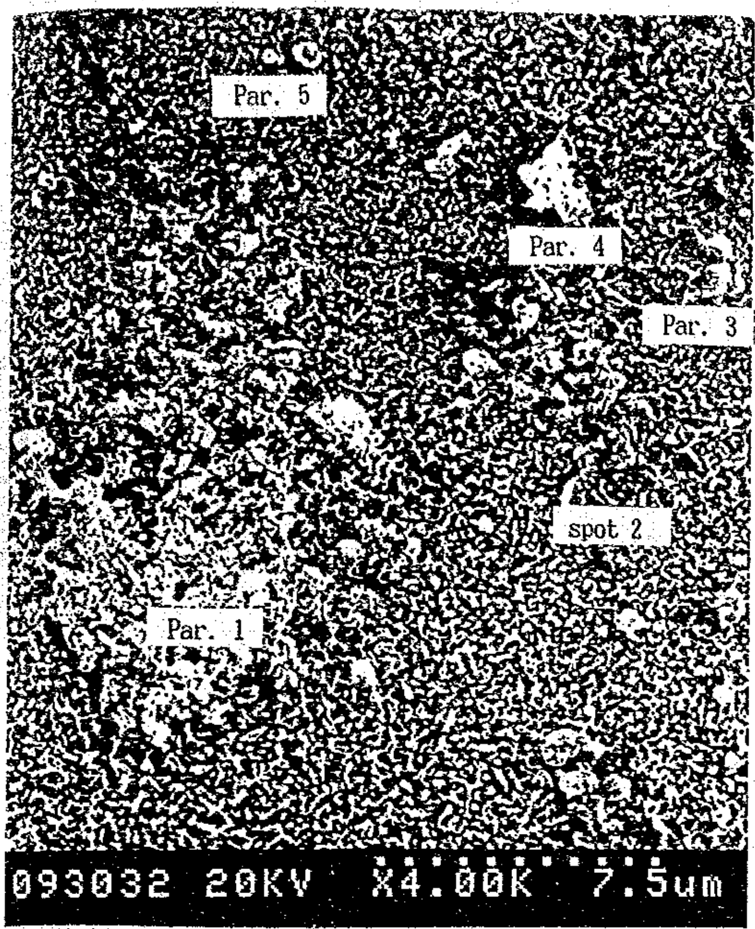


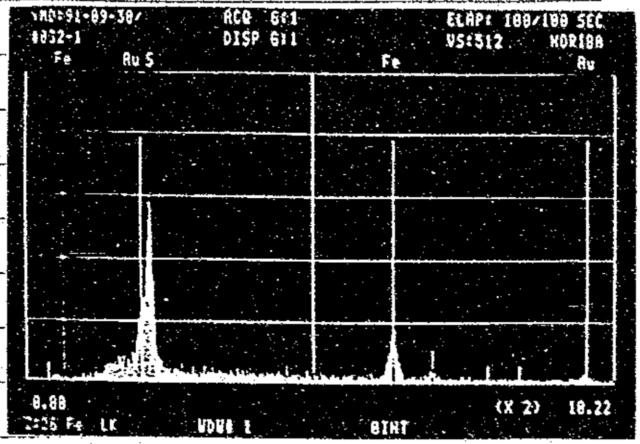
XMA1



-SEM2

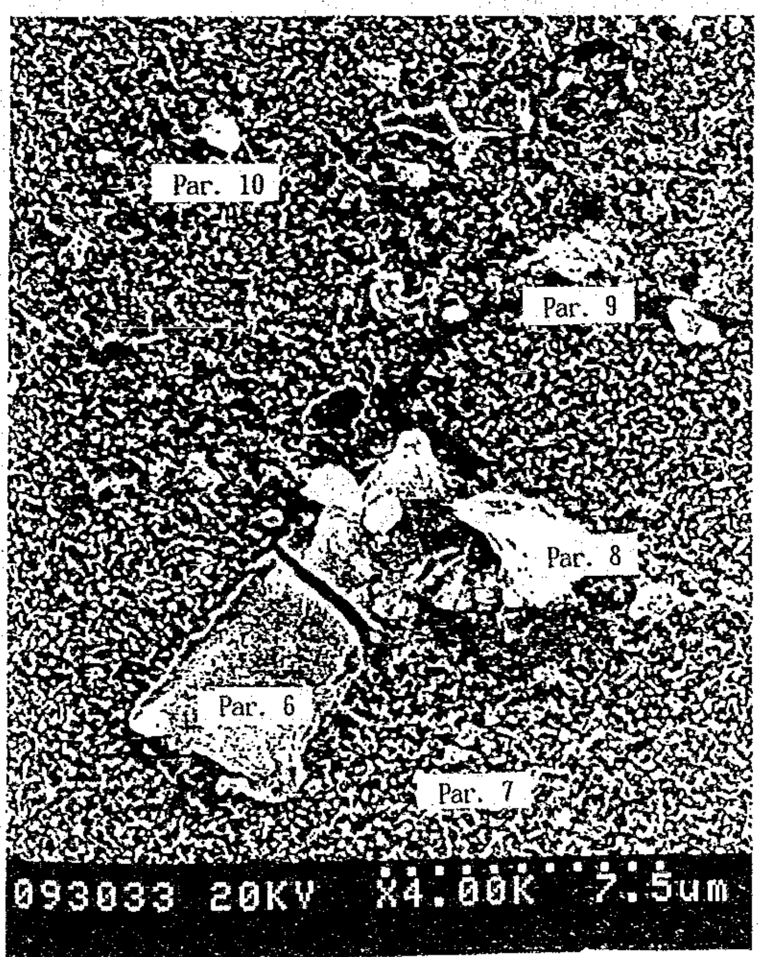
(1-Inlet, No. 8070004)

