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19 NOV 1991

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COATING CHARACTERIZATION

For Research and Development, and for Production control in the field of coatings there is need for simple, reliable and fast methods to measure/control characteristics of CVD/PVD Coatings

The presentation deals mainly with the following:

COATING THICKNESS

COATING ADHESION

SURFACE CLEANLINESS EVALUATION

and

HARDNESS MEASUREMENT

CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE S.A.
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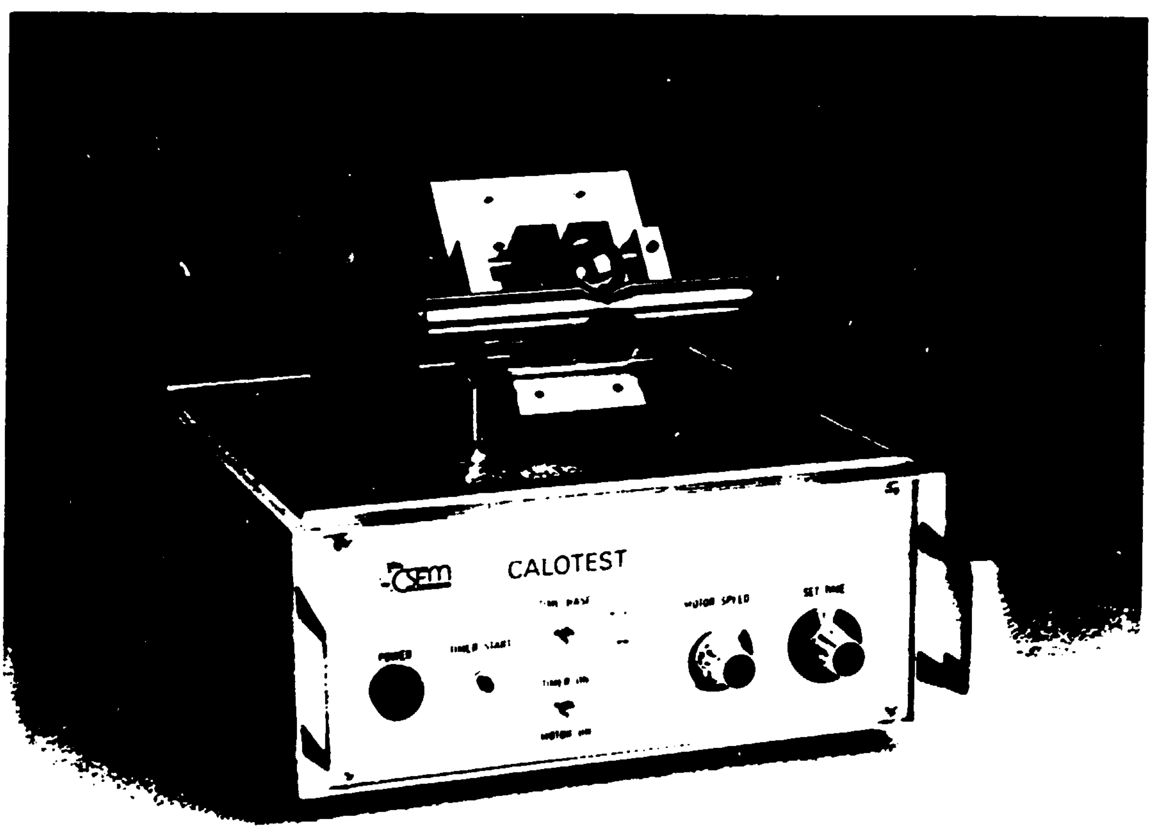
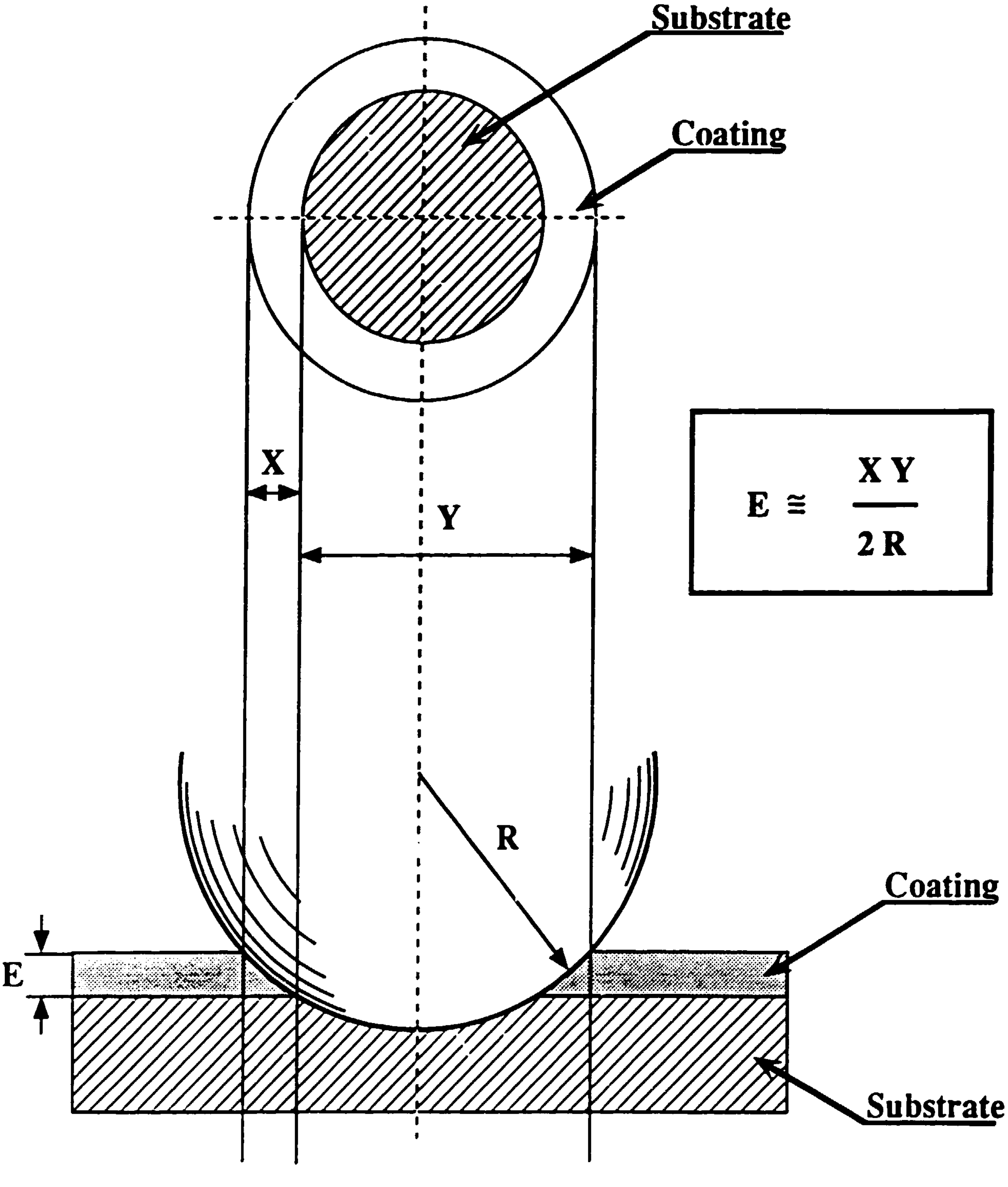
CALOTEST



PRINCIPLE



$$E \cong \frac{X\,Y}{2\,R}$$

CSEM

CALOTEST

NOTES

DETERMINATION rapidly and accurately of layer thickness at different places on the specimen surface

PRECISION essentially depends on roughness (coating and/or substrate) and on the accuracy of the optical measurement system.

PRATICAL MEASUREMENT

STARTING

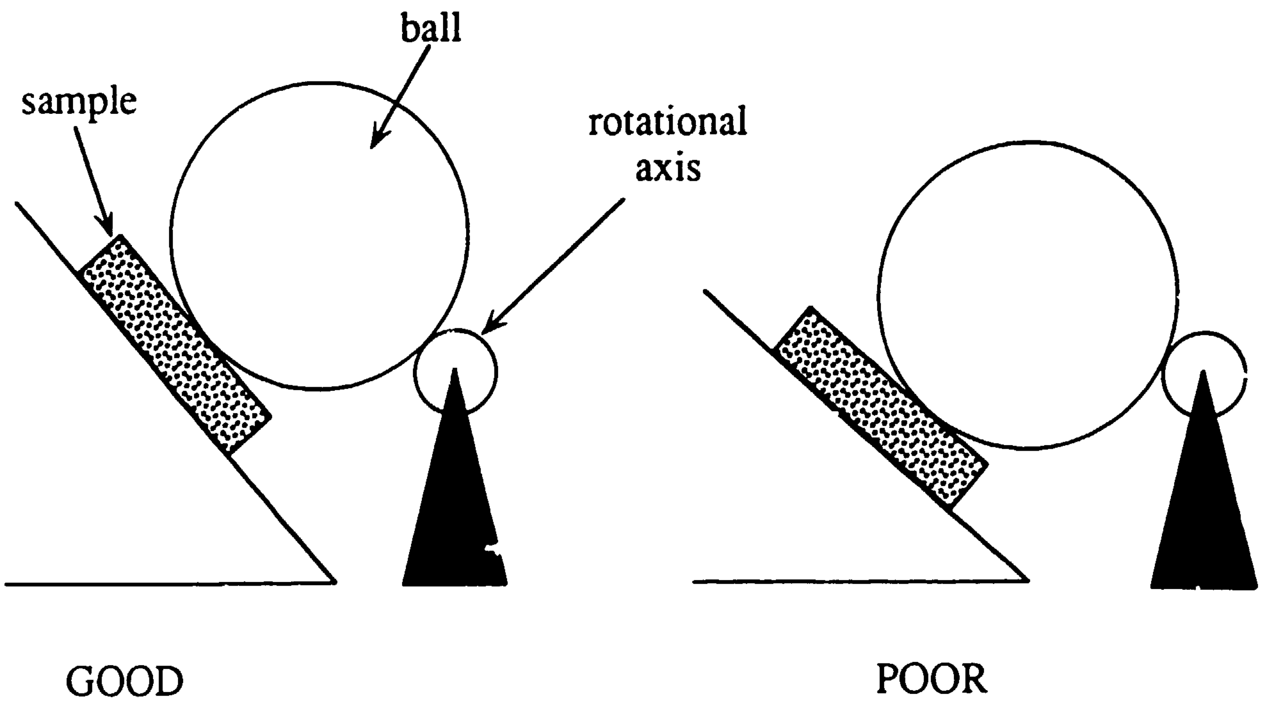
- Sample mounting and positioning
- Preparation
- Instrument settings

- then, Motor ON and Power ON

STANDARD SETTINGS are:

- Ø ball 30 mm
- Motor speed between 5 and 7

SAMPLE POSITIONING and MOUNTING



PRATICAL MEASUREMENT

PREPARATION

- Apply diamond lapping paste with a drop of oil on the ball (grade 0.5, 1, 3 µm etc).
- Add alcohol (isopropanol) to clean the rotation axel.

The action of the diamond coated ball rotating against the specimen creates a small crater.

ERODING THE CRATER THROUGH THE COATING

Depending of the coating/substrate system:

- stop the rotation after a few seconds
- examine the crater with a loop to see if the coating has been penetrated. If not, continue the erosion (if necessary, do a chemical etch).

PRATICAL MEASUREMENT

CHEMICAL ETCH (if necessary)

- for Steels ➡ Marble solution
- for Cemented carbides ➡ Murakami solution
- Others

MEASUREMENT

$$E \cong \frac{X\,Y}{2\,R}$$

SOCIETE SUISSE DE CHRONOMETRIE

53e CONGRES - LA CHAUX DE FONDS [illegible] et [illegible] SEPTEMBRE [illegible]

C O M M U N I C A T I O N No [illegible]

"MESURES D'EPAISSEUR DE COUCHES PAR ABRASION SPHERIQUE"

Communication des Messrs. H. Bovine et R. Rocchi

LABORATOIRE SUISSE DE RECHERCHES HORLOGERES, NEUCHATEL

RESUME :

Sur la base d'un principe connu, le LSRH a mis au point un appareil simple pour la mesure rapide de couches superficielles. Une bille en acier enduite de pâte abrasive est entraînée en rotation sur l'échantillon à mesurer. On obtient une empreinte en forme de calotte sphérique dont 2 variables, en rapport avec le diamètre de la bille permettent de calculer rapidement l'épaisseur du revêtement avec une précision remarquable.

Un bref exposé concernant la théorie et le principe du procédé est suivi d'une série d'exemples illustrant les possibilités de cette méthode de mesure.

INTRODUCTION

Toutes les personnes travaillant dans le domaine des revêtements superficiels sont fréquemment confrontées au problème des mesures d'épaisseur de couches.

Elles ont à leur disposition plusieurs méthodes dont on peut citer les plus importantes : dissolution chimique, mesure d'augmentation du poids, coupe métallographique, coulométrie, rayons X, magnétisme etc.

Souvent ces méthodes font appel aux propriétés intrinsèques des matériaux mesurés, chacune étant limitée à quelques types de dépôts.

La méthode par abrasion sphérique décrite ici n'a pas la prétention de remplacer une ou plusieurs des techniques de mesure existantes.

Au contraire, elle vient les compléter en ce sens qu'elle permet de déterminer en un temps relativement court des épaisseurs en différents points d'un échantillon avec une grande précision, sur pratiquement n'importe quelle sorte de revêtement.

Ce sont Haas et Shockley, qui en [illegible], ont appliqué pour la première fois le principe de l'abrasion pour la mesure d'épaisseur de couches minces en utilisant un cylindre [1].

Plus tard, [illegible] et Roeder, en [illegible], ont remplacé le cylindre par une bille, le principe restant le même [2].

[illegible] a une forte activité dans le domaine des traitements de surface. Pour répondre à une demande interne toujours croissante de mesures d'épaisseurs, il a été amené à développer l'appareil représenté par les figures 1 et 2.

L'abrasion sphérique est de plus en plus utilisée actuellement, chaque fois qu'une coupe métallographique classique n'est pas nécessaire.

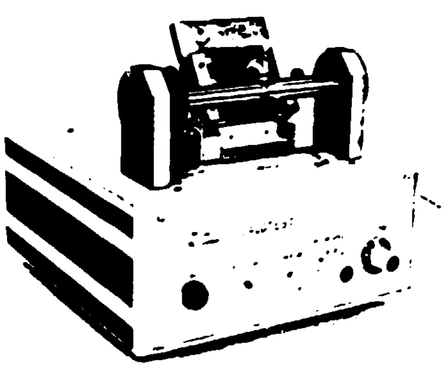


Fig 1 Vue générale de l'appareil

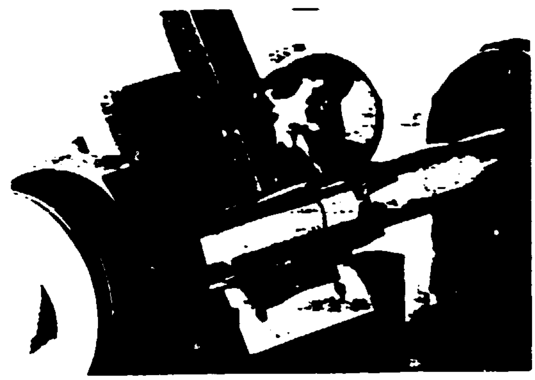


Fig 2 Détail de l'appareil, montrant la bille, le porte échantillon et l'échantillon

Un exemple d'empreinte en forme de calotte sphérique, obtenue avec cet appareil est représenté à la figure 3.

Elle correspond à une couche de Nickel de 6 µm sur laiton. L'image de cette empreinte mesurée au microscope servira au calcul de l'épaisseur.

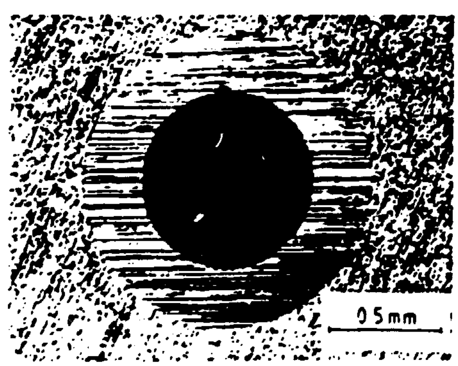


Fig 3 Exemple d'empreinte sphérique, revêtement de 6 µm de Ni sur laiton

PRINCIPE DE MESURE

Théorie

[illegible] produite par [illegible] à l'aide d'une bille sur une [illegible] d'une couche dont on veut déterminer [illegible]

La vue perpendiculaire est un rappel de l'image observée au microscope. Elle indique les 2 variables x et y utilisées pour le calcul de l'épaisseur en rapport avec le Ø de la bille.

La vue en coupe montre le substrat, la couche et la bille ainsi que les différentes variables utilisées dans les calculs.

Le résultat obtenu par cette méthode peut être comparé à celui obtenu à l'aide d'une coupe oblique, l'angle formé à la jonction couche-substrat-bille ayant une valeur comprise entre 0.7^{o} et 3.4^{o} pour des couches allant de 1 à 20µm.

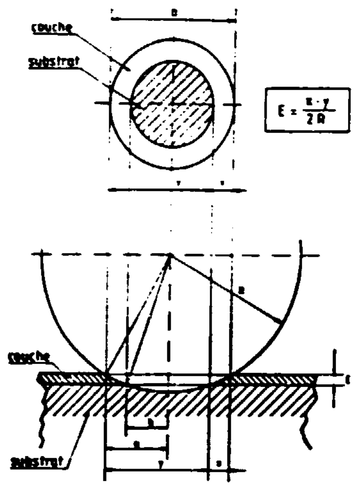


Fig 4 Schéma d'une empreinte sphérique vue perpendiculaire et en coupe

Par de simples relations géométriques, on peut exprimer l'épaisseur de la couche E, de la façon suivante :

$$E = \sqrt{R^2 - b^2} - \sqrt{R^2 - a^2} \qquad I$$

ou

$$E = R\left[\left(1 - \frac{b^2}{R^2}\right)^{1/2} - \left(1 - \frac{a^2}{R^2}\right)^{1/2}\right] \qquad II$$

Dans le cas qui nous préoccupe, c'est-à-dire quand E est de l'ordre de 0.5 à 20µm, pour R = 15mm, a^2/R^2 et b^2/R^2 sont inférieurs à 10^{-3} et l'on peut procéder à une simplification basée sur l'équation suivante :

$$(1 - c)^n = 1 - nc + \frac{n(n-1)}{2!} c^2 - \frac{n(n-1)(n-2)}{3!} c^3 + \dots \qquad III$$

Pour les mesures d'épaisseurs de couche l'on considère seulement les deux premiers termes c'est-à-dire : 1 - nc.

II devient alors

$$E = \frac{1}{2R} \left(a^2 - b^2 \right) \qquad IV$$

ou

$$E = \frac{xy}{2R} \qquad V$$

La simplification mathématique introduit une faible erreur dans l'épaisseur mesurée. Pour des couches entre 0.5 et 20µm, cette erreur est inférieure à 0.5% (2).

L'erreur introduite ainsi par la simplification mathématique est de loin inférieure à celle provenant de la lecture au microscope des valeurs x et y. En effet, les états de surface du substrat et du revêtement, leurs contrastes et la qualité du microscope font que l'incertitude dans la lecture de x et y peut atteindre ±5%. Pour des couches inférieures au micron cette incertitude peut s'élever à ±10%.

Les mesures faites par McDonald et Goetzberger ont montré que la méthode est reproductible et ont permis de calculer les écarts entre valeurs mesurées et valeurs moyennes (3) ce qui est illustré par la fig 5.

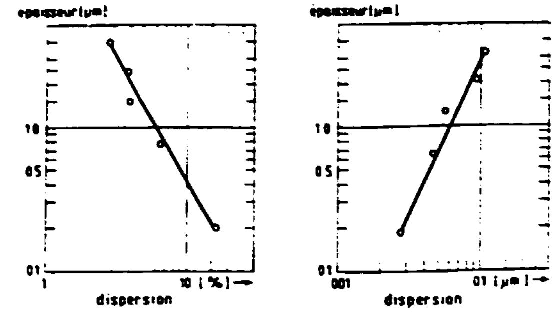


Fig 5 Dispersion des mesures en fonction de l'épaisseur de la couche en % et en µ (3)

Cette figure montre que la dispersion des résultats des mesures en %, diminue quand l'épaisseur du revêtement augmente, tandis que la dispersion en µm augmente avec l'épaisseur de la couche.

Le Ø total d'une empreinte, et par conséquent, les dimensions de x et y, ne sont pas fixes mais sont fonction de la profondeur d'abrasion. Il n'est donc pas possible de tracer une courbe unique indiquant le Ø d'une empreinte en fonction de l'épaisseur pour une bille déterminée.

La fig 6 représente schématiquement 3 empreintes obtenues sur le même échantillon avec des profondeurs d'abrasion différentes, choisies arbitrairement, de telle façon que le rapport entre x et y soit respectivement, 10, 5 et 2.

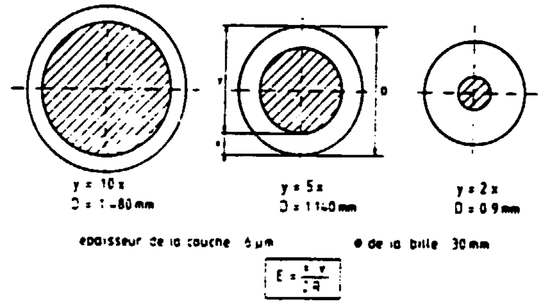


Fig 6 Variation du diamètre de l'empreinte en fonction de la profondeur d'abrasion pour une même couche

Comme la précision finale dépend de l'erreur de lecture qui peut affecter x et y, il est recommandé de choisir, lors des essais, des empreintes présentant un rapport $\frac{y}{x}$ compris entre 2 et 10. L'optimum, fixé expérimentalement, se situe entre 3 et 5.

La figure 7 montre qu'il est par contre possible de tracer des courbes indiquant le Ø d'empreinte en fonction de l'épaisseur pour une bille de Ø donné et des rapports y/x déterminés.

On y voit que pour une couche de 10µm, par exemple, le Ø de l'empreinte peut varier entre 1 et 2 mm.

D'après ces dimensions, il est possible de déterminer dans quelle mesure la méthode présentée ici peut être considérée comme destructive ou non.

Ce critère très relatif dépend avant tout des dimensions et de l'usage de la pièce à mesurer.

Si une boîte de montre est endommagée par une empreinte d'1mm de Ø, une pièce plus importante pourra recevoir une empreinte de 3mm de Ø, en dehors des zones fonctionnelles. Dans tous les cas, toutefois, les empreintes seront visibles à l'oeil nu.

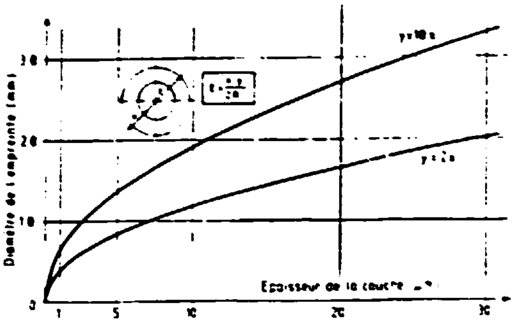


Fig 7 Ø de l'empreinte en fonction de l'épaisseur de la couche pour différentes profondeurs d'abrasion, avec bille Ø 30mm

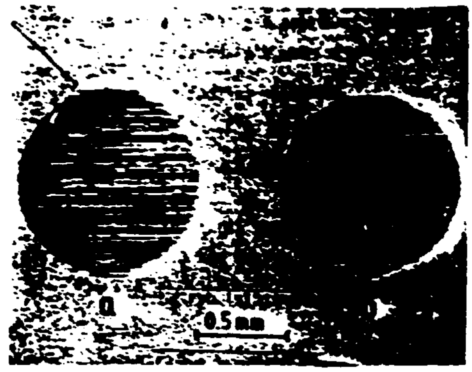


Fig 8 Influence de l'attaque chimique du substrat sur la lecture de l'empreinte
a) avant attaque b) après attaque

C'est également le cas pour les matériaux suivants :
- Rhodium/acier
- Nickel/acier
- Cuivre/laiton

Enfin chaque fois que cela est possible, une attaque chimique est souhaitable en vue d'une meilleure précision de lecture.

La précision de la mesure dépend également de l'état de surface du substrat et parfois du revêtement dont les irrégularités éventuelles peuvent entraîner une modification de la géométrie de l'empreinte.

Cette influence est d'autant plus grande que la couche est mince.

Figure 9 représente un revêtement de TiC (~6µm) sur métal dur dont la rugosité a provoqué la déformation de l'empreinte et rendue la mesure imprécise.

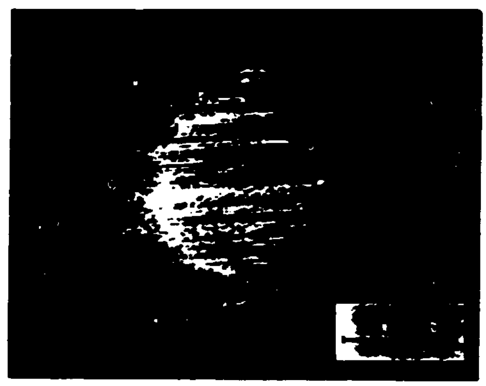


Fig 9 Influence de la rugosité sur la géométrie de l'empreinte

La figure 10 donne un exemple d'empreinte obtenue avec un revêtement mince déposé sur une surface polie. Il s'agit d'une couche de TiN de 0.9µm sur métal dur. Dans ce cas, la mesure est facilitée.

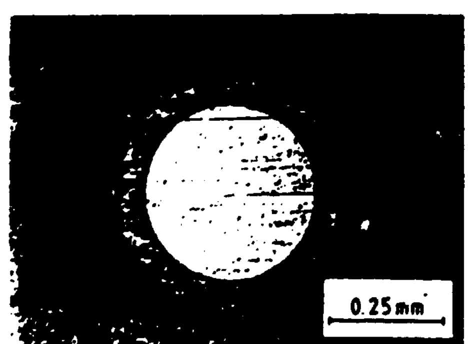


Fig 10 Exemple de couche mince sur substrat poli (ép.0.9µm)

Procédure de Mesure

La procédure à suivre lors de la mesure d'un revêtement sur un échantillon est brièvement décrite ci-après :

- L'échantillon fixé de façon rigide sur le porte-échantillon est rapproché de l'arbre pourvu d'un profil en V ; la distance entre ces deux dépend de la force que l'on veut faire exercer par la bille sur l'échantillon.

- On place une bille en acier (acier pour roulements à billes = 100Cr6) de diamètre 30mm sur le V et en contact avec l'échantillon ; ce Ø est considéré comme optimum par expérience. Une bille plus petite ne sera pas assez lourde pour obtenir une empreinte dans un temps acceptable. Une bille plus grosse sera encombrante sans offrir de grands avantages au niveau de la précision.

- La bille enduite d'une pâte de diamant (grains 1,3 ou 6µm) est mise en rotation par l'intermédiaire de l'axe tournant à une vitesse fixée à ~ 120 ou 1500 rpm en fonction de la nature de la couche (dureté, épaisseur présumée).

- Pour faciliter la rotation et assurer une bonne distribution de l'abrasif, un lubrifiant formé par le mélange huile-pétrole-toluène, est déposé sur la bille à l'aide d'un compte gouttes.

- La durée de l'abrasion qui est également fonction de la nature de la couche peut varier d'une à plusieurs minutes. Pour un revêtement plus épais et dur, le temps peut être écourté en commençant avec une pâte plus grossière et une vitesse élevée, pour finir avec une pâte plus fine à faible vitesse.

- L'abrasion peut être interrompue lorsqu'une empreinte telle que y= [illegible] est obtenue (voir fig 3). Après nettoyage, la mesure des variables x et y est effectuée, comme indiqué dans la première partie, à l'aide d'un microscope optique ou d'un projecteur de profil (episcope) : un grossissement de 50 ou 100 x est largement suffisant dans la plupart des cas.

- Si le contraste entre revêtement et substrat est insuffisant, il peut être accentué par une attaque chimique appropriée en fonction de la nature des matériaux en présence.

[illegible] cas, par exemple d'un dépôt d'Au galvanique de [illegible] sur du laiton [illegible] de même couleur, illustré par la figure [illegible]

[illegible] empreintes ont été faites sur le même échantillon. Sur la première, il est pratiquement impossible de distinguer l'interface. [illegible] attaque chimique du laiton, [illegible] la mesure peut être faite avec [illegible]

LIMITES D'APPLICATION

La méthode par abrasion sphérique est indépendante des propriétés des matériaux mesurés ou de leur mode d'élaboration.

Son application peut être envisagée partout où un contrôle rapide d'épaisseur de couches est nécessaire :

- galvanoplastie (Au, Cu, Ni, Ag, Rh etc...)
- éloxage
- revêtement chimique (Ni...)
- traitement de surface par CVD, PVD (TiC, TiN)
- traitement superficiel des aciers
- etc...

Elle peut être appliquée soit directement sur des parties non fonctionnelles de pièces utiles soit sur des témoins obtenus dans les mêmes conditions.

Elle est également valable dans les cas où l'un des matériaux est non métallique (céramique, plastique etc...).

Les épaisseurs à mesurer peuvent varier entre 0.5 et 20 µm ~.

En dessous de 0.5 µm, la mesure reste praticable mais la précision dépend fortement de l'état de surface.

Au dessus de 20 ou 30 µm, selon la dureté , la durée d'abrasion devient plus importante et une coupe métallographique peut être préférable si elle est possible.

En plus de son application principale à la mesure d'épaisseur, la méthode est fréquemment utilisée pour examiner une couche grâce à la coupe inclinée fournie par l'abrasion sphérique.

Ce moyen met en évidence des zones très minces qui seraient très difficiles à observer sur une coupe verticale.

Un exemple est fourni par la figure 11. Il s'agit d'une épaisse couche de TiC (~20 µm) sur acier, avec une couche préliminaire de Cr (~2 µm) et des zones intermédiaires.

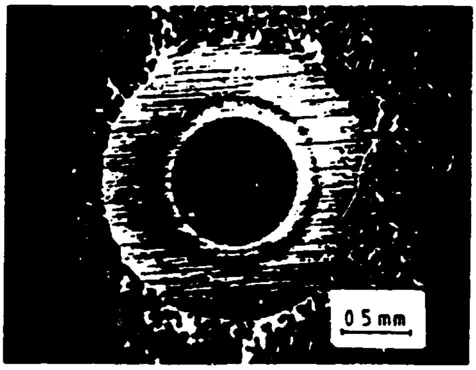


Fig 11 Exemple de couches minces successives mises en évidence par abrasion sphérique.

Dans tous les exemples précédents, il n'a été question que de revêtements déposés sur des surfaces planes.

La méthode décrite ici est également valable pour la mesure de revêtements sur des pièces cylindriques.

Dans ce cas, l'empreinte obtenue se présente avec un pourtour elliptique; les valeurs x et y servant au calcul de l'épaisseur sont relevées sur le grand axe de l'ellipse, le principe restant le même.

D'autre part, il est également possible d'effectuer des mesures d'épaisseur sur des surfaces sphériques revêtues, pour autant que leur rayon de courbure soit largement supérieur à celui de la bille.

La figure 12 donne un exemple d'empreinte obtenue sur un cylindre [illegible] 9.6mm recouvert d'une couche de Nickel de ~ 6 µm.

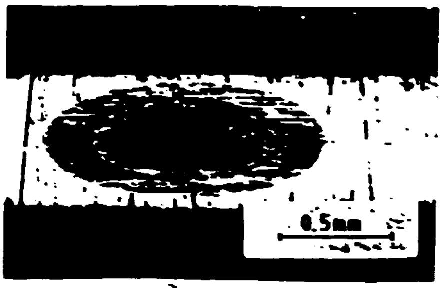


Fig 12 Empreinte sur un cylindre de 9.6 mm (couche ~ 6 µm)

La figure 13 représente une empreinte obtenue sur une couronne de remontoir en laiton recouverte d'or. L'irrégularité du pourtour à la limite or-laiton est très probablement due à des défauts géométriques de la surface de la couronne.

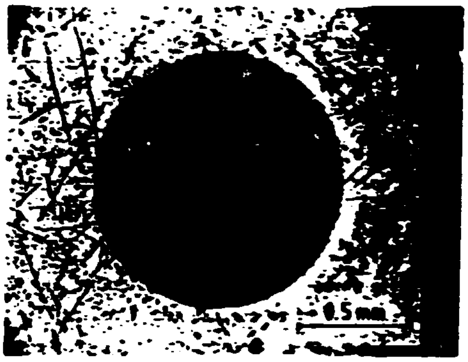


Fig 13 Couche d'Au sur une couronne de remontoir

CONCLUSIONS

L'appareil décrit ici offre un moyen rapide de mesurer l'épaisseur d'une grande variété de revêtements superficiels avec une précision relativement grande.

Les limites d'épaisseur pouvant être mesurées dépendent d'une part de la qualité de l'état de surface pour les plus minces, d'autre part, de la durée d'abrasion pour les plus épaisses. Le domaine usuel s'étend de 0.5 µm à 20 µm mais n'est pas restrictif.

La mesure peut être effectuée en différents points d'un échantillon fournissant ainsi des valeurs locales ou moyennes.

De plus, cette méthode est indépendante de la nature des matériaux mesurés.

La mesure d'épaisseur par abrasion sphérique peut donc être utilisée avantageusement chaque fois qu'une coupe métallographique n'est pas nécessaire ou n'est pas réalisable.

REMERCIEMENTS

Nous remercions Mr G Dubied pour l'importante contribution qu'il a apportée à la réalisation de l'appareil décrit.