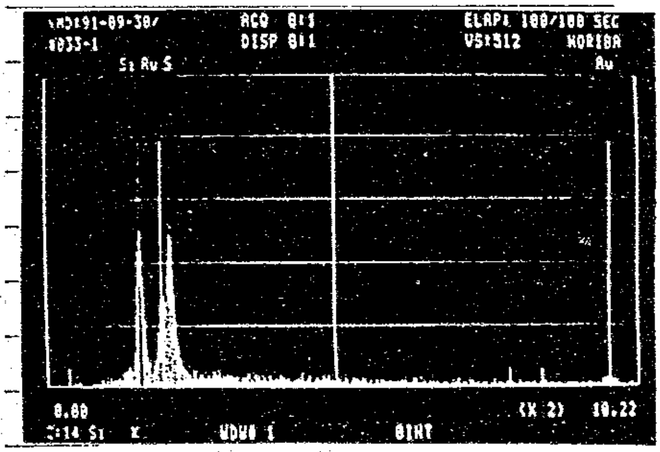




XMA 2

SEM 3

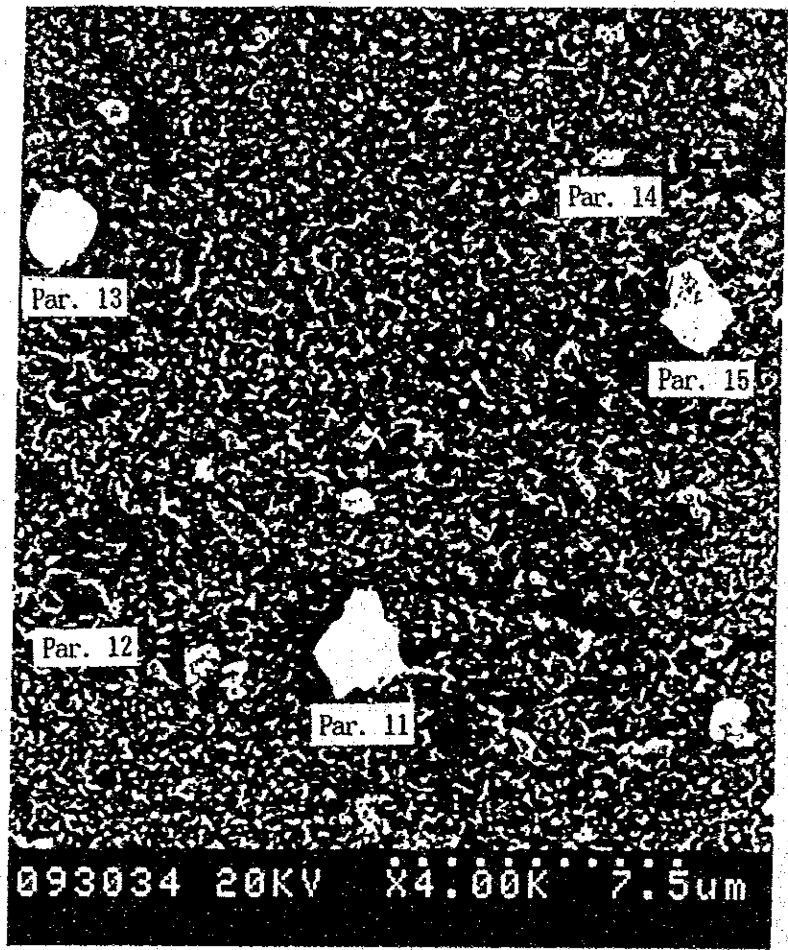




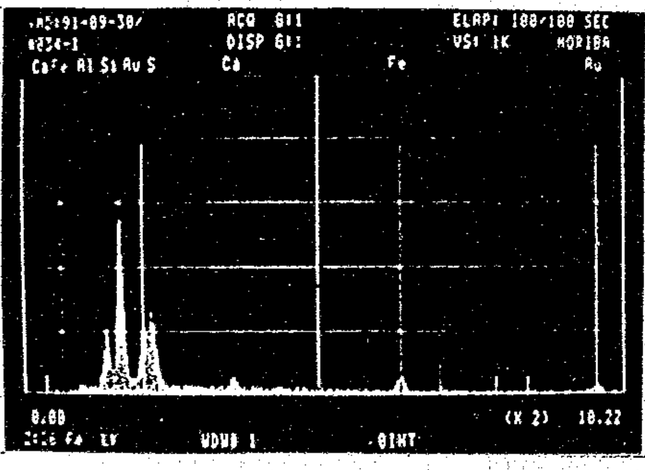
XMA 3

SEM 4

(1-Inlet, No. 8070004)

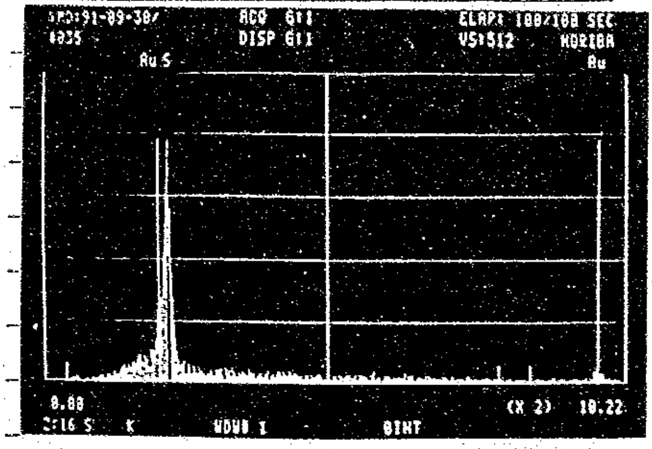


SEM 5

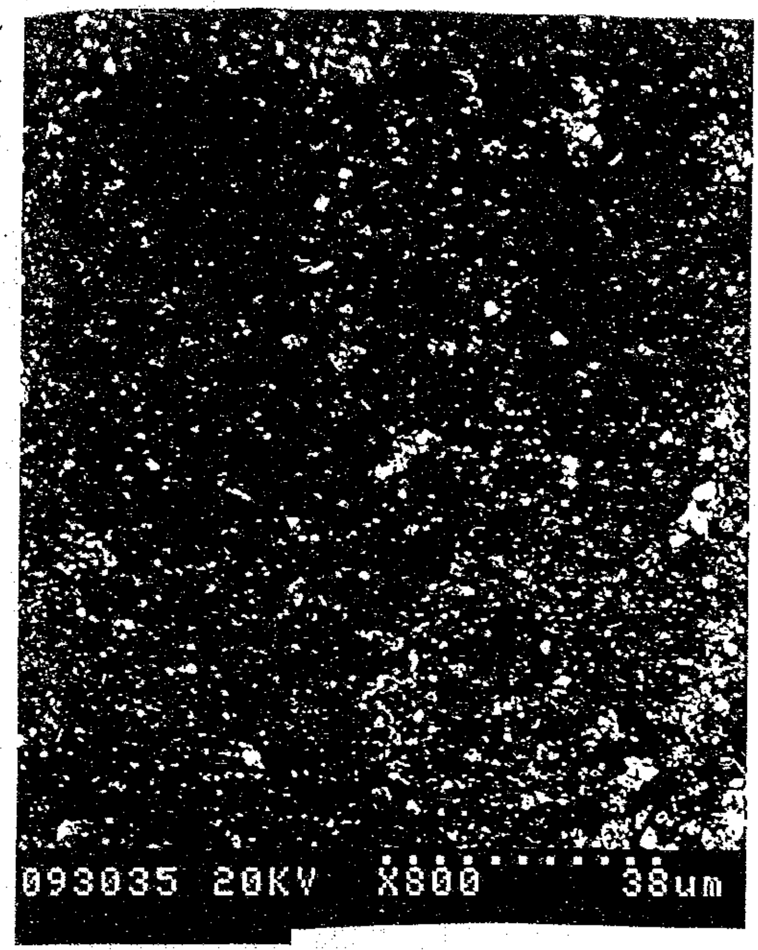


XMA 4

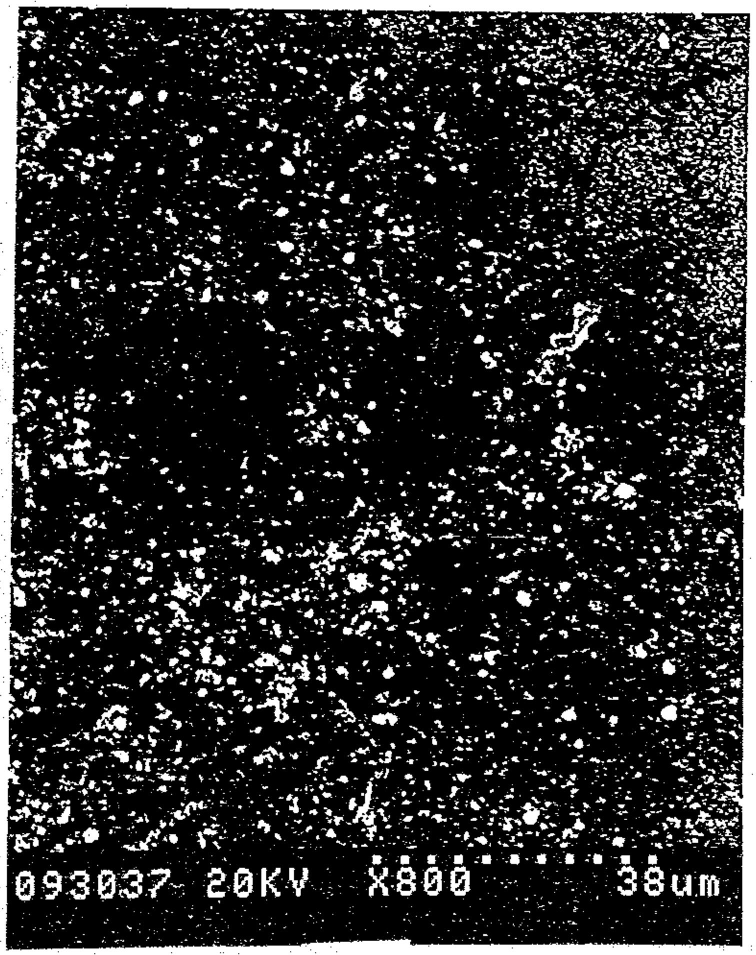
(3-Outlet, No. 8070009)