REFERENCES

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[2] [illegible], E. Roeder, "Vorrichtung zur Messung geringer Schichtdicken", Praktische Metallographie [illegible], (1969), p. 557-566

[3] B. McDonald and A. Goetzberger, "Measurement of the Depth of Diffused Layers in Silicon by the Grooving Method", J. Electrochem. Soc., 109, Nr 2, p. 141-144 (1962)

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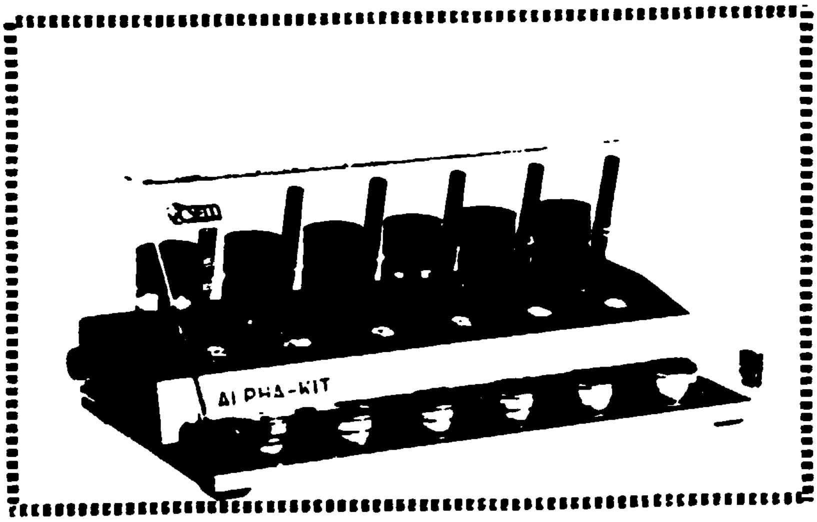
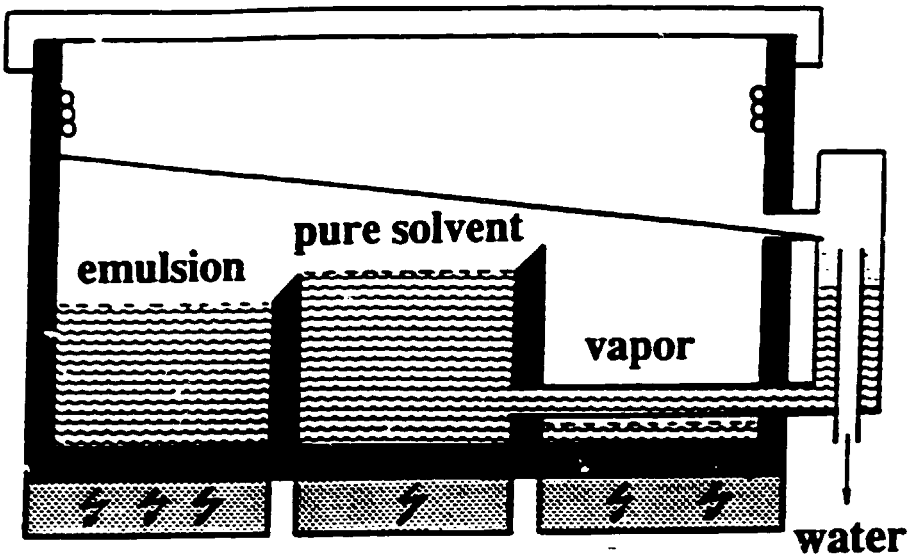
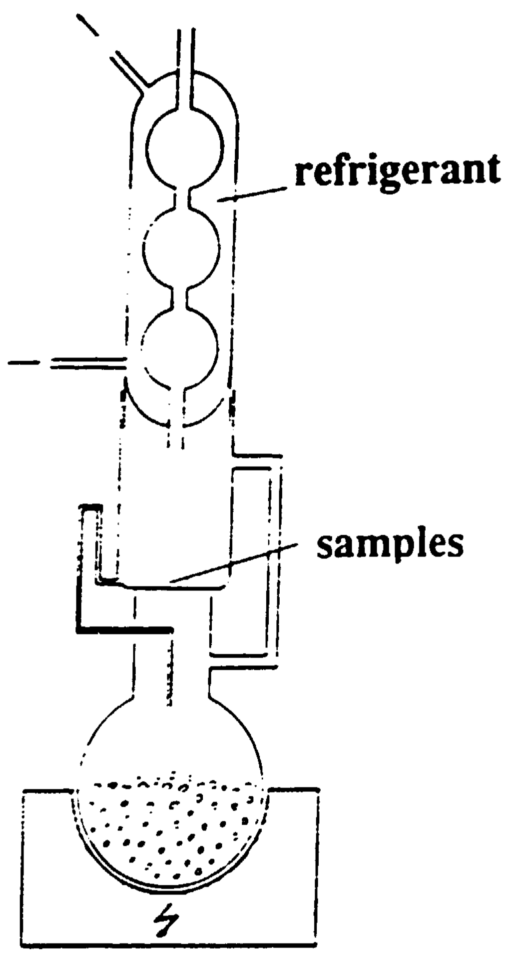
ALPHA - KIT



CLEANING MACHINES:
Industrial and Laboratory types



Industrial system



Soxhlet extractor
(Laboratory device)

SOLVENTS FOR CLEANING PURPOSES
Aliphatic (Alkylic) Hydrocarbons

	Boiling point °C	Density	Volatility Index	Toxicity MAC (ppm)	Flash point °C
Petrol ether	35 - 40	0.64	1.5	1000	- 40
Benzine (range 80 - 95°)	80 - 90	0.69	7.5	500	- 15
Benzine (range 110 - 140°)	110 - 140	0.73	~15	300	0
White spirit	150 - 180	0.76	30	300	15
Kerosene	200 - 230	0.76	50	300	40

Volatility index : evaporation time compared to diethylether = 1 at room temperature under same conditions

Toxicity : maximal admissible concentration in parts by million (volume) in working rooms

SOLVENTS FOR CLEANING PURPOSES
Aromatic (Arylic) Hydrocarbons

	Boiling point °C	Density	Volatility Index	Toxicity MAC (ppm)	Flash point °C
Benzene	80	0.879	3	25	- 10
Toluene	110	0.867	6.1	200	+ 4
Xylene (mixture of isomers)	137 - 140	0.86	13.5	200	+ 27

Volatility index : Diethylether = 1

SOLVENTS FOR CLEANING PURPOSES
Alcohols and cetones

	Boiling point °C	Density	Volatility Index	Toxicity MAC (ppm)	Flash point °C
Methanol	65	0.792	6.3	100	+ 11
Ethanol	78	0.791	5.3	1000	+ 12
Isopropanol	82	0.785	8.5	400	+ 12
n - Propanol	97	0.804	12	200	+ 15
n - Butanol	116	0.810	33	100	+ 29
2-Methoxyethanol	124	0.964	35	25	+ 36
Acetone	56	0.792	2	1000	< 0

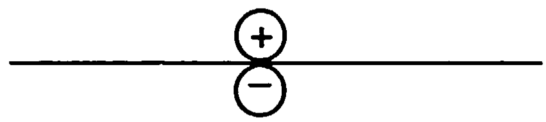
Volatility index : Diethylether = 1

SOLVENTS FOR CLEANING PURPOSES
Chlorinated solvents

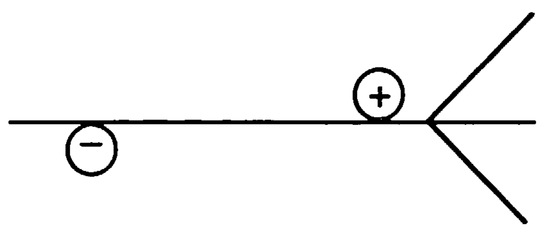
	Boiling point °C	Density	Volatility Index	Toxicity MAC (ppm)	Flash point °C
Trichlorethylene	87	1.462	6	100	-
Perchlorethylene	121	1.611	13	100	-
1,1,1 Trichloroethane	74	1.319	3.5	200	-
Carbon tetrachloride	76	1.594	5	10	-
Chloroforme	61	1.480	4.2	25	-
Methylene chloride	38	1.325	3	250	-
1,1,1 Trichloro - 1,2,2 trifluoroethane	47	1.568	2.9	500	-

Volatility index : Diethylether = 1

POLARITY OF MOLECULES



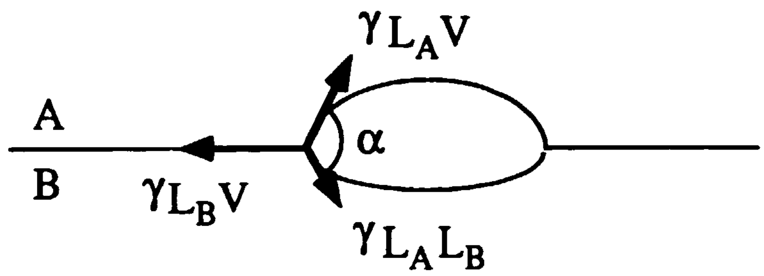
non polar molecule



polar molecule

⊕ and ⊖ represent the center of gravity of positive respectively negative charges

EQUILIBRIUM OF A DROPLET ON A LIQUID



$\gamma L_A V$ = Surface tension of liquid A

$\gamma L_B V$ = Surface tension of liquid B

$\gamma L_A L_B$ = Interfacial tension between liquids A and B

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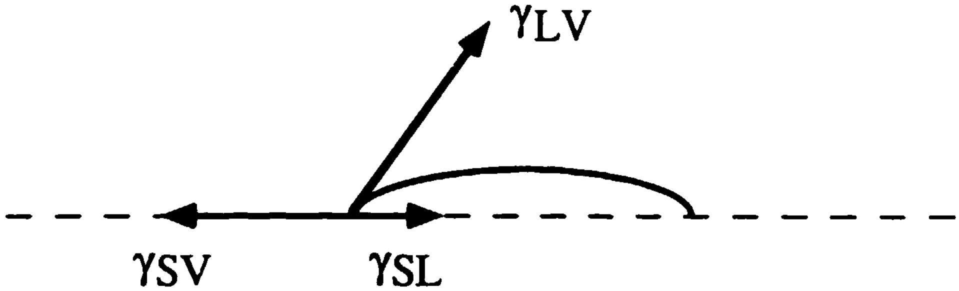
EQUILIBRIUM OF A DROPLET ON A SOLID SURFACE



γ_{LV} = Surface tension of the liquid

γ_{SV} = Surface tension of the solid substrate (depending on the adsorbed products)

γ_{SL} = Interfacial tension between liquid and substrate (negligible in a first approximation)

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TENSIOACTIVE AGENTS

Action on water-soluble or oily products

	Hydrophile - Lipophile Balance
Sorbitan Trioleate	1.8
Esters Palmitate/Stearate of Ethyleneglycol	2.7
Glycerol - monostearate	3.8
Alkyl - aryl - sulfonate	11.7
Oleate of Triethanolamine	12
Oleate of Potassium	20
Laurylsulfate of Sodium	40

Low values of "Hydrophile - Lipophile - Balance" are suitable for emulsions "water in oil" and high values for emulsions "oil in water".

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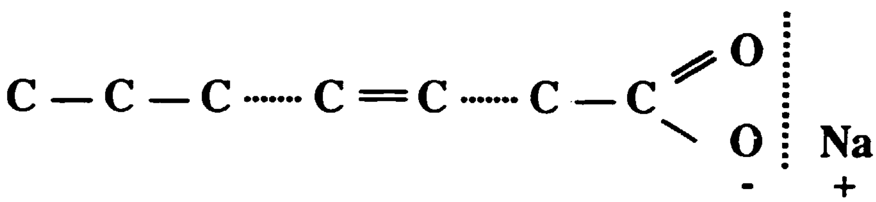
TENSIOACTIVE AGENTS
Different Types

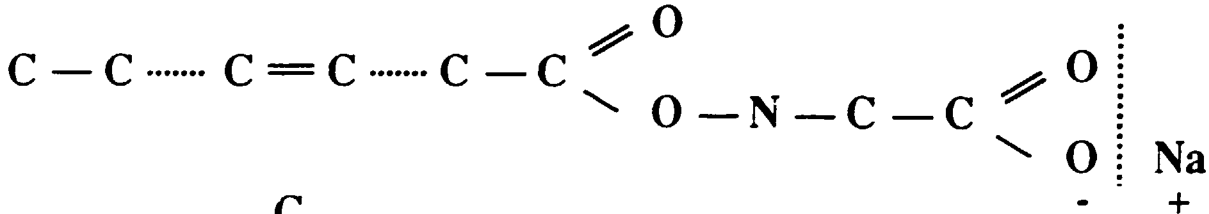
1 ANIONIC AGENTS

Soaps
Salts of long-chained fatty acids and alkalies or organic basic components (e.g. amines)



C_{16}

Sodium palmitate



C_{18}

Sodium salt of oleyl - sarcosine

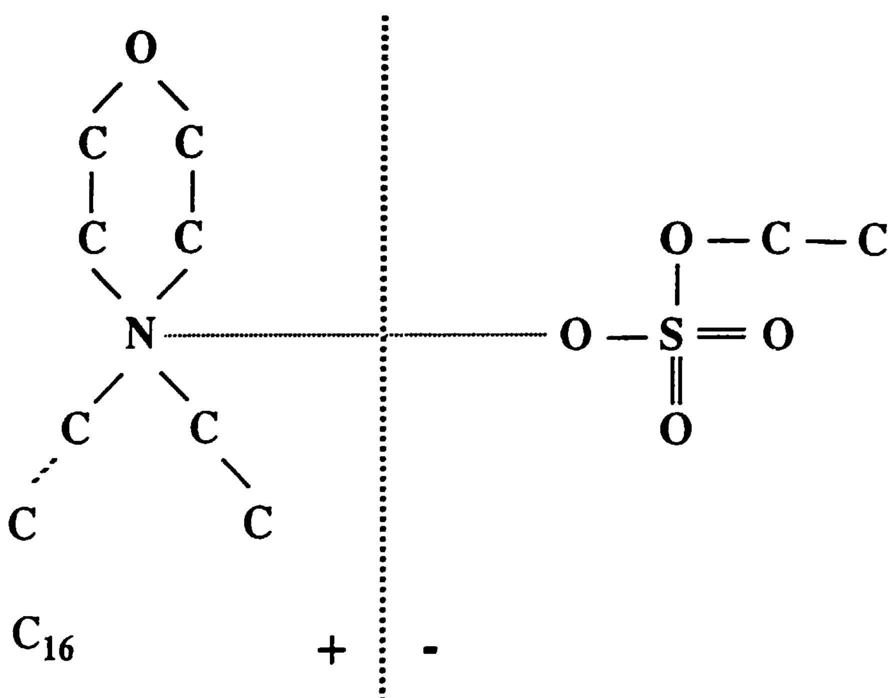
The anion has tensioactive properties
Limitation of use: alcaline range

TENSIOACTIVE AGENTS
Different Types

2 CATIONIC AGENTS

Salts of long-chained base and acid without tensioactive properties.

Example: Ethosulfate of cetylethylmorpholine



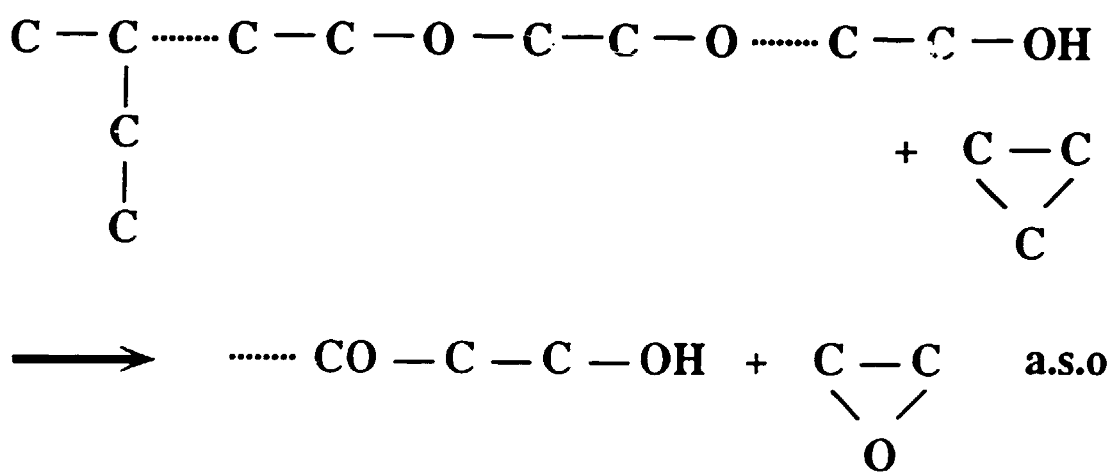
The cation has tensioactive properties
Range of use: acide solutions
Use of wetting agent in solutions with low pH-values

TENSIOACTIVE AGENTS
Different Types

3 NON IONIC AGENTS

Tensioactive character of the whole molecule.
The electrolytic dissociation does not matter.

Action of alcohols phenol, amine or mercaptan on Ethylene - oxide.



Mechanism of reaction with Ethylene - oxide

Miscibility with water decreases by heating. The temperature where the solubility limit in aqueous solutions in overpassed is the "cloud point".

CLEANING SOLUTIONS
Different types

1 STRONG ALCALINE SOLUTIONS

Composition

Aqueous solutions of

- tertiary sodium phosphate
- sodium pyrophosphate
- sodium tripolyphosphate
- sodium hexametaphosphate
- ash soda (carbonate)
- sodium metasilicate

Additives

- hydrophile tensioactive agents
- copper desactivator (if necessary)

Working conditions

- temperature 80°C - 100°C
- ultra - sounds

Use

- before galvanic depositions
- to remove films of greasy or fatty products in the triglyceride films

CLEANING SOLUTIONS
Different types

2. "First" cleaning bath

Composition

Aqueous solution containing

- about 5% oleic acid, eventually partially oleic soaps of sodium or potassium
- ammonia (25% in water) 5%
- alcohol or acetone 20%
- rest: water

Working conditions

- Temperature 20°C - 40°C
- Ultrasounds

Use

To clean metallic parts (especially copper and copper alloys). The product removes copper or zinc oxides and altered residues of oils or greases present in traces on surface.