XMA 5

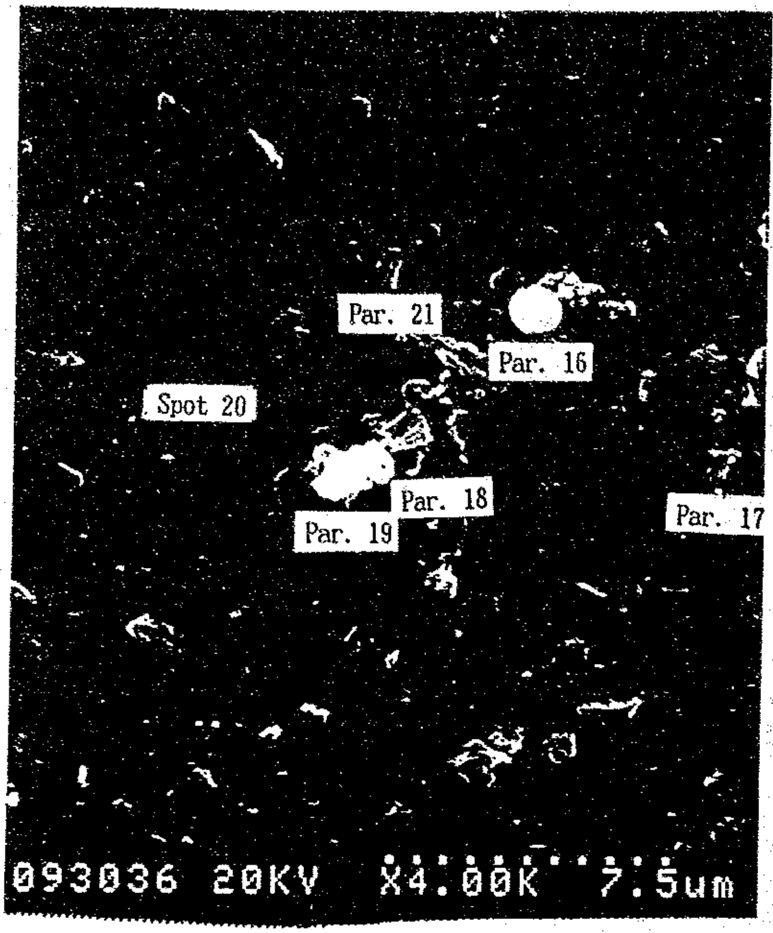


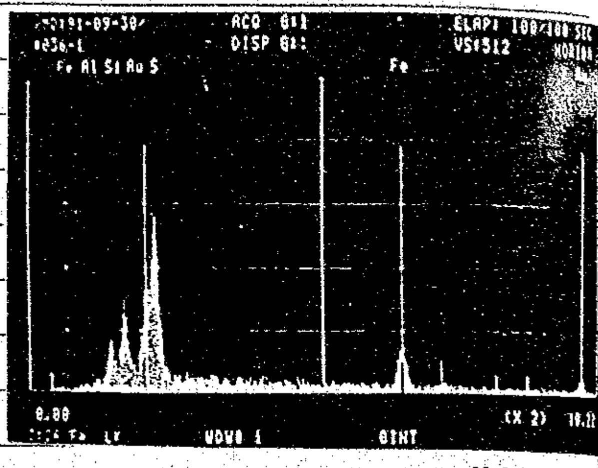
SEM 6



SEM 7

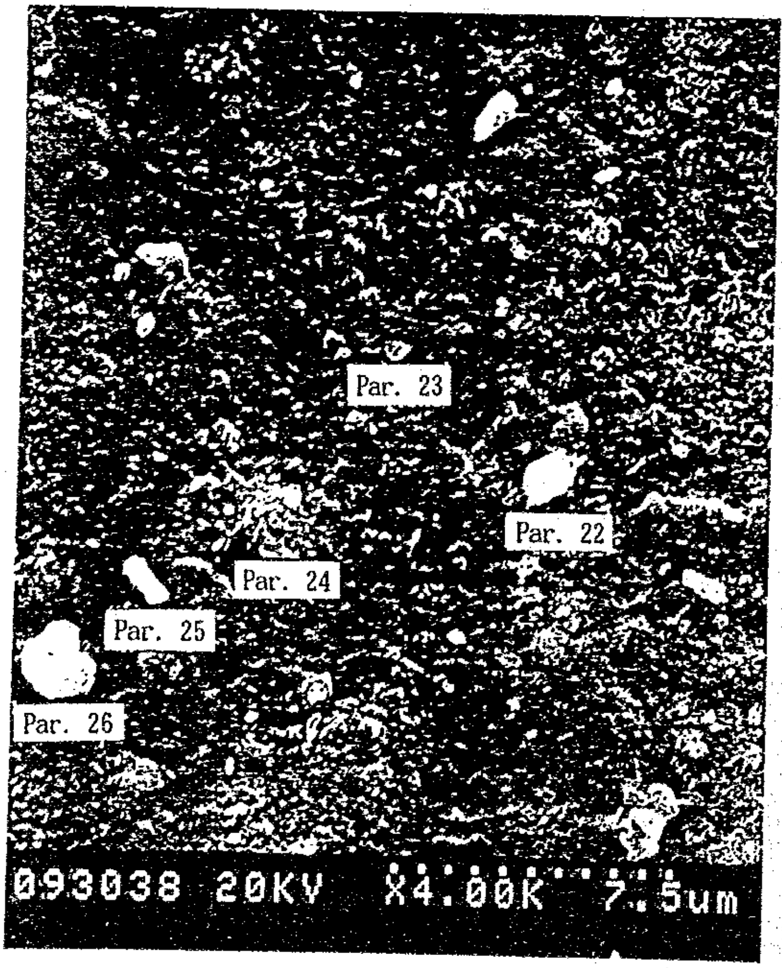
(3-Outlet. No. 8070009)