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CLEANING SOLUTIONS
Different types

3. Optimizated "First" cleaning bath

Composition

Apueous solution containing

Oleylsarcosine	20 g/l
Di-iso-propylamine	25 g/l
Diethylene triamine	5 g/l
Fluorinated tensioactive agent	0,5 g/l
Ethylealcohol or acetone	50 g/l
water to complete to	1 l

Working conditions

- Temperature 20°C - 40°C
- Ultrasounds

Use

To clean different metallic parts especially copper and copper alloys from traces of oxides, altered residues of fatty oils or water-soluble residues.

Remark

By increasing the proportion of amines the mixtures become more active, but the corrosive effect is also increased.

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CLEANING SOLUTIONS
Before rinsing

1 RINSING AFTER CLEANING TREATMENT

- by water, then by alcohol
- by dewatering agents after water rinsing
- by special products such as
- methyleglycol
- diethyleneglycol - diethylether
- diethyleneglycol - dibutylether

2 RINSING PROCESS

- by homogeneous products
  (arylic hydrocarbons, chlorinated solvents)
- by mixture of different solvents (e.g. aliphatic hydrocarbons, chlorinated solvent, arylic hydrocarbons)
- by azeotropic mixtures

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CLEANING MACHINES
Industrial types

1 RINSING POSITION WITH SEVERAL RINSING BATHES PUMPED

- Advantage : Simplified apparatuses
- Disadvantage : The solvents are spoiled quickly because the transfer of dissolved products is relatively important

2 SEVERAL RINSING BATHES WITH TRANSFER OF THE ITEMS TO BE RINSED FROM ONE TO THE NEXT

- Advantage : The transfer of dissolved products is less important and the rinsing bathes can be in use for a longer time before they have to be changed.
- Disadvantages : More important apparatuses
  Higher loss of rinsing vapours

3 SYSTEM USING VAPOURS FROM LAST RINSING BATH

- Advantage : best rinsing process, even when the last rinsing bath has a too high value of not volatile residues. (normally limited to 10 mg/l)

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CLEANING PROCESS

Non polar solvents	:	Aliphatic hydrocarbons Arylic hydrocarbons
Low polar solvents	:	Perchlorethylene Trichlorethylene Methylene Chloride
Polar solvents	:	Methylisobutylcetone Isoamylacetate Dimethylcetone (Acetone)
High polar solvents	:	Isopropanol Ethanol Methanol
Very high polar	:	Water Alcaline aqueous solutions

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CLEANING PROCESSES
Influence on the behaviour of lubricants

TO AVOID SPREAD OUT OF LUBRICANTS

- finish the cleaning process with polar solvents such as alcohols, cetones

- add to the last rinsing bath special additives, such as

  - carboxylic acids (e.g. stearic acid)

  - phenolic compounds (e.g. hydroquinone)

  - partially polymerized perfluoro- poly- ethers or - polyesters

  - treat the cleaned surfaces with special silicone products; the end of the polimerization can be done on the surfaces themselves (baking at temperatures till 180°C).

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CLEANING PROCESSES
Regeneration of solvents
control of solvents

REGENERATION

- Separation solvent / water
- Distillation of the solvents
- Addition of stabilisators
  (especially for chlorinated compounds)
- Filtration (if contaminants are most solid)

CONTROL OF SOLVENTS

- Acid reaction (from decomposition especially chlorinated compounds and esters in contact with water)
- Non volatil contaminants (evaporation and weight of residue)
- Contaminated by light or high temperatures
  (important for halogenated compounds)

  Test with steel plates let into the vapour phase or liquid phase in the rinsing bathes and transferred to humide environment. The apparition of general rust in many fine points is the sign of a contamination. Such a solvent can no longer be regenerated in the working plant.

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TESTING OF CLEANED SURFACES

Alpha - Kit

Non polar liquids for tests with increasing surface tension

LIQUIDS	COLOR	KINETMATIC	SURFACE TENSION
1	colorless	0.35	19.7
2	clear red	0.70	21.9
3	dark red	0.54	23.1
4	yellow	0.36	29.1
5	gren	0.47	34.6
6	blue	0.97	41.6

CSEM

ALPHA - KIT

Nature of liquids for tests

Liquid	Nature
1	Perfluorinated polyether
2	dimethylpolysiloxane
3	methylalkylpolysiloxane
4	partially liquid 3 partially hydrocarbon with ether groups
5	partially hydrocarbon with ether group and triester of phosphoric acid
6	triester of phosphoric acid

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BEHAVIOUR OF SURFACES

Steel / brass well cleaned

Behaviour

Liquids 1-4	spread out totally
Liquid 5	spreads out partially
Liquid 6	does not spread out but contact angle < 10° (low)

Steel / Brass treated with stearic acid / hydroquinone

Liquids 1-2	spread out
Liquid 3	spreads out partially
Liquids 4-6	does not spread out (contact angle increasing from 4-6)

Ruby well cleaned without other treatment

Liquids 1-3	spread out totally
Liquids 4-5	spread out partially
Liquid 6	does not spread out (contact angle > 25°; high)

CSEM

BEHAVIOUR OF SURFACES

Effect by chemically similar products

Steel / Brass	treated with silicone polymenized in situ
Liquids	
1	does not spread out
2	spreads out quickly (chemical similitude)
3	spreads out partially (contact angle approx 6°-10°)
4-6	do not spread out (contact angle in general high)
Steel / Brass	treated with perfluorinated ethers/ esters
Liquids	
1	contact angle low < 5° spreading out nearly complete
2-6	no spreading out high contact angles (> 25°)

CSEM

TESTS WITH ALPHA-KIT

Put from bottle a few drops into the oil-container and with the special cleaned oiler put droplets of about 0,5 - 1 mm in diameter on the surface to be tested.

Consider the surface area of the droplet after about 10-15 min, time to be entered into the internal specifications of the factory.

CSEM - Institute is at your disposal to interprete the results.

ALPHA - KIT

(A DEVICE FOR THE CONTROL OF THE CONDITION OF CLEANED SURFACES)

The behaviour of a drop of oil deposited onto a surface depends in a large extent on invisible films, which remain after the cleaning process. The same is also true for the conditions of friction and seizure. To avoid haphazard work the person responsible for the cleaning process must have at his disposal a method of control which allows him to make the presence of superficial films of various types conspicuous.

The first idea, that comes to mind is to deposit drops of the watch oil, that one intends to use. In this manner a direct result could be obtained, but would be difficult to interpret, because the usual watch oils contain polar products, which themselves produce films on the cleaned surfaces. By working with non-polar and non-volatile liquids, an interaction with the cleaned surface need not be feared. The shape of the drop depends on the surface tension of the liquid and the apparent surface tension of the solid surface. The latter can be determined within relatively narrow limits when there is at one's disposal a set of liquids, with graduated surface tensions.

LSRH has developed an apparatus which enables this technique to be applied to the control of surface cleanliness. This device is covered by a patent pending.

As actually used, the set of liquids consists of 6 oils with the following characteristics:

Oil N^o	Colour code	Kinematic viscosity at 20^o, stokes	surface tension dynes/cm
I	colourless	0,35	19,7
II	clear red	0,70	21.9
III	dark red	0,54	23,1
IV	yellow	0,36	29,1
V	green	0,47	34,6
VI	blue	0,97	41,6

The oil N^o I is a fluorinated compound. The oil N^o II and III are silicones. The oils N^o IV, V and VI are non-polar, base compounds, which are usually found in watch oils.

In going from N^o I to N^o VI, more rounded drops are obtained. It is necessary to take into account the fact that the drops do not reach an equilibrium state immediately. Usually one drop of the series is at the limit of spreading out. For the lower numbers spreading is more likely to occur. It is possible to determine above which number the absence of spreading is guaranteed, even after one or two days. The apparent tension of the solid surface then corresponds approximately to the tension for the drop showing the first signs of spreading.

This apparent surface tension is characteristic of the condition of a cleaned surface. Once a cleaning technique has been elaborated and gives quite favourable results, one can define this condition by the apparent surface tension. The person responsible for the cleaning process tries to maintain this tension. He is warned, if a change has taken place in the cleaning process by the condition of the deposited drops on the cleaned pieces.

When a surface has received a treatment such as to form a film (an epilame for example), its apparent surface tension is changed. The difference can serve as a control of the treatment. However, it is necessary to consider a property, which can be the origin of errors. When an oil is deposited on to a film with quite distinct chemical properties for example a fluorinated oil on an epilame which is also based on fluorinated compounds, spreading out phenomena are sometimes observed, which are not in accordance with the surface tension of the oil, but are caused by an interpenetration between the oil and the film. This is the reason why different types of oil are used for the first items of the series. On a stearic epilame the first three oils will not spread out if the treatment has been well made. On an epilame based on silicone compounds, the drops of the oils N° II and III are less rounded than the drops of the oil N° I. The results are the opposite for a fluorinated epilame. These considerations allow an appreciation to be made of the nature of the epilame film.

On the surface of a metal or a mineral oxide which is perfectly cleaned and dried, the oils N° I to V spread out. The last oil is just at the limit. The apparent surface tension is about 40 dynes/cm.

On a quite clean plastic support, the apparent surface tension does not always reach this value. It is necessary to take in to consideration a possible chemical relationship between the plastic and the oil, which leads to the described spreading-out phenomena. Furthermore the hygrometric state of the plastic has a relatively high importance.

(see fig. 1, page 6)

The figures overleaf show by 4 examples the described conditions. In each case a steel plate has been prepared by delicately brushing under water with subsequent degreasing in a Soxhlet extractor using a mixture of toluene and tertiary butylic alcohol. After this preparation the different treatments mentioned below have been made.

The two lines of drops shown consist of:

At the top: 2 drops of Synt-A-Lube oil and 2 drops of Chronax D oil.

At the bottom: The drops of the LSRH series of oils N° I to VI (from left to right).

The following commentary can be made:

A): No further cleaning process
All of the drops with the exception of the oil N° VI spread out; the apparent surface tension is about 40 dynes/cm.

B): Ultrasonic cleaning in a solution of amine soap
The behaviour of Synt-A-Lube oil is only a little better. For the other oils, the result is practically the same; apparent surface tension: 40 dynes/cm. The polar character of Synt-A-Lube oil permets the anchorage of a layer which avoids spreading.

C): Epilaming with Aretol
All of the oils remain at their position with the exception of the drop N° 1, which is not well rounded; the apparent surface tension is about 19 dynes/cm.

fig. A

Cleaned in the Soxhlet-extractor with no further treatment.

fig. B

Ultrasonically cleaned in a solution of amine soaps.

fig. C

Cleaned and treated with ARETOL.

fig. D

Treated with ARETOL-Epilame, then ultrasonically cleaned in a solution of amine soaps.

D): Treatment with Aretol-Epilame, followed by ultrasonic cleaning in a solution of amine-soaps:
The watch oils like the oil N° VI do not spread out. The drop N° V is at the limit. The drops N° I to IV spread out; the apparent surface is nearly 36 dynes/cm.

Directions for use.

The test is preferentially made on plane surfaces, which should be as large as possible. On watch-stones it is better not to work in the oil-bearing holes, but on the plane surfaces.

In the case of pieces with several surface conditions: brushed, polished, sandblasted, etc, the drops must be deposited on each surface.

The surface must not be treated by a further cleaning process before examination. It is only permissible to blow away dust with an air jet.

With the aid of an oiler of the corresponding colour, a little drop of oil of the set is selected with the knowledge of the surface condition. According to the behaviour of this oil, drops of two or three other oils directly preceeding or following the first are tested, until it is possible to define the limit between the spreading oil and the oil which does not spread out.

It is seldom necessary to use the whole set. When the aim is to control an epilame, one works mostly with the first numbers. When testing a cleaning process, the higher numbers are used.

An initial visual examination is made a few minute after the drops have been deposited. Moreover, in all cases, where it is possible, another examination is made the next day after about twenty hours.

Interpretation.

1) When the aim is to supervise a cleaning process, the first requirement is that there is no change between two successive observations of the pieces treated by the same technique. It is actually rare, that a given apparent surface tension of a support is prescribed, but it would be desirable to arrive at that, especially when a certain experience in the application of the CESN-method has been made.

It is possible to say, that a watch oil, with a given surface tension will remain at the deposited place as well as a liquid of the CESN-series, having the same surface tension, but the reverse is not true, the watch oil can be better.

2) If the aim is to control an epilame treatment, usually the first three oils are deposited. If they do not spread out, the epilame treatment is quite in order and the layer presents no chemical relationship with the oils of the set.

If the oil N° I spreads out while the oils N° II and III do not, then the epilame is on a fluorinated base.

If the oil N° I does not spread out, while the oils N° II and III spread out a little, then it is probable, that the epilame is on a silicone base. The confirmation may be given with the oil N° IV, the drop from which must be well rounded.

Remark: The application of this method is particularly easy for an operator accustemed to depositing drops of watch oils. However the interpretation is limited to a certain pratical experience, because the observations made at CSEM, where this method has been used for two years, show that there is a large variety in the surface condition of pieces, cleaned industrially.

During the introduction period, CSEM is quite prepared to aid the practicioners who wish to apply this method, by furnishing information which makes the interpretation of the results easier. If necessary please contact the

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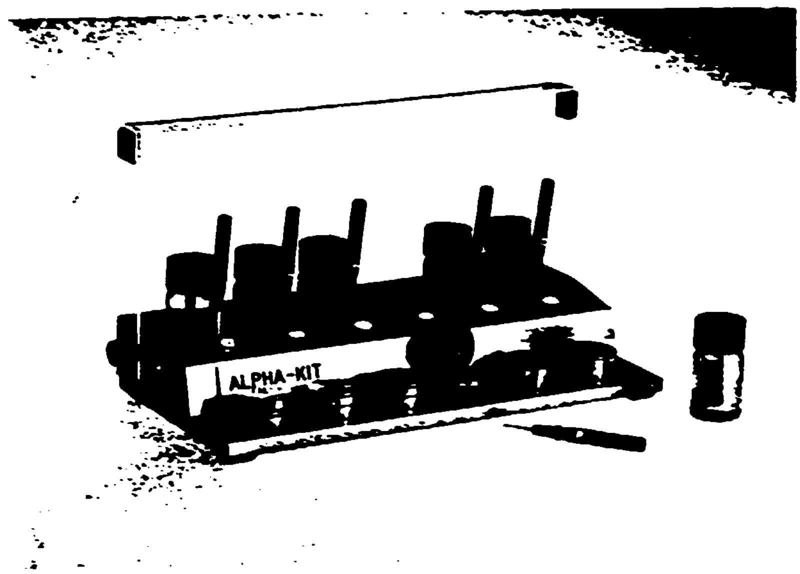
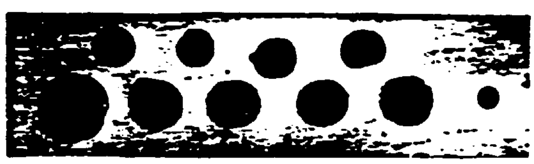
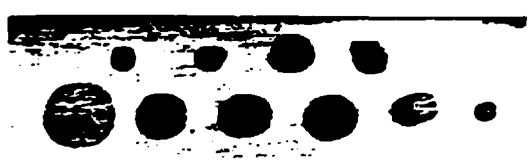
Systems, Instruments and
Engineering Section



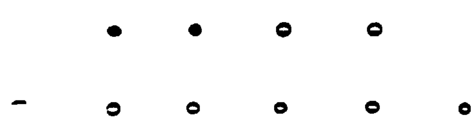
ALPHA KIT



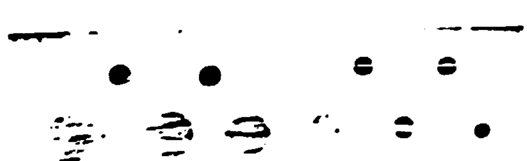
Cleaned in the Soxhlet-extractor with no further treatment.



Ultrasonically cleaned in a solution of amine soaps



[illegible] and treated with [illegible]



Treated with [illegible], then [illegible]
cleaned in a solution of amine soaps.

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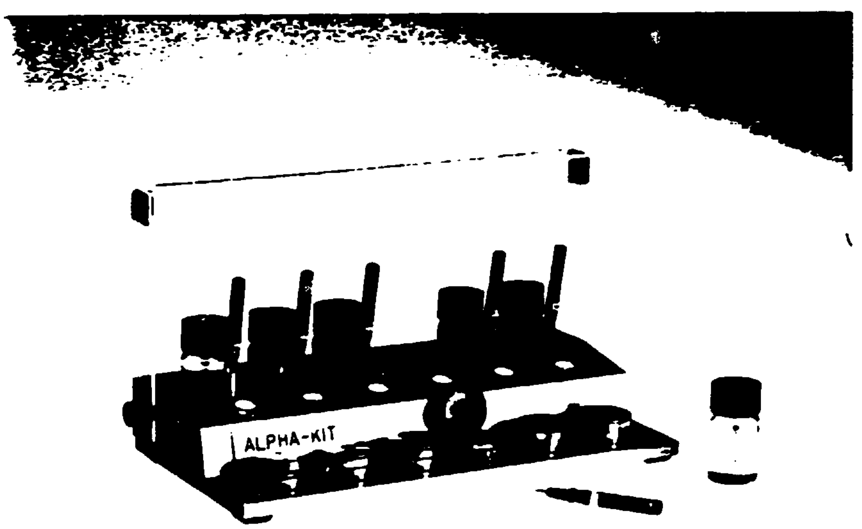
ALPHA - KIT
for Surface Cleanliness Evaluation

Effective surface cleanliness is a factor of particular importance in many processing steps of microtechnology. In order to provide a reliable way of supervising cleaning processes, CSEM has developed a simple device to obtain qualitative information about the surface state of a wide variety of materials. The technique which has been used successfully for over a decade relies on the visual observation of the spreading out of droplets of carefully selected liquids on the surface to be inspected.