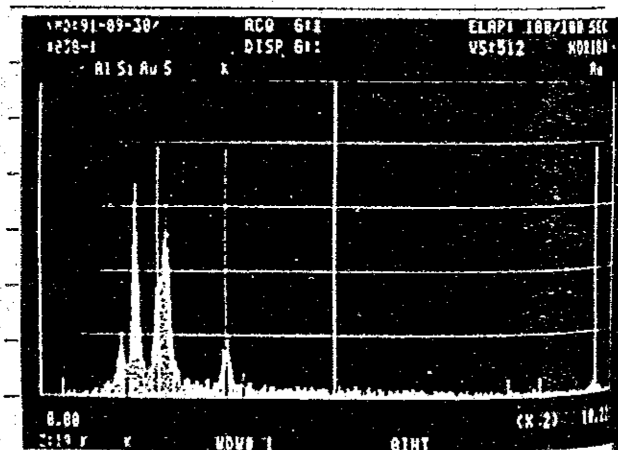




XMA 6

SEM 8

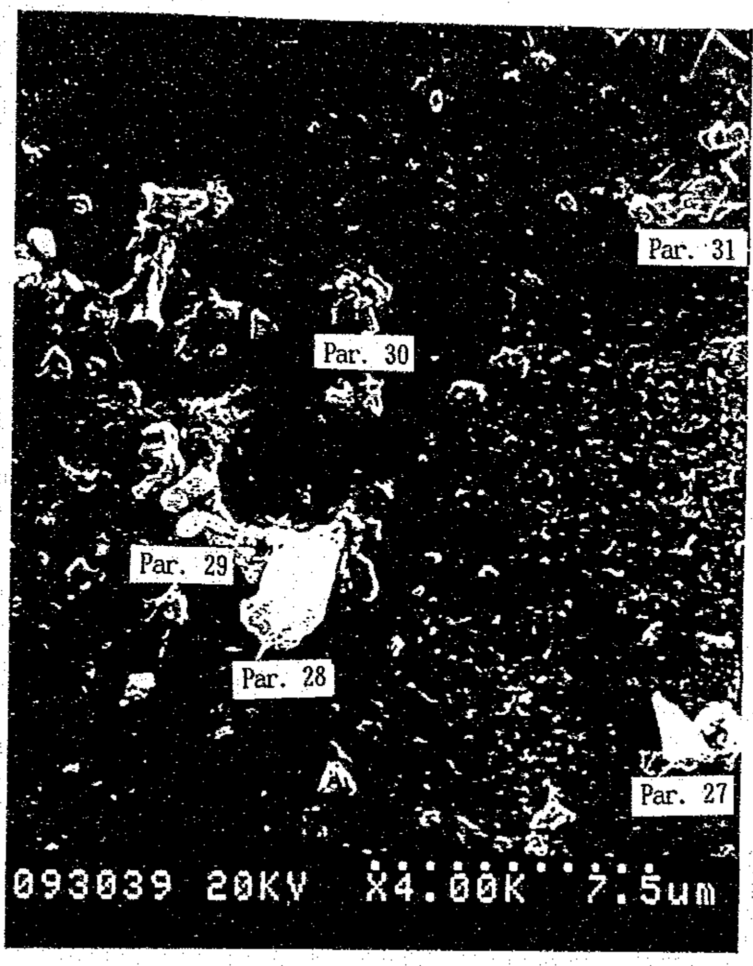




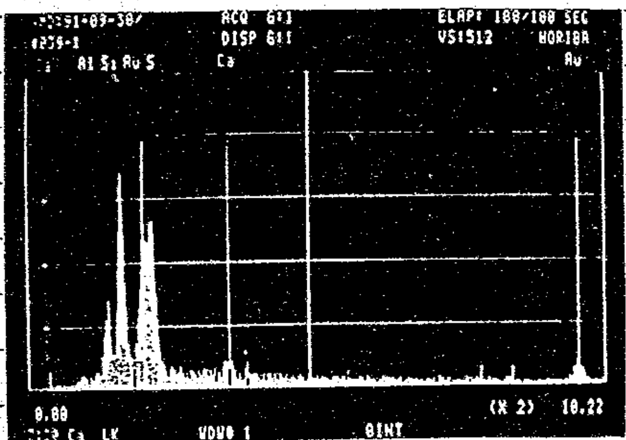
XMA 7

SEM 9

(3-Outlet, No. 8070009)

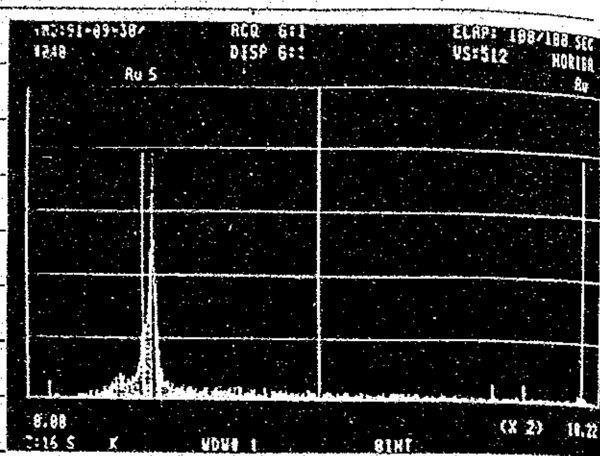


SEM10

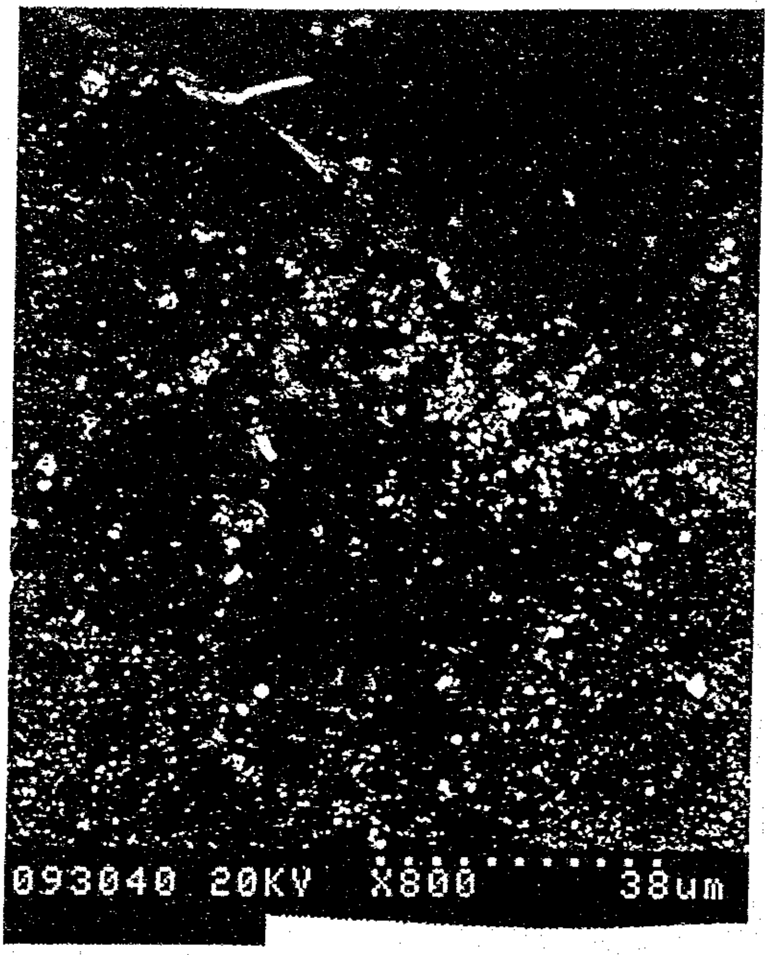


XMA8

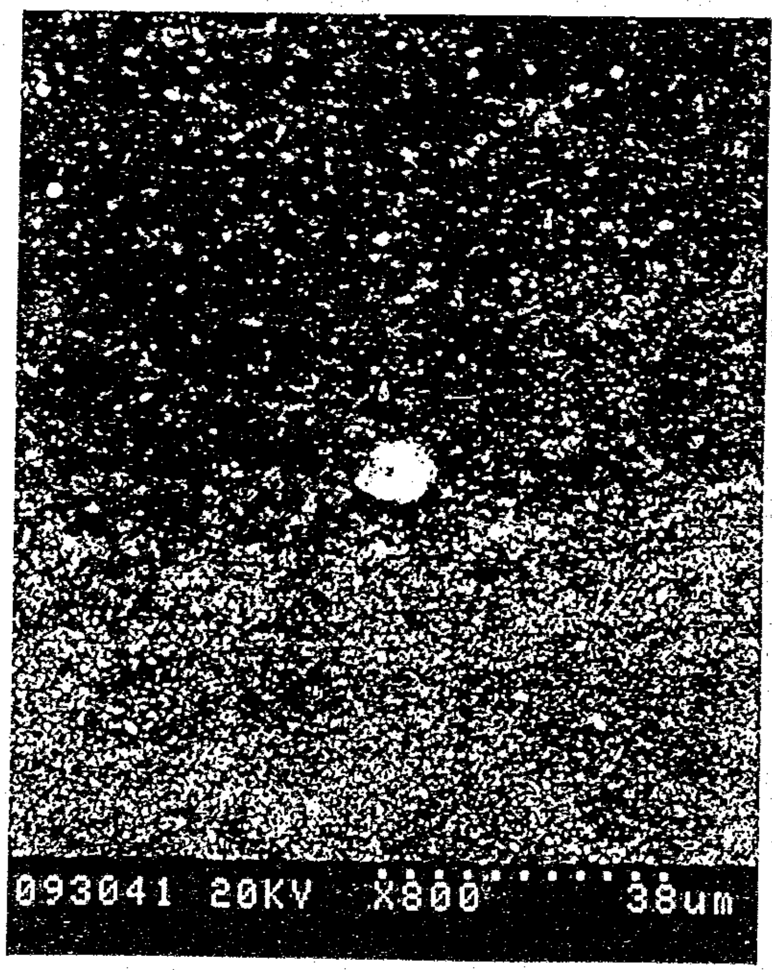
(3-Outlet, No. 8070009)



XMA 9

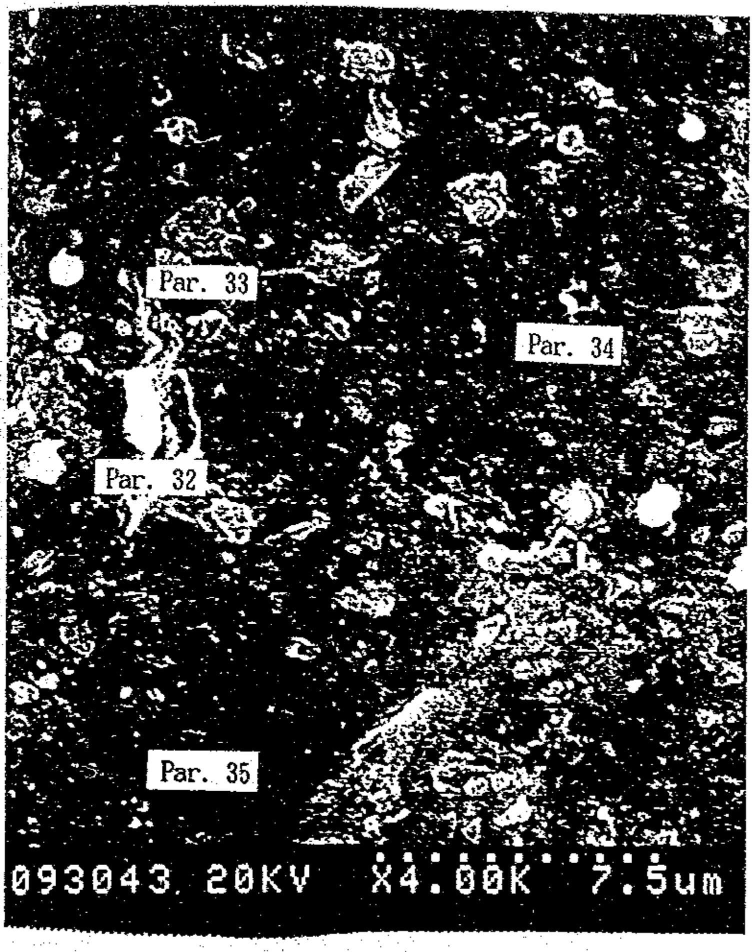


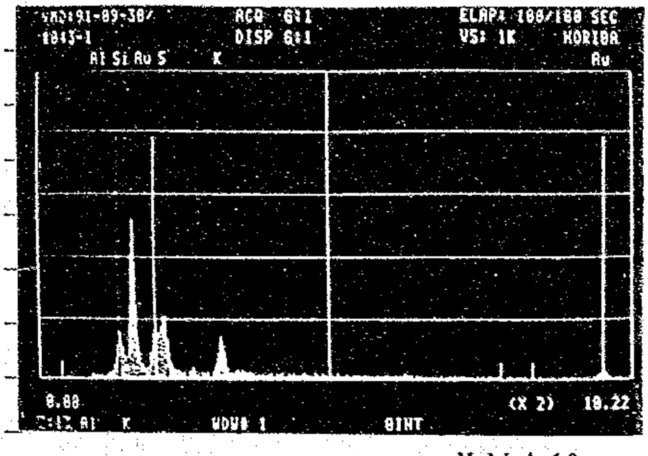
SEM11



SEM12

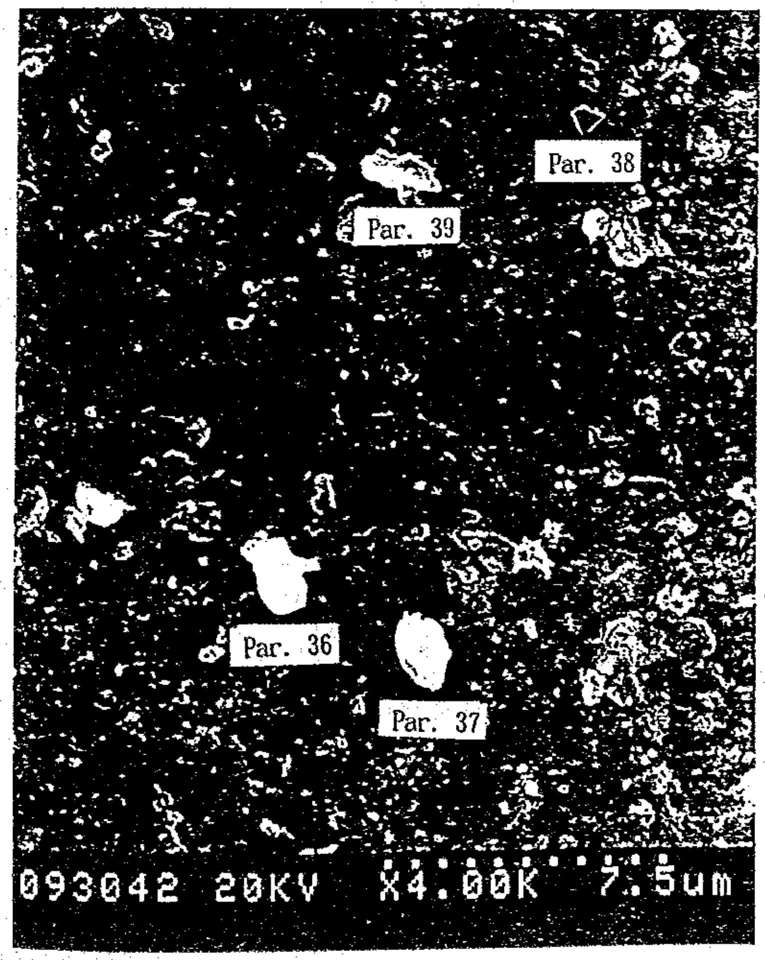
(3-Outlet.No.8070009)