The behavior of a drop of oil deposited on a surface is governed by the surface tension of the oil and the apparent surface tension of the surface, which in turn is strongly influenced by otherwise undetectable films remaining after insufficient cleaning processes. Thus the observation of the shape of droplets of a set of liquids having graduated and known surface tensions enables one to detect the presence of unwanted surface contamination.

Alpha-Kit consists of a collection of six oils containing non-polar and non-volatile molecules which serve to make superficial films on most metal and plastic substrates conspicuous.

-WS RELEASE

The characteristics of the oils selected for Alpha-Kit are as follows:

Oil N°	Color code	Kinematic viscosity at 20°C (centistokes)	surface tension (mN/m)
I	colorless	35	19.7
II	clear red	70	21.9
III	dark red	54	23.1
IV	yellow	36	29.1
V	green	47	34.6
VI	blue	97	41.6

Available Apparatus

The Alpha-Kit working plate carries all the necessary material to perform qualitative tests in the field, that is:

- 6 oil cups
- corresponding oilers
- oiler cleansers (elder-pith)
- 6 bottles of oil

Application Notes

The tests are preferably done on a plane surface. As the oil number increases, ever rounder drops are obtained after they have reached equilibrium. The apparent surface tension of the solid surface then corresponds approximately to the value of the drop which shows the first signs of spreading. It is not necessary to use the whole set.

Interpretation is subject to a certain practical experience, especially due to the large variety of surface conditions and industrial cleaning processes.

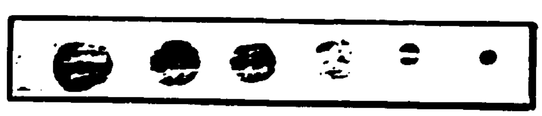
The photos below illustrate three equilibrium conditions of the same substrate after test:

A

1 2 3 4 5 6

B

1 2 3 4 5 6

C

1 2 3 4 5 6

A) ultrasonic cleaning in amine soap solution,
B) cleaning and treatment with antispreading solution,
c) treatment B followed by ultrasonic cleaning in amine soap solution.

JFC/HTa/ARe/cbr
August 1989

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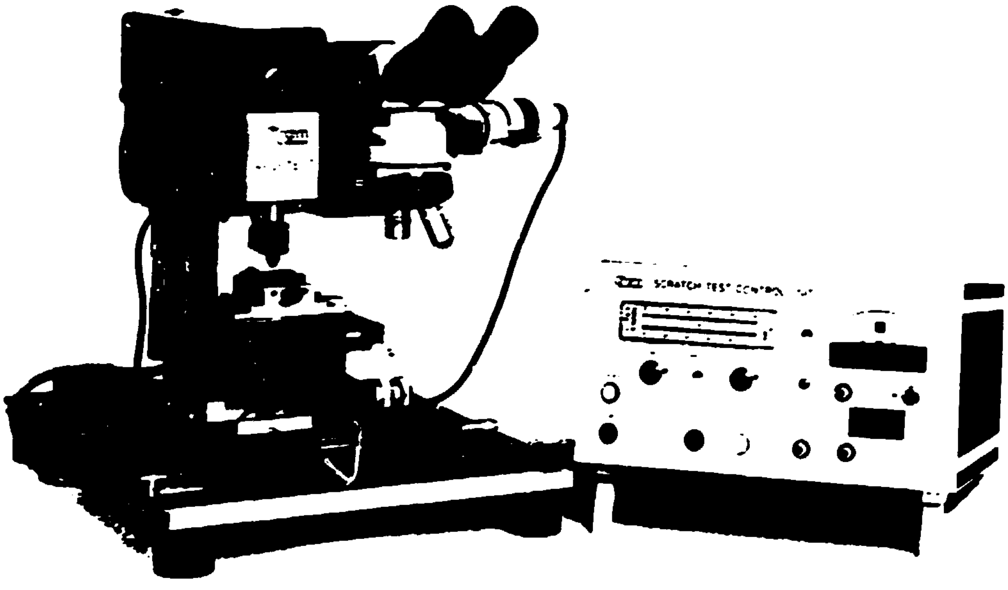
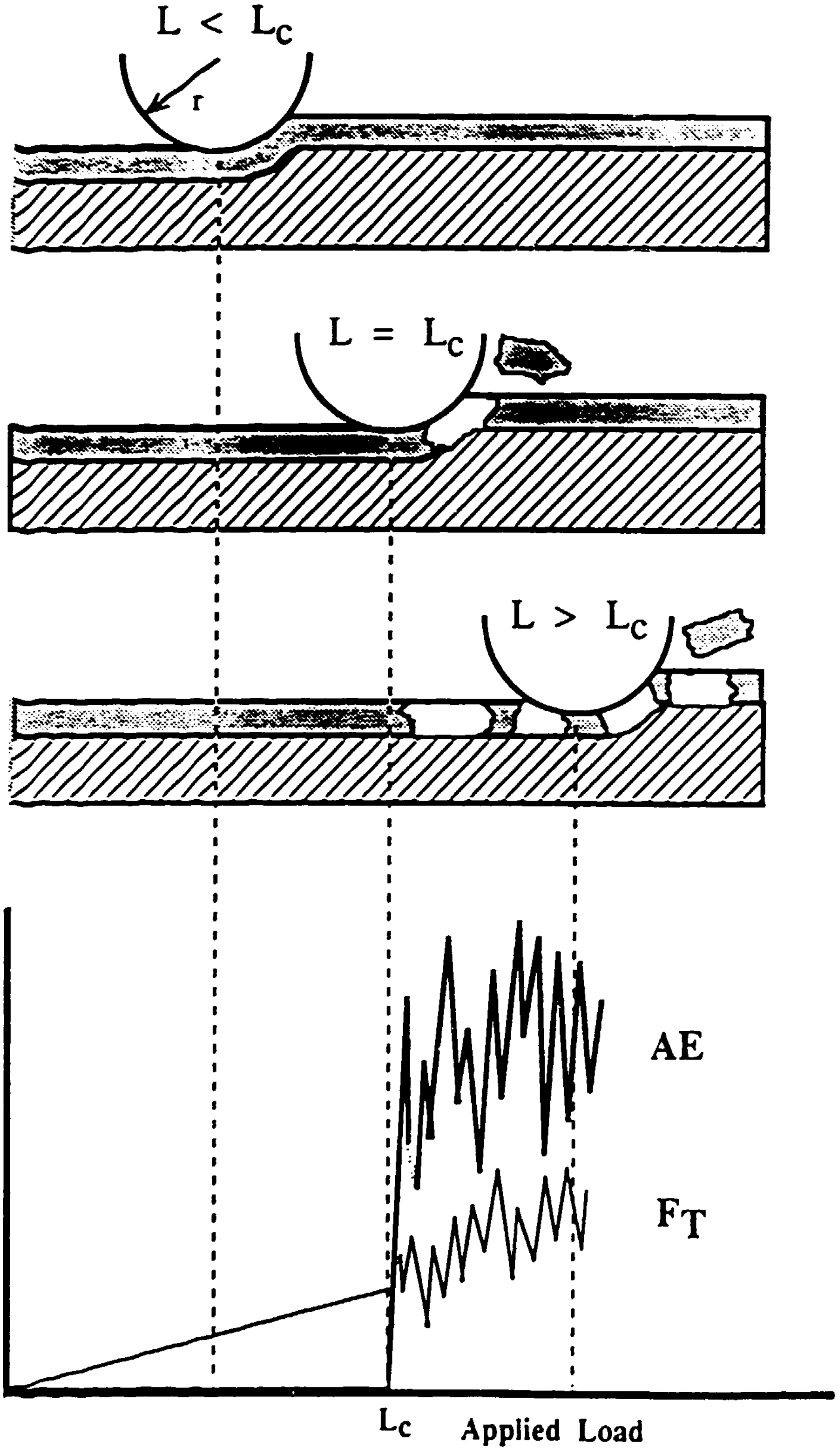
CSEM REVETEST®
Automatic Scratch-Tester



PRINCIPLE

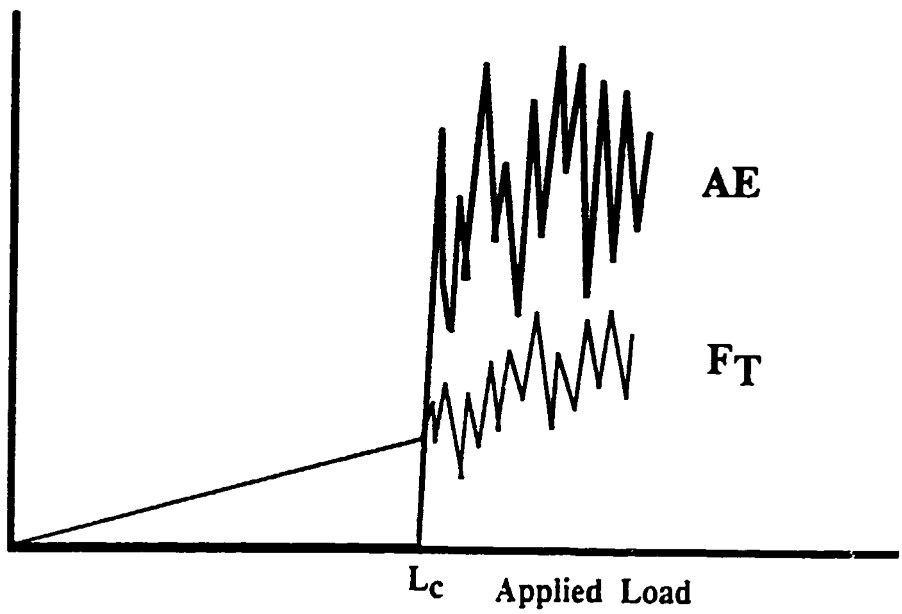


REVETEST®
Adhesion characterization

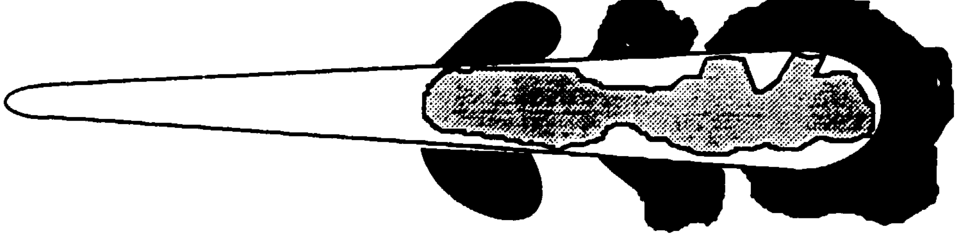
INVESTIGATION METHODS

The REVETEST® provides three different means of analyzing the scratch:

- 2 methods ON-LINE: F_T AND AE



- and thereafter optical observation through a microscope.



STARTING AND PREPARATION

STEP 1 **Power ON**

wait approximately 30 min before using the instrument

STEP 2 **Instrument settings**

- Progressive or constant load
- Load range (100 or 200 N)
- F_{min} and F_{max}
- Loading rate
- Scratching speed
- Sensitivity of AE signal
- set button located on the REVETEST® machine in position AUTO-RETURN.

STEP 3 **X-Y Recorder**

- connection to Control Unit
- set button "PEN" in position AUTO
- paper
- X and Y scales

STEP 4 **Sample mounting and adjustment**

- fix the sample in a sample holder
- adjust the sample at approx. 0.5 to 1 mm from the indentor tip

STEP 5 **Offset at 0 of:**

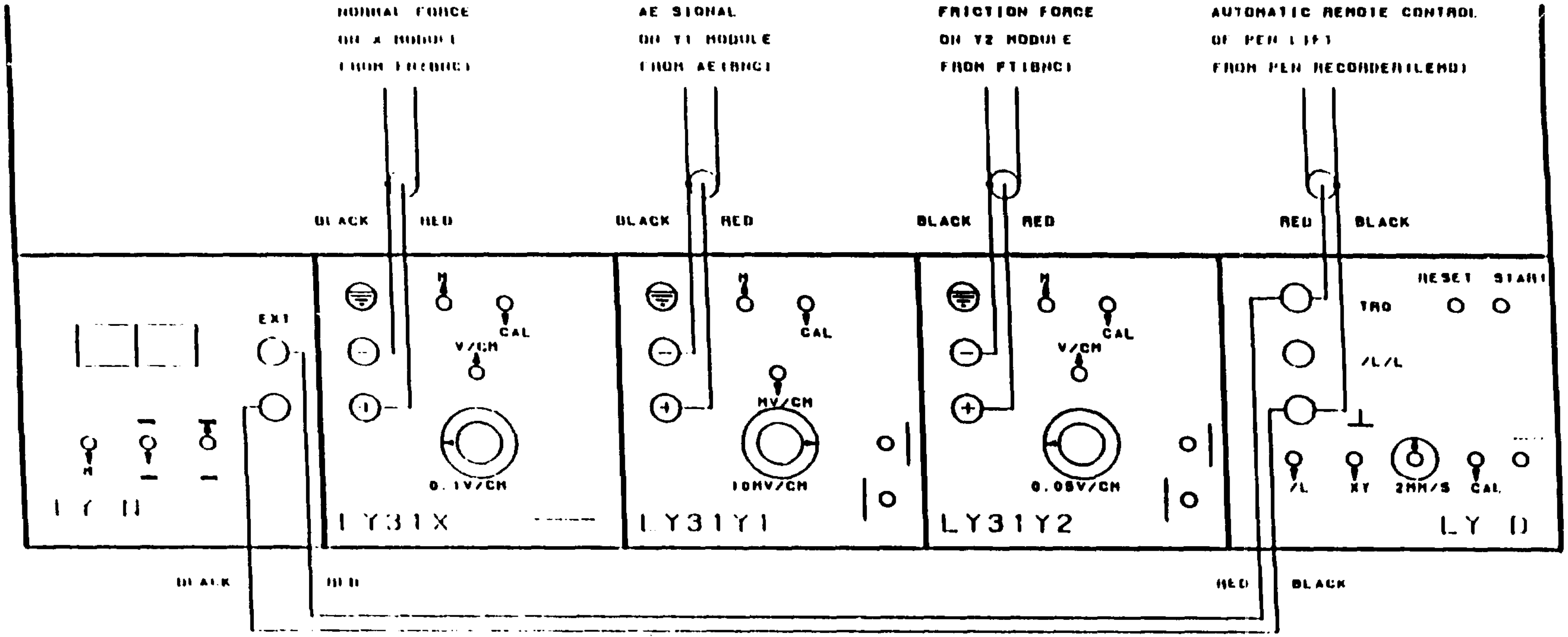
- F_T
- Distance

INSTRUMENT SETTINGS

STANDARD CONDITIONS are:

dL/dt	=	100	N/min
dx/dt	=	10	mm/min
SAE	=	1.2	
Scale	=	100	N
Fmin	=	0	N
Fmax	=	100	N
Indentor radius		200	µm

WIRING OF LYNSEIS 18100 RECORDER



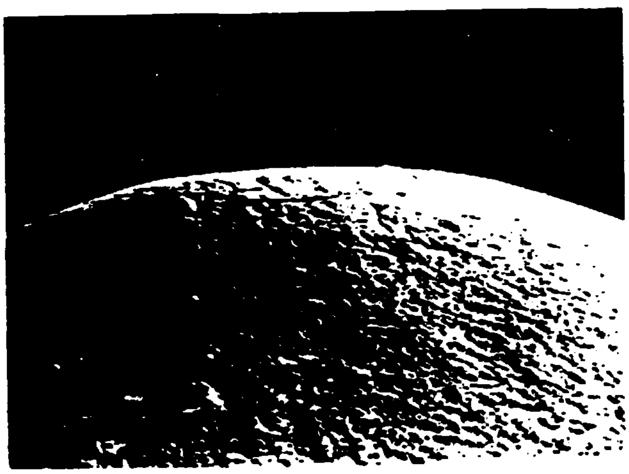
POSSIBLE SCALE OF THE DIFFERENT CHANNELS are:

in progressive mode	X =	0.1	V/cm
in constant mode	X =	5	mm/sec
for both modes	Y_1 =	10	mV/cm (AE signal)
	Y_2 =	0.05	V/cm (F_T measurement)

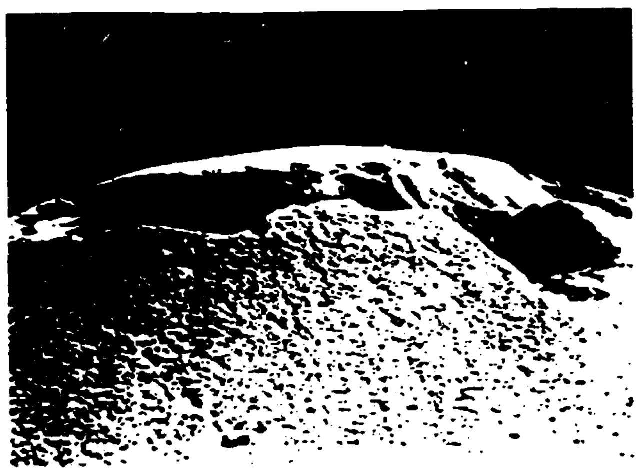
PRACTICAL RECOMMENDATIONS

- Control the diamond tip with a loop (for example)