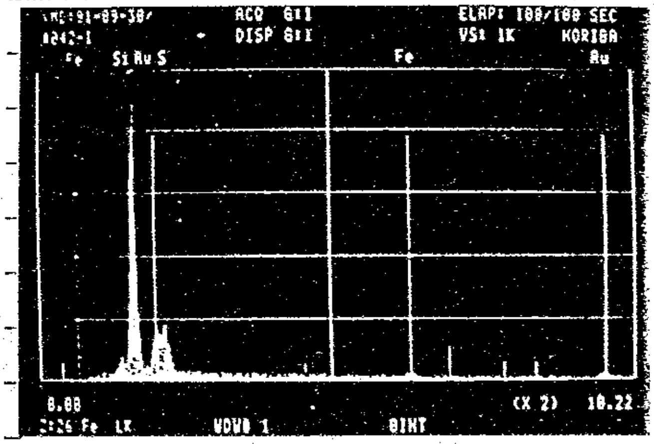




XMA10

—SEM13—

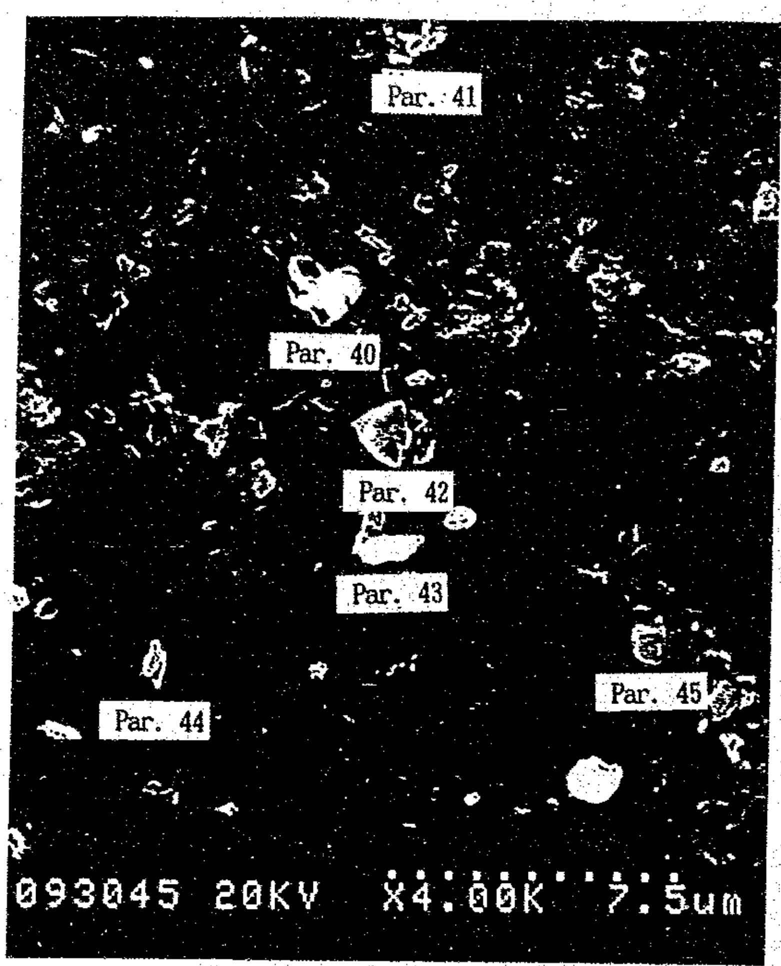




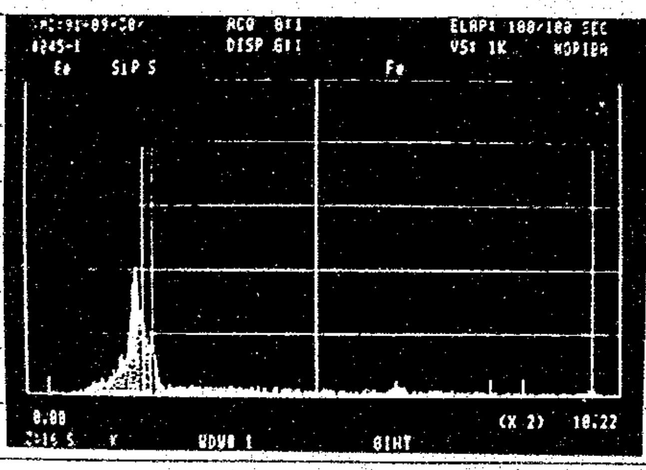
XMA11

—SEM14—

(3-Outlet, No. 8070009)