Good



Eroded



Broken

- Clean the indentor with alcohol after each scratch (some transfer of material could occur)
- Sample has to be cleaned, i.e. grease and particles removed

PRACTICAL MEASUREMENT

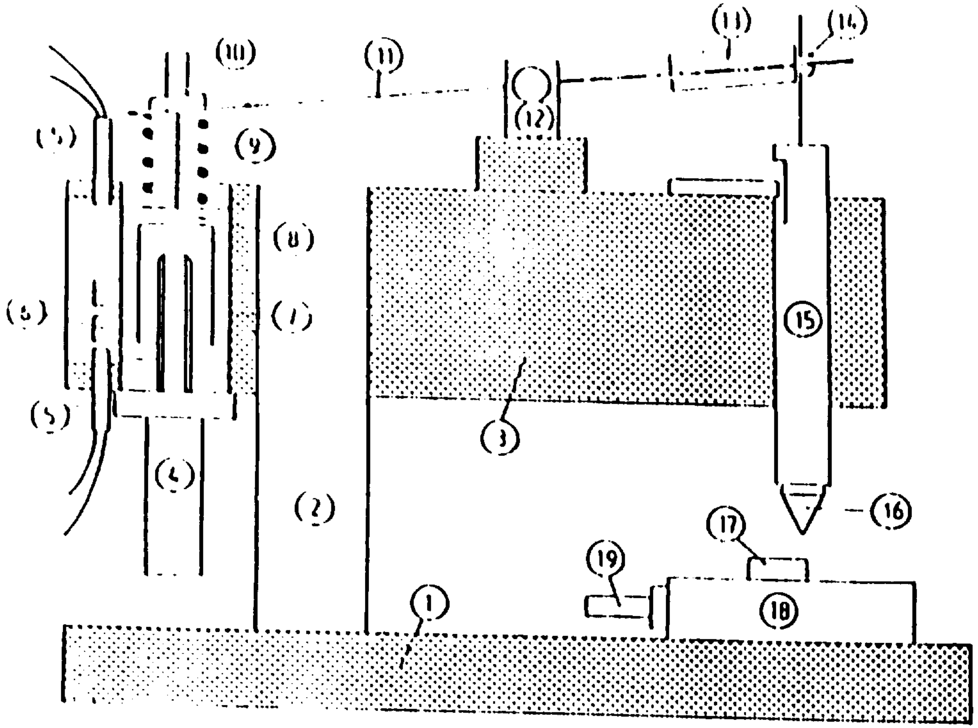
- the sample is under the diamond indentor
- Press "RUN" and the test begins
- Stop the test by pressing RESET
  or wait until it is finished
- Observe the scratch under the microscope and determine the optical critical load and correlate it with the AE and/or FT graphs
- Change the instrument settings if it is necessary
- Clean the indentor with alcohol

V/e recommend a minium of 3 scratches per sample

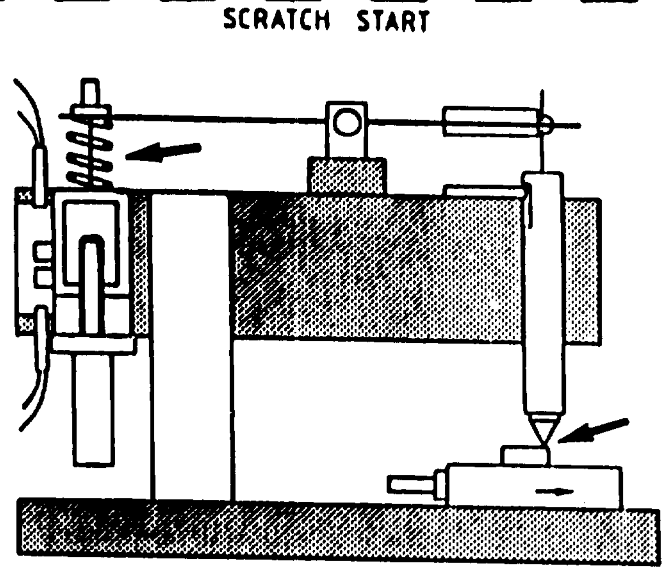
MECHANICAL AND ELECTRONICAL CONCEPTS

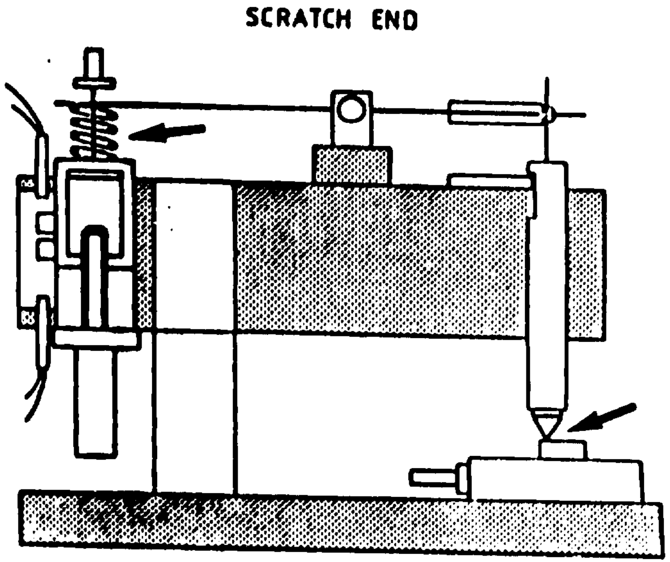
	Support
1. General Specifications	D.U. p.14
2. Mechanical devices	
• Loading system	Drawing
• Acoustic Emission detection	D.U. p.ll, 18-21
• Microscope	M.D.U. p. 1-7
• Friction force measurement	F.D.U. p. 1-9
3. Electronic Control-Unit	
• Electrical functions distribution (PCB Nr 1,2,3,5 and 6)	D.U. p. 28-38 F.D.U. p. 10-13
4. Summary diagnosis of the electrical functions	
• Signal measurements on the 64 pins connector	D.U. p. 23-25, 39
5. Interfaces/Accessories	
• X/Y recorders	D.U. p. 7-9
• PC-INT accessory	For information
- PC requirements	"
- Printers/plotters	"
• Video Camera Adaptation	"

D.U : Directions for use
M.D.U : Measurement Microscope Equipment Directions for use
F.D.U : Device for Friction parameter Determinations for use



1	base	11	lever arm
2	column	12	beam
3	head	13	load cell
4	load driving motor	14	spherical bearing
5	proximity switches	15	sliding point holder
6	movement stops	16	diamond tip
7	translation screw	17	sample
8	nut	18	sample table
9	load spring	19	sample table driving motor
10	point lift command rod		





CSEM

SCRATCH-TESTER

PCB1: AEMETRE

PCB2: MEASURE FN

PCB3: FRICTION MEASURE FT

PCB4: NOT USED

PCB5: LOGICAL+MOTOR DRIVER

PCB6: SUPPLY

+WIRING OF:

FRONT PANEL

REAR PANEL

MECHANICAL PART

SCRATCH-TESTER CSEM

	A			C	
	GND ANALOG	1	1	GND ANALOG	
	GND ANALOG	2	2	GND ANALOG	
	+15 VOLTS	3	3	+15 VOLTS	+0.2V -0.2V
	-15 VOLTS	4	4	-15 VOLTS	+0.2V -0.2V
0.0 TO +5.0V	MIN	5	5	MAX	+5.0V TO 0.0V
		6	6		
		7	7	FN/2	0.0 TO +2.5V
0.0 TO +2.5V(5.0)	FN	8	8		
0.0 TO +2.5V(5.0)	FT	9	9	v*	0 TO 1.0V(FOR v =1)
0.0 TO +1.0V	AE	10	10	AE'	INTERNAL USE
		11	11		
		12	12	/ZOON	0V ON,+15V OFF
		13	13		
0V ON,+1.2V OFF(IF..)	/PEN OFF	14	14	/LAMP RUN	+0.5V ON,+24V OFF
+0.5V ON,+24V OFF	/LAMP STOP	15	15	RECORDER+	+12V
0V ON, +12V OFF	/PEN DOWN	16	16	RECORDER-	+12V ON, 0V OFF(IF..)
0V ON, +12V OFF	/FORWARD	17	17	/FORCE PROG.	0V ON, +12V OFF
+12V ON, 0V OFF	>MIN	18	18	/>MAX	0V ON, +12V OFF
0V ON, +12V OFF	/RESET	19	19	/AUTO	0V ON, +12V OFF
0V ON, +12V OFF	/RUN	20	20	/STOP	0V ON, +12V OFF
ABOUT +2.90V	SPEED Y (H)	21	21	SPEED Z (V)	ABOUT +2.90V
+12V ON, 0V OFF	DETECT. FOR.	22	22	DETEC. BACK	+12V ON, 0V OFF
+12V ON, 0V OFF	DETECT. UP	23	23	DETEC. DOWN	+12V ON, 0V OFF
	MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	AB. +3.7VGO, -22VBACK
	MOTOR- Z (V)	25	25	MOTOR- Z (V)	
	MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	AB. +6.5VGO, -22VBACK
	MOTOR- Y (H)	27	27	MOTOR- Y (H)	
ABOUT +5.80V	TACHY+ Y (H)	28	28	TACHY+ Z (V)	ABOUT +2.90V
	+12 VOLTS	29	29	+12 VOLTS	+0.2V, -0.2V
	+24 VOLTS	30	30	+24 VOLTS	+2.0V, -2.0V
	GND DIGITAL	31	31	GND DIGITAL	
	GND DIGITAL	32	32	GND DIGITAL	
	A			C	

ANALOG (pins 1–12)

DIGITAL (pins 13–32)

VOLTAGE IN ... FOR 200 N

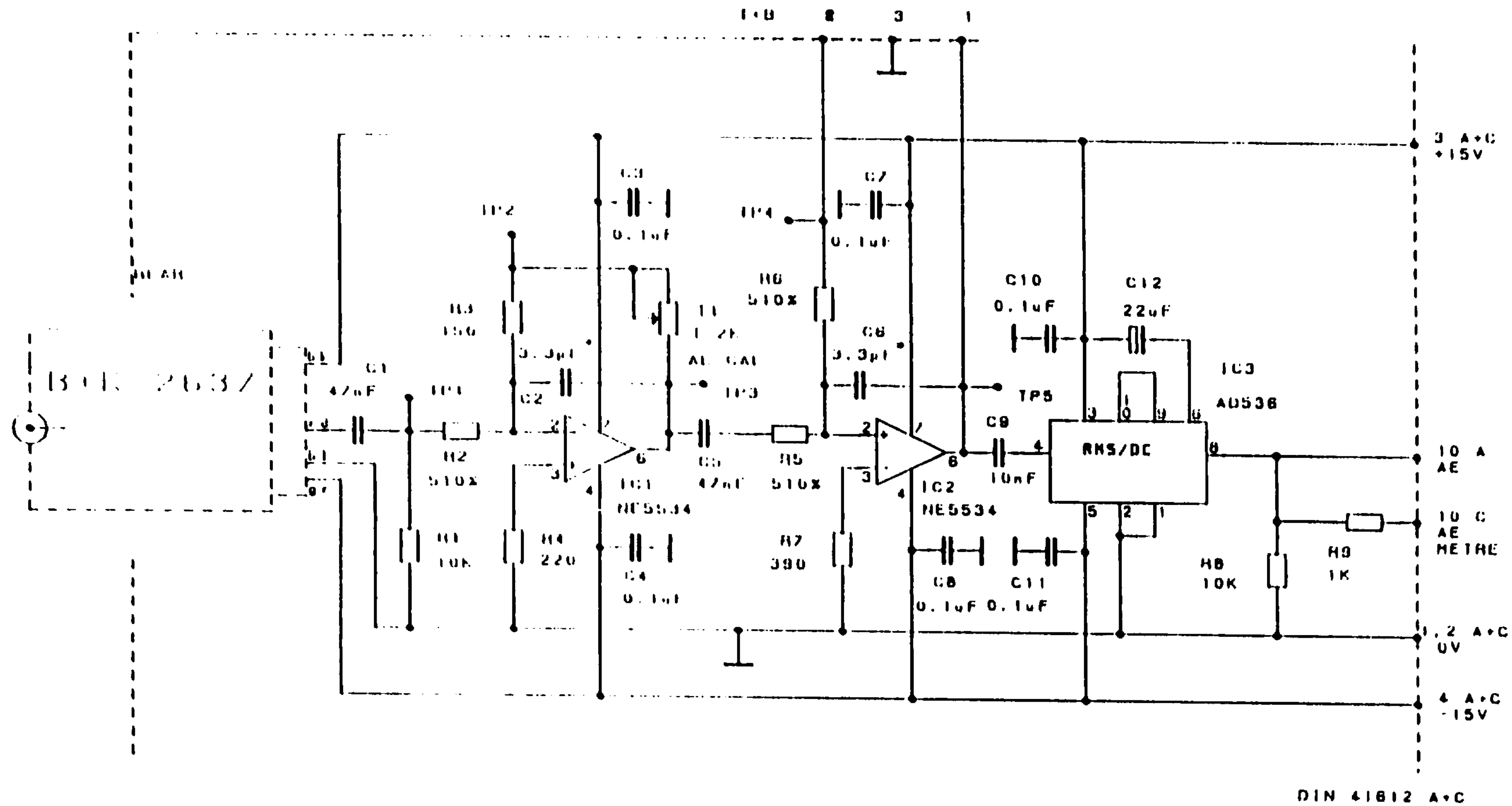
DIN41612 A-C

C S E M NEUCHATEL

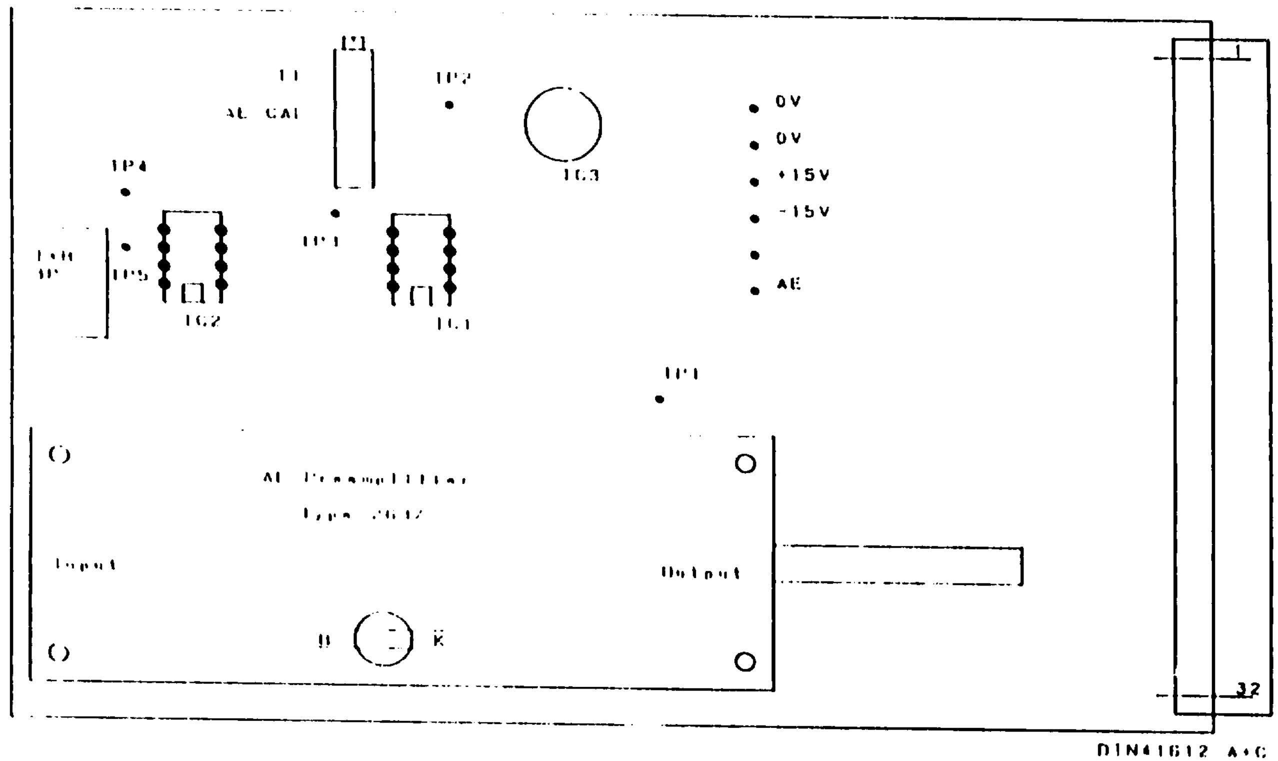
Title: BUS

Size: E | Document Number: 54.1415 | REV: 1

Date: December ?, 1989 | Sheet ? of ?