SEM15



XMA12

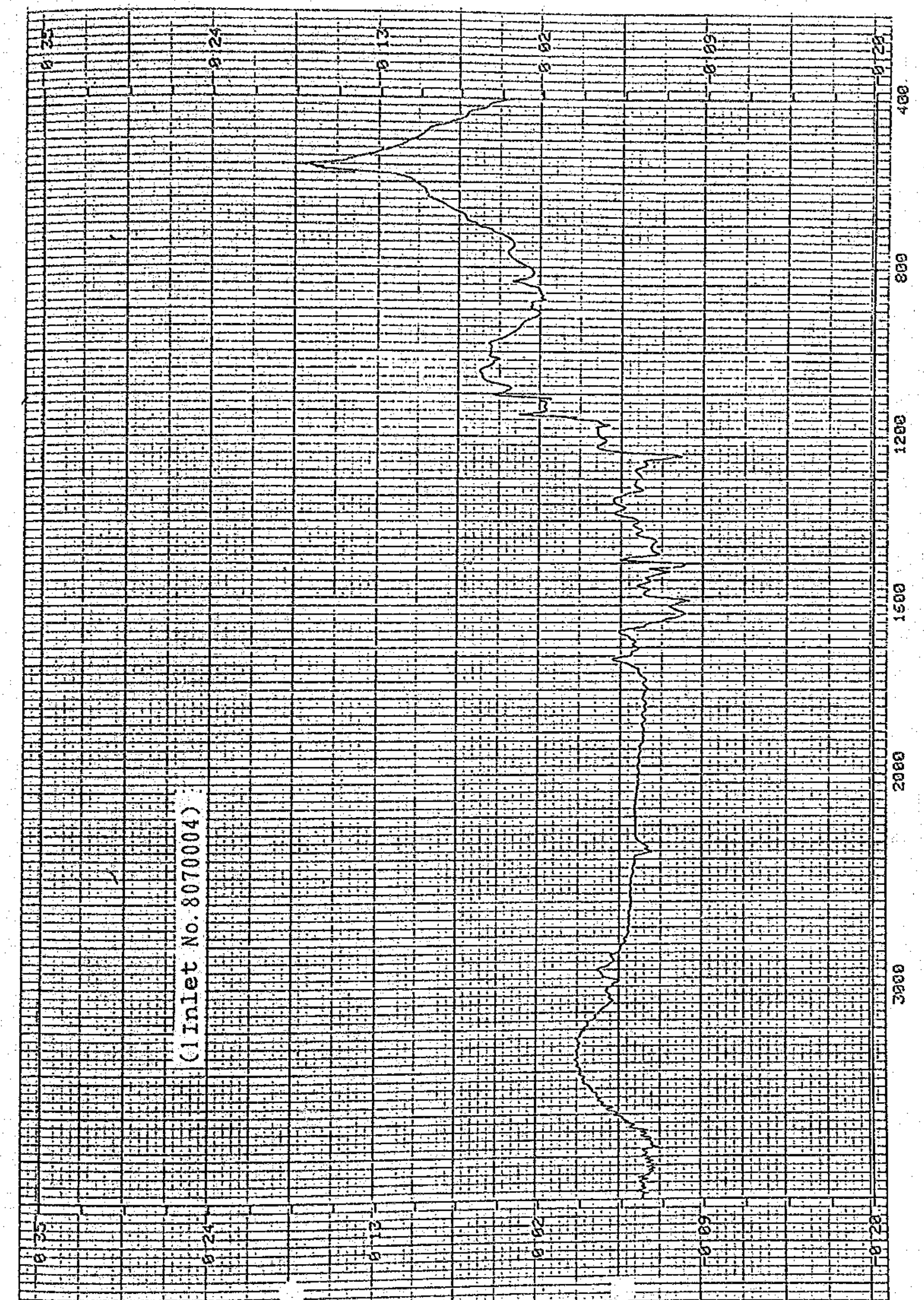

(1 Inlet No.8070004)
0.35
0.24
0.13
0.02
-0.09
-0.20
400
800
1200
1600
2000
3000

Fig 2

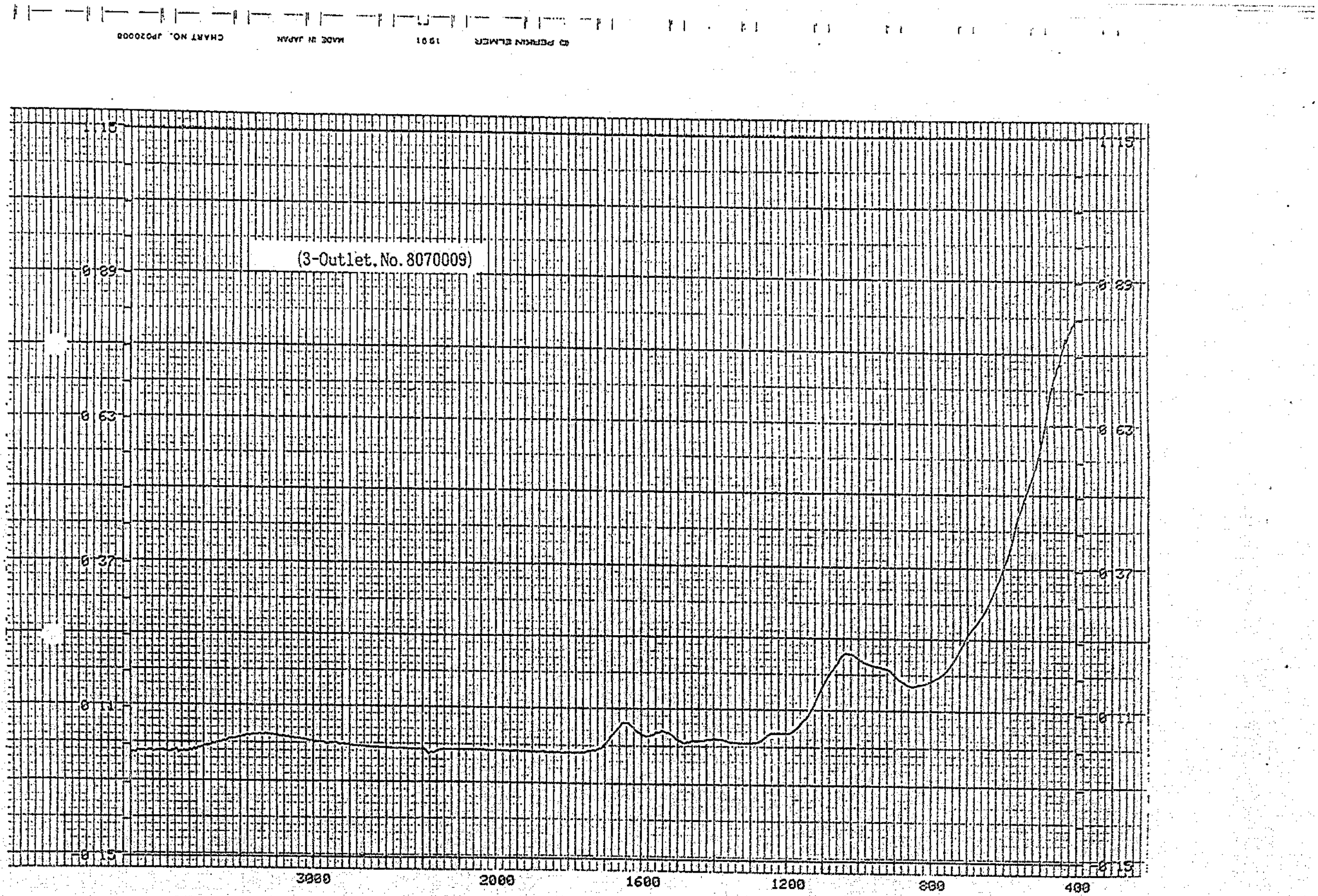


Fig 3

R６－２　文献検索結果

文献調査

最近の MSF 及び ROに関する過去 10 年間の文献について検索を行った。
検索に使用したﾃﾞｰﾀﾍﾞｰｽはSTN の CA を使用し、検索手順及びｷｰﾜｰﾄﾞは次のとおり、

ｽﾃｯﾌﾟ	ｷｰﾜｰﾄﾞ	件数	
1	MSF	165	
	MULTISTAGE	5123	
	FLASH	8912	
	MULTISTAGE FLASH	521	
	MSF OR MULTISTAGE FLASH	596	L8
2	RO	2195	
	REVERSE	16249	
	OSMOSIS	8460	
	REVERSE OSMOSIS	6780	
	SWRO	2	
	RO OR REVERSE OSMOSIS OR SWRO	8819	L9
3	HYBRID	14217	L10
4	L8 OR L9	21	L11
5	HYBRID	14217	
	DESALT	1441	
	DESALINAT?	7589	
	HYBRID AND (DESALT OR DESALINAT)	18	L12
6	L11 OR L12	28	L13
7	ENGLISH	5896525	
	JAPANESE	1032382	
8	L13 AND (ENGLISH OR JAPANESE)	23	L14

抽出した文献数は２３件であった。このうちRO法に関するものが 18 件と一番多く、このうちMSFとの組合せに関するものが 6 件である。このほか、透過気化（PV)法との組合せが 4 件、ED 法との組合せが 3 件、UF 膜との組合せが 2 件、その他の組合せが 3 件であった。

文献調査の結果、ﾊｲﾌﾞﾘｯﾄﾞRO法の膜選定に関する実験はこれまで行われていなかった。

また、種々の試算によればﾊｲﾌﾞﾘｯﾄﾞ法として MSF法と組合せることによってROの建設費と運転費が RO 単独よりも10 %低下する。[(2)] また、発電を組み込んだMSF法とのﾊｲﾌﾞﾘｯﾄﾞの場合は次のような利点が上げられている。[(3)]

(1)共通の取水が可能なこと。

(2)RO法設備の電力は付属の発電設備から供給できること。

(3)MSF法とRO法の生産水を混合して得られた水はＷＨＯの基準を満足すること。

(4)造水コストが単独のRO法に較べて 10～15%減少する。

(5)高回収率が採用できることから取水及び前処理関係費が減少する。

(6)RO法の第２段目が不用となる。

(7)膜交換率が低下する。

(8)エネルギー消費量が減少する。

しかし、これらの試算では、このようなﾊｲﾌﾞﾘｯﾄﾞ法に適合するためには従来の膜性能では運転圧力を 80 Kg/cm^2 もの高圧力の耐久性を持った RO膜が必要であり、高回収率運転ができる塩排除率が必要とされる。

海水淡水化ﾊｲﾌﾞﾘｯﾄﾞ法に関する文献

1．使用ﾃﾞｰﾀﾍﾞｰｽ　STN FILE CA
2．検索期間
3．検索結果

```
=> S MSF OR MULTISTAGE FLASH
            165 MSF
           5123 MULTISTAGE
           8912 FLASH
            521 MULTISTAGE FLASH
                  (MULTISTAGE(W)FLASH)
L8          596 MSF OR MULTISTAGE FLASH

=> S RO OR REVERSE OSMOSIS OR SWRO
           2195 RO
          16249 REVERSE
           8460 OSMOSIS
           6780 REVERSE OSMOSIS
                  (REVERSE(W)OSMOSIS)
              2 SWRO
L9         8819 RO OR REVERSE OSMOSIS OR SWRO

=> S HYBRID
L10       14217 HYBRID

=> S (L8 OR L9) AND L10
L11          21 (L8 OR L9) AND L10

=> S HYBRID(L)(DESALT? OR DESALINAT?)
          14217 HYBRID
           1441 DESALT?
           7589 DESALINAT?
L12          18 HYBRID(L)(DESALT? OR DESALINAT?)

=> S L11 OR L12
L13          28 L11 OR L12

=> S L13 AND (ENGLISH OR JAPAN)/LA
        5896525 ENGLISH/LA
        1032382 JAPAN/LA
L14          24 L13 AND (ENGLISH OR JAPAN)/LA

=> S L14 NOT P/DT
        1602145 P/DT
L15          23 L14 NOT P/DT
```

抄録付きで出力

```
L16  ANSWER 1 OF 23  COPYRIGHT 1991 ACS
AN   CA114(16):145961w
TI   Pervaporation-based hybrid systems
AU   Ray, Rod; Friesen, Dwayne; Wytcherley, Randi; Schofield, Richard
LO   USA
SO   Proc. Int. Conf. Pervaporation Processes Chem. Ind., 4th, 200-14.
     Edited by: Bakish, Robert A.  Bakish Mater. Corp.: Englewood, N. J.
SC   48-1 (Unit Operations and Processes)
DT   C
CO   56XCAO
PY   1989
```

LA Eng
AN CA114(16):145961w
AB The concept of a pervaporation-based hybrid system is described for use in sepg. a process stream into 2 streams, one enriched in the solute and the other enriched in the solvent. In this hybrid system, a solute-removal unit operation (pervaporation) is balanced with a solvent-removal unit operation (reverse osmosis) to enable each unit to operate under conditions as close to optimum as possible; thus, the unit operations work synergistically as an efficient system. In the example presented, a pervaporation/reverse-osmosis hybrid system performs a sepn. that neither membrane process can perform alone. Such a hybrid system can offer the flexibility needed to sustain optimum performance, accommodating changes in membrane performance or fluctuations in the compn. of the feed stream that inevitably occur over time.

L16 ANSWER 2 OF 23 COPYRIGHT 1991 ACS
AN CA112(12):104488n
TI Hybrid desalting systems
AU Awerbuch, Leon; May, Sherman; Soo-Hoo, Randall; Van der Mast, Victor
CS Bechtel Group Inc.
LO San Francisco, CA, USA
SO Desalination, 76(1-3), 189-97
SC 61-4 (Water)
SX 48, 52
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(12):104488n
AB Currently, most large scale seawater desalination plants are dual-purpose multistage flash plants producing both power and desalinated water. These plants produce high purity distd. water and provide excess elec. power for sale at a typical ratio of 10 MW/Mgal-day.