C S E M NEUCHATEL		
Title: PCB 1, AEMETRE, Electrical circuit		
Size: A	Document Number: 54.1401	REV: 3
Date: February 14, 1989	Sheet 1 of 1	



C S E M NEUCHATEL	
Title	PCB1, AEMETHE
Size: A	Document Number: 54.1402
Date: February 14, 1989	Sheet 1 of

SCRATCH-TESTER CSEM
DIN41612 A+C

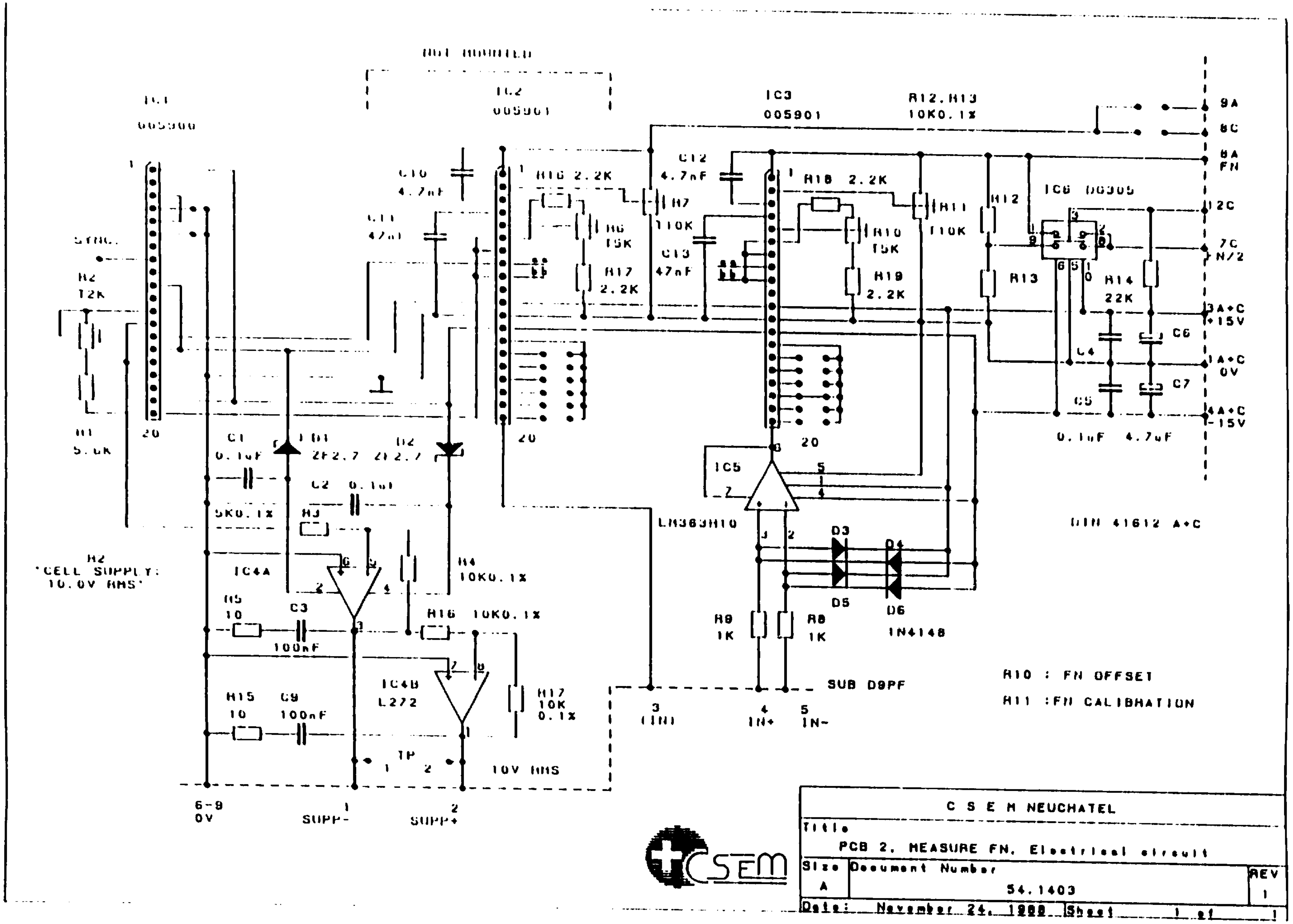
ANALOG

A			C
	A	**C**	
GND ANALOG	1	1	GND ANALOG
GND ANALOG	2	2	GND ANALOG
+15 VOLTS	3	3	+15 VOLTS
-15 VOLTS	4	4	-15 VOLTS
MIN	5	5	MAX
	6	6	
	7	7	FN/2
FN	8	8	
FT	9	9	u=
0.0 TO +0.2V — AE	10	10	AE'
	11	11	
	12	12	/200N
	13	13	
/PEN OFF	14	14	/LAMP RUN
/LAMP STOP	15	15	RECORDER+
/PEN DOWN	16	16	RECORDER-
/FORWARD	17	17	/FORCE PROG.
>MIN	18	18	/>MAX
/RESET	19	19	/AUTO
/RUN	20	20	/STOP
SPEED Y (H)	21	21	SPEED Z (V)
DETECT. FOR.	22	22	DETEC. BACK
DETECT. UP	23	23	DETEC. DOWN
MOTOR+ Z (V)	24	24	MOTOR+ Z (V)
MOTOR- Z (V)	25	25	MOTOR- Z (V)
MOTOR+ Y (H)	26	26	MOTOR+ Y (H)
MOTOR- Y (H)	27	27	MOTOR- Y (H)
TACHY+ Y (H)	28	28	TACHY- Z (V)
+12 VOLTS	29	29	+12 VOLTS
+24 VOLTS	30	30	+24 VOLTS
GND DIGITAL	31	31	GND DIGITAL
GND DIGITAL	32	32	GND DIGITAL
	A	**C**	

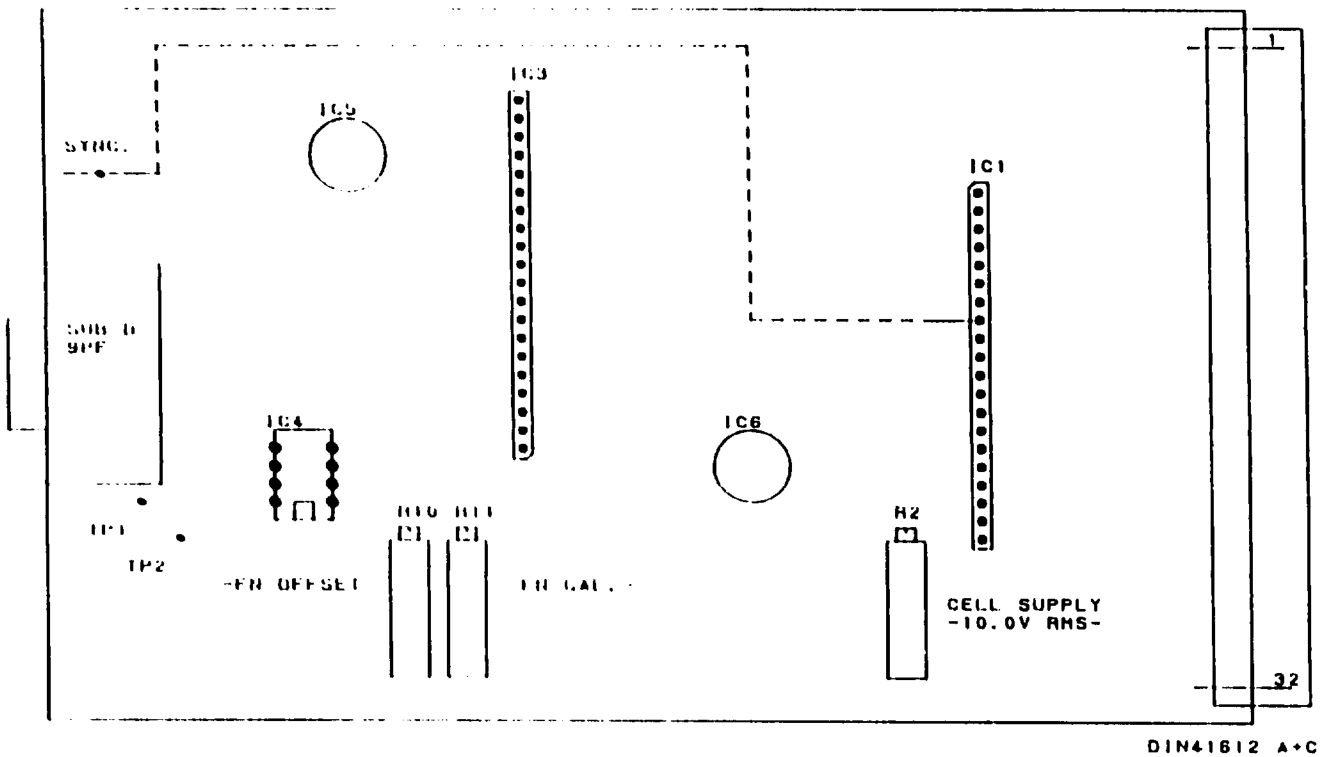
VOLTAGE IN (..) FOR 200 N

DIGITAL

C S E M NEUCHATEL	
Title: BUS	
Size: E — Document Number: 54.1401.02.	REV: 1.1
Date: January 5 1990	Sheet 1 of



IC3
005901
R12, R13
10K0.1%
9A
9C
8A
FN
C12
4.7nF
R18 2.2K
R7
10K
C13
47nF
R10
15K
R19
2.2K
R11
10K
R12
R13
IC6 DG305
R14
22K
12C
7C
FN/2
3A+C
+15V
C6
C4
1A+C
0V
C7
C5
4A+C
-15V
0.1uF 4.7uF
C10
4.7nF
R16 2.2K
R6
15K
R17
2.2K
SYNC.
R2
12K
R1
5.6K
20
C1
0.1uF
ZD1
ZF2.7
D2
ZF2.7
C2 0.1uF
5K0.1%
R3
R2
"CELL SUPPLY:
10.0V RMS"
IC4A
R5
10
C3
100nF
R4
10K0.1%
R16 10K0.1%
IC4B
L272
R15
10
C9
100nF
R17
10K
0.1%
TP
1 2
10V RMS
6-9
0V
1
SUPP-
2
SUPP+
IC5
LM363H10
D3
D4
D5
D6
1N4148
R9
1K
R8
1K
SUB D9PF
3
(IN)
4
IN+
5
IN-
DIN 41612 A+C
R10 : FN OFFSET
R11 :FN CALIBRATION
C S E M NEUCHATEL
Title
PCB 2, MEASURE FN, Electrical circuit
Size
A
Document Number
54.1403
REV
1
Date: November 24, 1988 Sheet 1 of 1



C S E M NEUCHATEL		
Title: PCB2, MEASURE FN		
Size: A	Document Number: 54.1404	REV: 1
Date: February 16, 1989	Sheet 1 of 1	

SCRATCH-TESTER CSEM
DIN41612 A+C

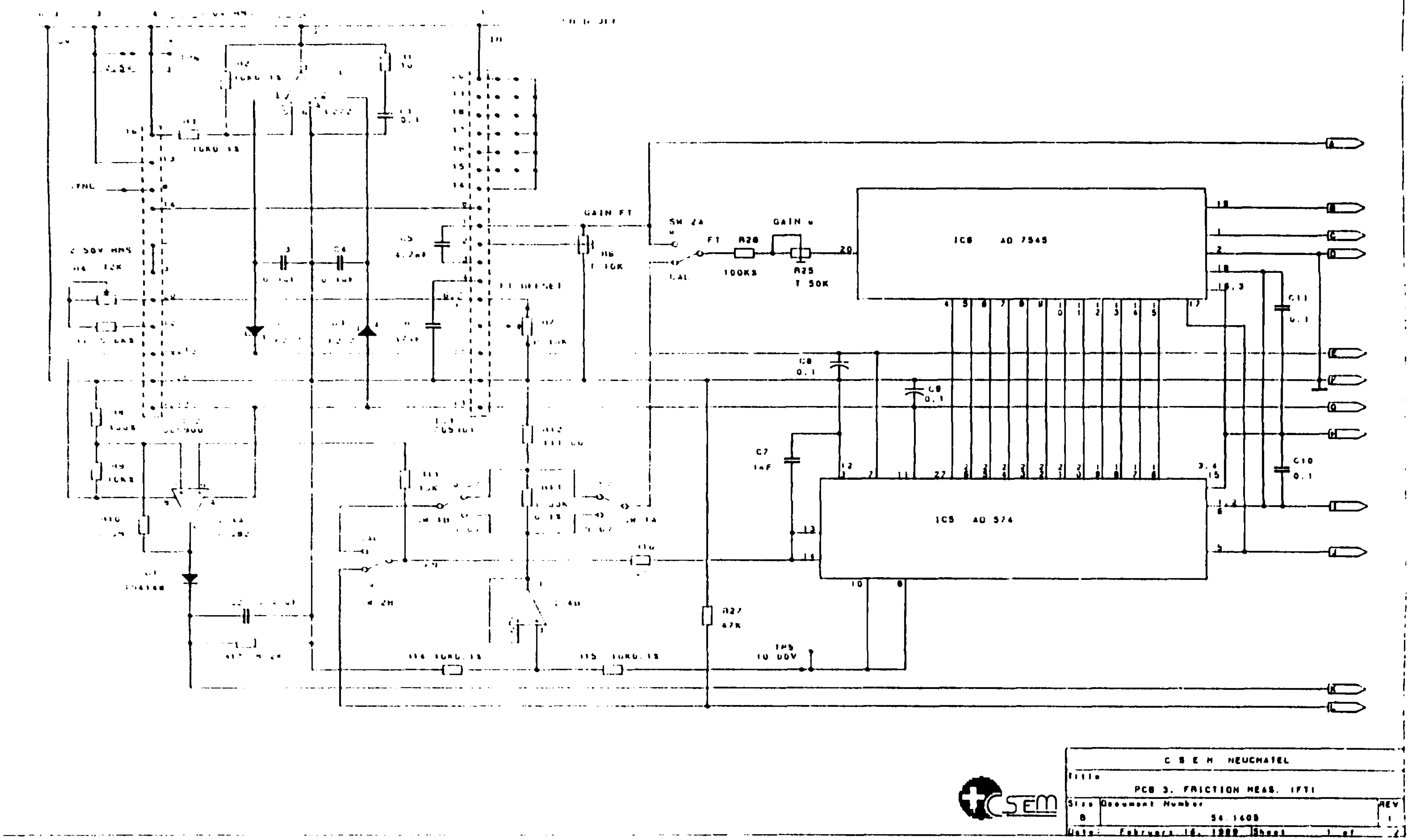
ANALOG

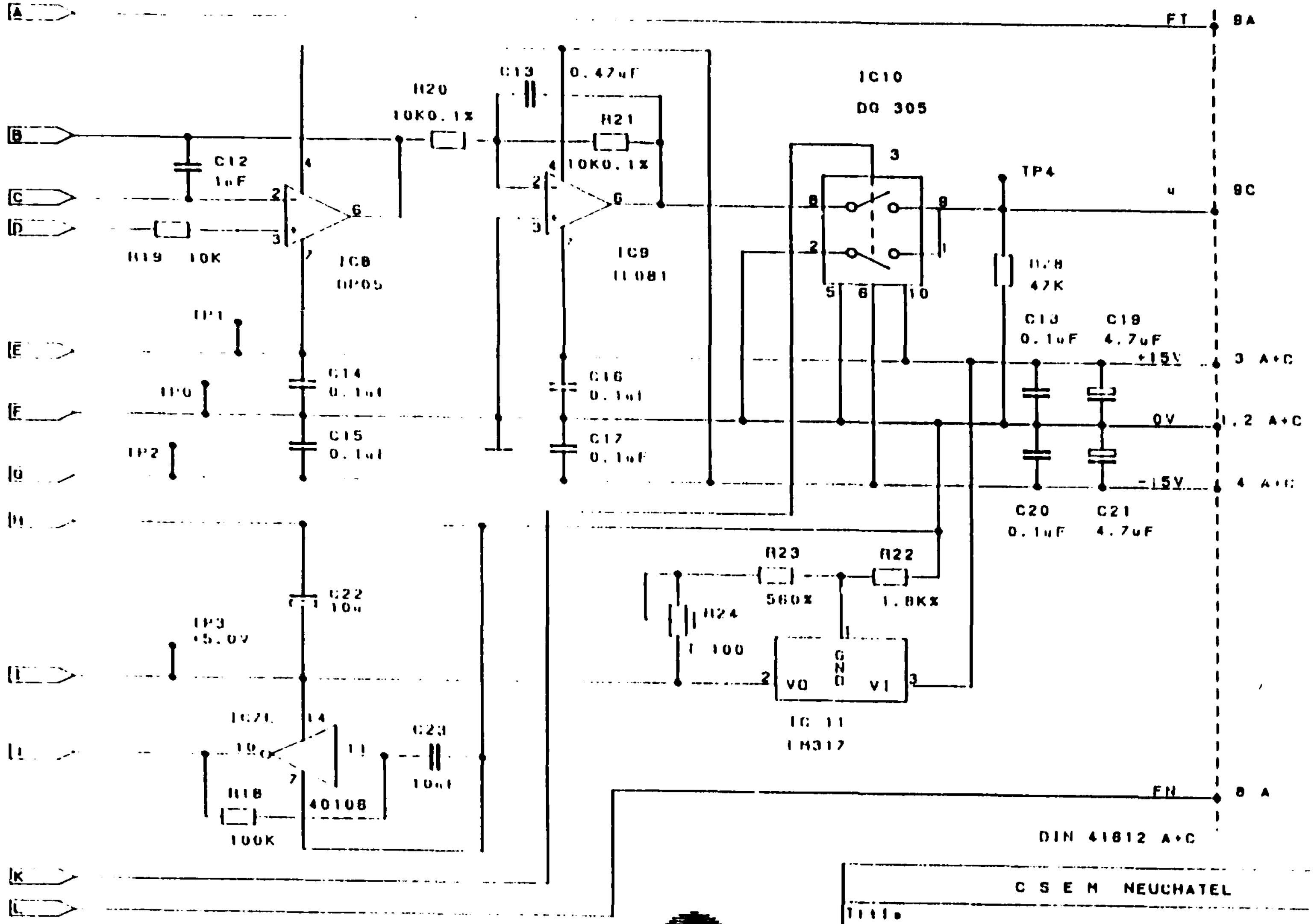
A			C	
GND ANALOG	1	1	GND ANALOG	
GND ANALOG	2	2	GND ANALOG	
+15 VOLTS	3	3	+15 VOLTS	
-15 VOLTS	4	4	-15 VOLTS	
MIN	5	5	MAX	
	6	6		
	7	7	FN/2	0.0 TO +2.5V
FN (0.0 TO +2.5V(5.0))	8	8		
FT	9	9	u*	
AE	10	10	AE'	
	11	11		
	12	12	/200N	0V ON, +15V OFF
	13	13		
/PEN OFF	14	14	/LAMP RUN	
/LAMP STOP	15	15	RECORDER+	
/PEN DOWN	16	16	RECORDER-	
/FORWARD	17	17	/FORCE PROG.	
>MIN	18	18	/>MAX	
/RESET	19	19	/AUTO	
/RUN	20	20	/STOP	
SPEED Y (H)	21	21	SPEED Z (V)	
DETECT. FOR.	22	22	DETEC. BACK	
DETECT. UP	23	23	DETEC. DOWN	
MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	
MOTOR- Z (V)	25	25	MOTOR- Z (V)	
MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	
MOTOR- Y (H)	27	27	MOTOR- Y (H)	
TACHY+ Y (H)	28	28	TACHY- Z (V)	
+12 VOLTS	29	29	+12 VOLTS	
+24 VOLTS	30	30	+24 VOLTS	
GND DIGITAL	31	31	GND DIGITAL	
GND DIGITAL	32	32	GND DIGITAL	
A			C	