L16 ANSWER 3 OF 23 COPYRIGHT 1991 ACS
AN CA112(12):104487m
TI Optimum design for a hybrid desalting plant
AU Al-Mutaz, I. S.; Soliman, M. A.; Daghthem, A. M.
CS Coll. Eng., King Saud Univ.
LO Riyadh 11421, Saudi Arabia
SO Desalination, 76(1-3), 177-87
SC 61-4 (Water)
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(12):104487m
AB Two stage reverse osmosis desalination plants require only 1/2 of the multistage flash installation cost while producing water with comparable price. By combining seawater reverse osmosis plants with the dual purpose multistage flash plants, the capital and operating costs can be reduced and the excess power can be efficiently utilized. The design parameters for such a hybrid plant are the applied pressure, the recovery, the no. of stages, and heat transfer areas for the multistage flash plant. Different cost scenarios are suggested and their effect on the optimum parameters are

investigated. Significant savings can be obtained from upgrading of multistage flash and reverse osmosis plants instead of hybridization.

L16 ANSWER 4 OF 23 COPYRIGHT 1991 ACS
AN CA112(12):104358v
TI Prospects of hybrid RO [reverse osmosis]-MSF [multistage flash] desalting plants in Kuwait
AU Al-Marafie, A. M. R.
CS Coll. Eng. Pet., Kuwait Univ.
LO Kuwait 13060, Kuwait
SO Desalination, 72(3), 395-404
SC 61-0 (Water)
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(12):104358v
AB A review with 9 refs. discusses the economic feasibility of a hybrid single-stage reverse osmosis-multistage flash desalination plant and the benefits that Kuwait could accrue if such a system is implemented. Topics covered include water consumption pattern in Kuwait, features of a hybrid system, and the economics of a hybrid reverse osmosis-multistage flash desalination plant.

L16 ANSWER 5 OF 23 COPYRIGHT 1991 ACS
AN CA112(12):104353q
TI Integrated production of power and water
AU Al-Sofi, Mohamed Abdul Kareem
CS Saline Water Convers. Corp.
LO Alkhobar 31952, Saudi Arabia
SO Desalination, 76(1-3), 89-105
SC 61-0 (Water)
SX 48
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(12):104353q
AB The review and discussion, with 16 refs., covers integrated prodn. of power and water, including seawater desalination, reverse osmosis, multistage flash evapn., hybrid water desalination plants, and system flexibility and reliability.

L16 ANSWER 6 OF 23 COPYRIGHT 1991 ACS
AN CA112(10):83736z
TI Process arrangements for hybrid seawater desalination plants
AU Kamal, I.; Schneider, W.; Tusel, G. F.
LO Homburg/Saar, Fed. Rep. Ger.
SO Desalination, 76(1-3), 323-35
SC 61-4 (Water)
SX 52
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(10):83736z

AB The combination of 2 once-through multistage flash (MSF) desalination plants, or once-through MSF and reverse osmosis with power recovery, can lead to more economical plant designs than the brine recycle process currently used. Various combinations are compared wih a ref. case to illustrate the considerable power savings and improvement in the overall cost.

L16 ANSWER 7 OF 23 COPYRIGHT 1991 ACS
AN CA112(6):38583m
TI Dehydration of multicomponent organic systems by a reverse osmosis/pervaporation hybrid process. Module, process design and economics
AU Rautenbach, R.; Herion, C.; Franke, M.
CS Inst. Verfahrenstech., RWTH Aachen
LO Aachen D-5100, Fed. Rep. Ger.
SO Proc. Int. Conf. Pervaporation Processes Chem. Ind., 3rd, 274-86. Edited by: Bakish, Robert A. Bakish Mater. Corp.: Englewood, N. J.
SC 45-4 (Industrial Organic Chemicals, Leather, Fats, and Waxes)
DT C
CO 56POAK
PY 1988
LA Eng
AN CA112(6):38583m
AB For the recovery of a solvent mixt. from an aq. mixt., a process was developed consisting of reverse osmosis (RO) and phase sepn. in a first stage. The aq. phase of the separator was recirculated to the RO unit, thus permitting a high water recovery rate without exceeding the limiting orgs. concn. in the RO modules. The org. phase of the separator, contg. .apprx.30% water, was dehydrated to 2% water by pervaporation; results of iso-PrOH pervaporation expts. and calcns. on lab. and pilot scales were presented. Reasons for significantly lower performance of the pilot plant than predicted were discussed.

L16 ANSWER 8 OF 23 COPYRIGHT 1991 ACS
AN CA110(18):156441v
TI Dehydration of multicomponent organic systems by a reverse osmosis pervaporation-hybrid process - module-, process design and economics
AU Rautenbach, R.; Herion, C.; Franke, M.
CS Tech. Akad. Wuppertal
LO Wuppertal, Fed. Rep. Ger.
SO Desalination, 70(1-3), 445-53
SC 45-4 (Industrial Organic Chemicals, Leather, Fats, and Waxes)
SX 42, 60
DT J
CO DSLNAH
IS 0011-9164
PY 1988
LA Eng
AN CA110(18):156441v
AB The recovery of water and solvents from the aq. phase of materials obtained after steam stripping of active carbon adsorbents (used in paint-drying ovens) was discussed. The advantages of using a hybrid process consisting of a reverse-osmosis stage, a second phase sepn., and a pervaporation stage were illustrated.

L16 ANSWER 9 OF 23 COPYRIGHT 1991 ACS
AN CA110(12):101419p
TI Two examples of hybrid processes: electrodialysis - contact sludge reactor and reverse osmosis - phase separator

AU Rautenbach, R.; Kopp, W.; Herion, C.
CS Inst. Verfahrenstech., RWTH Aachen
LO Aachen 5100, Fed. Rep. Ger.
SO Chim. Oggi, (10), 51-5
SC 61-4 (Water)
SX 48, 60
DT J
CO CHOGDS
IS 0392-839X
PY 1988
LA Eng
AN CA110(12):101419p
AB Two examples are presented for substantially increasing the water recovery rate of membrane processes by the addn. of a mech. unit operation. In the 1st case, a crystallizer/clarifier was integrated into the retentate loop of an electrodialysis. In presence of sufficient amts. of seeding crystals, the crystallizer/clarifier prevented scaling and/or blocking of the electrodialysis membranes and spacers even at very high water recovery rates. Based on exptl. results, $MgSO_4$ and $CaCO_3$ were pptd. and sepd. besides $CaSO_4$. In the 2nd case, a gravity settler was integrated into the retentate loop of a reverse osmosis sepg. water from an aq. soln. of several org. solvents of industrial effluents. By recycling the water-rich phase from the settler, the water recovery rate of the process was extended to figures far above the limits of the reverse osmosis process set by osmotic pressure and chem. stability of the membranes.

L16 ANSWER 10 OF 23 COPYRIGHT 1991 ACS
AN CA108(24):206840f
TI Membrane-based hybrid processes
AU Gienger, J. K.; Ray, R. J.
CS Bend Res., Inc.
LO Bend, OR 97701-8599, USA
SO AIChE Symp. Ser., 84(261, New Membr. Mater. Processes Sep.), 168-77
SC 48-1 (Unit Operations and Processes)
DT J
CO ACSSCQ
IS 0065-8812
PY 1988
LA Eng
AN CA108(24):206840f
AB The evaluation of membrane-based hybrid processes is illustrated by generic optimization curves that are based on optimization variables appropriate for the particular sepn. examd. The optimization is described of a reverse-osmosis (RO)/evaporator hybrid process to conc. corn steep water, and a membrane/vapor-recompression hybrid process to recover energy from the exhaust air from coal drying.

L16 ANSWER 11 OF 23 COPYRIGHT 1991 ACS
AN CA108(2):10910j
TI Hybrid desalting systems - a new alternative
AU Awerbuch, Leon; Van der Mast, Victor; Soo-Hoo, Randall
CS Bechtel Natl. Inc.
LO San Francisco, CA, USA
SO Desalination, 64, 51-63
SC 61-4 (Water)
DT J
CO DSLNAH
IS 0011-9164