VOLTAGE IN (..) FOR 200 N

DIGITAL

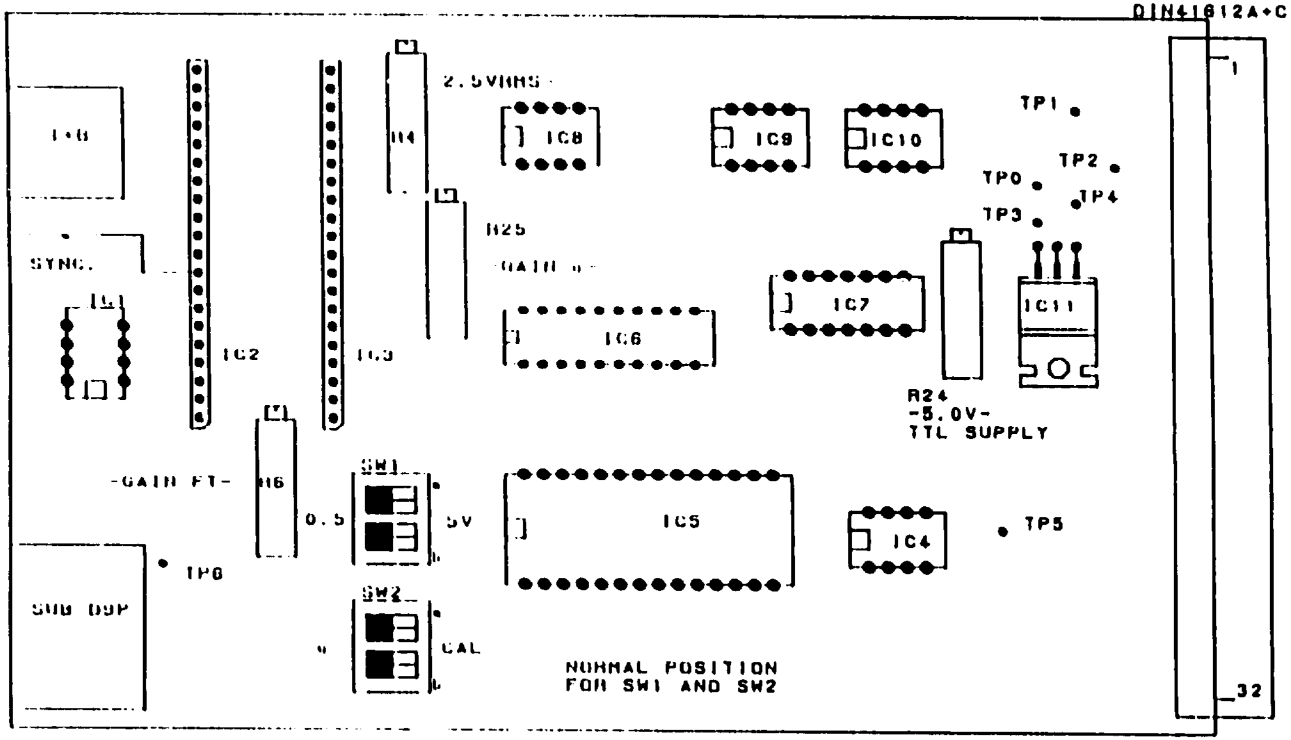
C S E M NEUCHATEL	
Title: BUS	
Size: B — Document Number: 54.1403.24	REV: 1
Date: January 3, 1990 — Sheet	


GAIN FT
SW 2A
FT
R28
100KΩ
GAIN
R25
T 50K
CAL
IC6 AD 7545
IC5 AD 574
C11
0.1
C10
0.1
C8
0.1
C9
0.1
C7
1nF
R27
47K
TP5
10 00V
R6
FT OFFSET
C S E M NEUCHATEL
Title
PCB 3. FRICTION MEAS. (FT)
Size
Document Number
B
54.1408
REV
Date:
February 16, 1989
Sheet
1 of 2



C S E M NEUCHATEL

Title	PCB 3, FRICTION MEAS. (FT)	
Size A	Document Number 54.1408	REV 1
Date: November 28, 1988	Sheet 2 of 2	



	CALIBRATION SW2A ->, SW2B ->	MEASURE SW2A <-, SW2B <-
SW1A ->, SW1B ->	u = 1.00V	u = 0.00V OR X.XXV
SW1A <-, SW1B <-	u = 1.00V	
SW1A ->, SW1B <-	u =10.00V	
SW1A <-, SW1B ->	u = 0.10V	

SW1A & SW2A = FT (OUT PIN 8A)
SW1B & SW2B = FN (IN PIN 8A)
(u OUT PIN 8C)

C S E M NEUCHATEL		
Title: PCB3, FRICTION MEAS. (FT)		
Size: A	Document Number: 54.1407	REV: 1
Date: February 18, 1989	Sheet 1 of 1	

SCRATCH-TESTER CSEM
DIN41612 A+C

ANALOG

	A			C	
	GND ANALOG	1	1	GND ANALOG	
	GND ANALOG	2	2	GND ANALOG	
	+15 VOLTS	3	3	+15 VOLTS	
	-15 VOLTS	4	4	-15 VOLTS	
	MIN	5	5	MAX	
		6	6		
		7	7	FN/2	
0.0 TO +2.5V(5.0)	FN	8	8		
0.0 TO +2.5V(5.0)	FT	9	9	v*	0 TO 1.0V(FOR v =1)
	AE	10	10	AE'	
		11	11		
		12	12	/200N	
		13	13		
	/PEN OFF	14	14	/LAMP RUN	
	/LAMP STOP	15	15	RECORDER+	
	/PEN DOWN	16	16	RECORDER-	
	/FORWARD	17	17	/FORCE PROG.	
	>MIN	18	18	/>MAX	
	/RESET	19	19	/AUTO	
	/RUN	20	20	/STOP	
	SPEED Y (H)	21	21	SPEED Z (V)	
	DETECT. FOR.	22	22	DETEC. BACK	
	DETECT. UP	23	23	DETEC. DOWN	
	MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	
	MOTOR- Z (V)	25	25	MOTOR- Z (V)	
	MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	
	MOTOR- Y (H)	27	27	MOTOR- Y (H)	
	TACHY+ Y (H)	28	28	TACHY- Z (V)	
	+12 VOLTS	29	29	+12 VOLTS	
	+24 VOLTS	30	30	+24 VOLTS	
	GND DIGITAL	31	31	GND DIGITAL	
	GND DIGITAL	32	32	GND DIGITAL	
	A			C	VOLTAGE IN (..) FOR 200 N

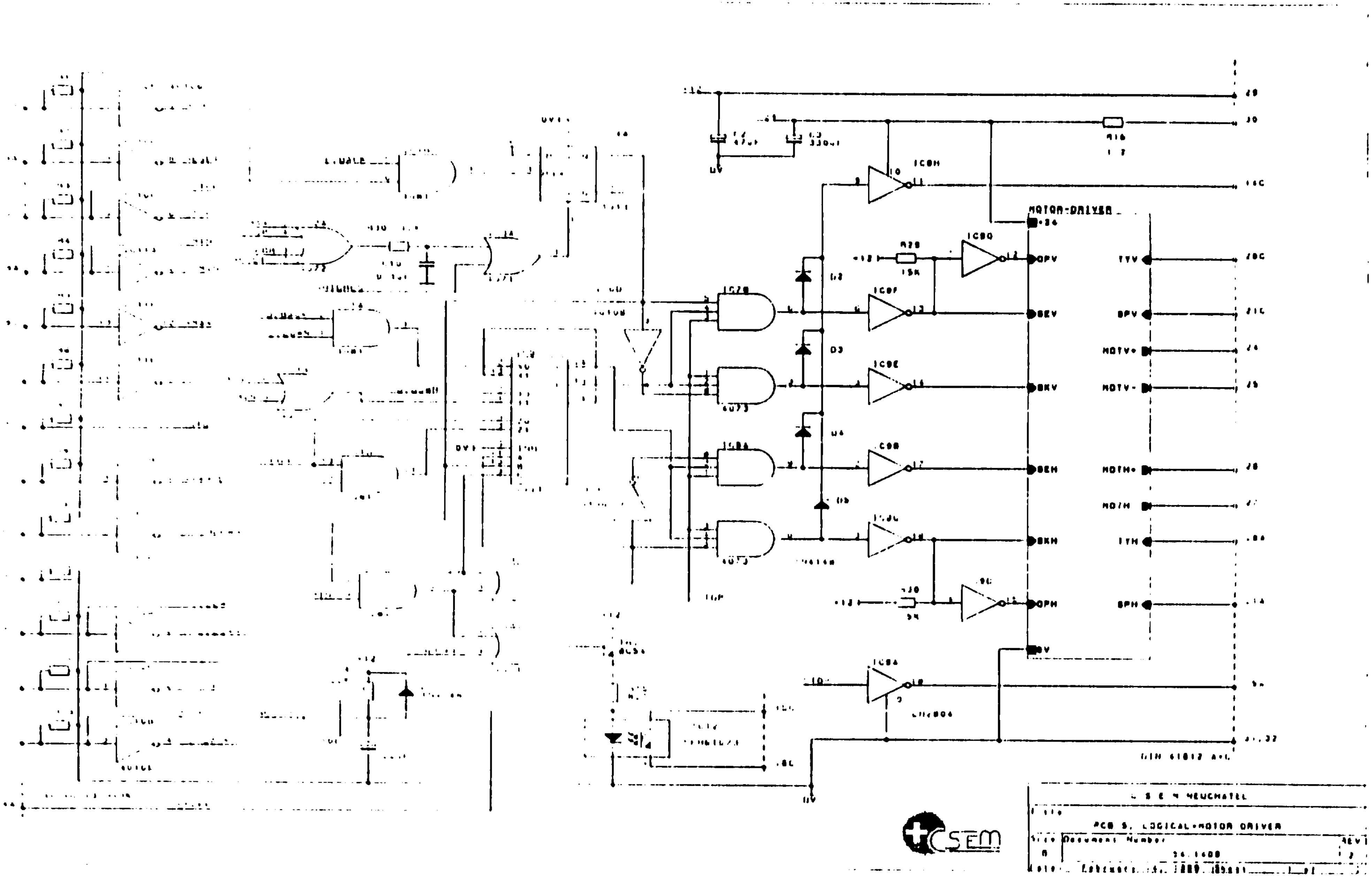
DIGITAL

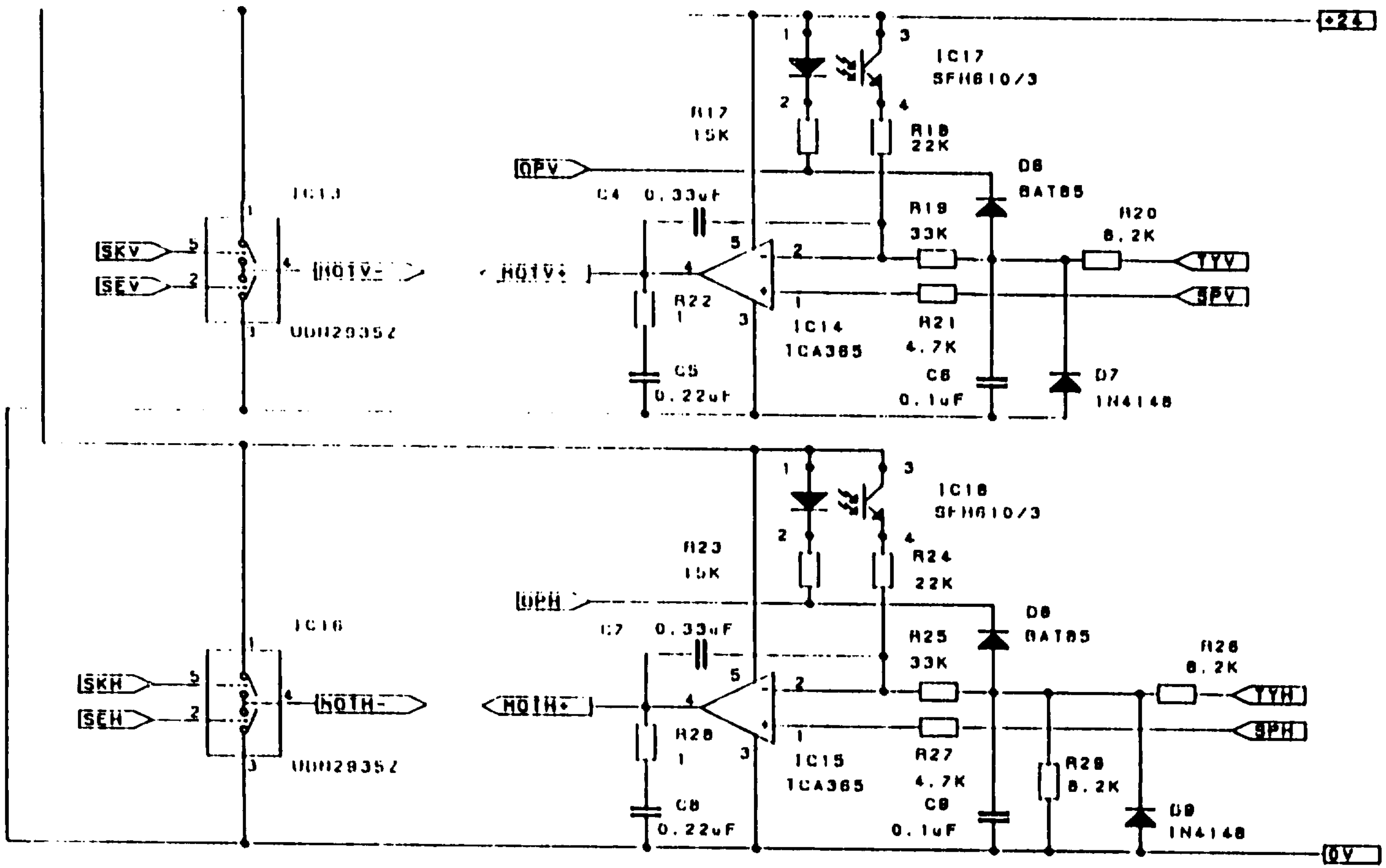
C S E M NEUCHATEL

Title
BUS

Size Document Number: 54.1405.08.07 REV 1

Date: January 5, 1990 Sheet


MOTOR-DRIVER
IC8H
IC8D
IC8F
IC8E
IC8B
IC8A
IC7B
4073
R16
R28
15K
R30
5K
D2
D3
D4
D5
TTV
BPV
MOTV+
MOTV-
MOTH+
MOTH
TTH
BPH
OPV
BEV
BKV
BEH
BKH
OPH
C.S.E.M NEUCHATEL
PCB 5, LOGICAL-MOTOR DRIVER
Document Number
REV
CSEM



C S E M NEUCHATEL		
Title: PCB 5, MOTOR DRIVER		
Size: A	Document Number: 54.1409	REV: 1
Date: November 25, 1988	Sheet 2 of 2	

SCRATCH-TESTER CSEM
DIN41612 A+C

ANALOG

	A			C	
	GND ANALOG	1	1	GND ANALOG	
	GND ANALOG	2	2	GND ANALOG	
	+15 VOLTS	3	3	+15 VOLTS	
	-15 VOLTS	4	4	-15 VOLTS	
0.0 TO +5.0V	MIN	5	5	MAX	+5.0V TO 0.0V
		6	6		
		7	7	FN/2	
	FN	8	8		
	FT	9	9	u*	
	AE	10	10	AE*	
		11	11		
		12	12	/200N	
		13	13		
0V ON,+1.2V OFF(IF..)	/PEN OFF	14	14	/LAMP RUN	+0.5V ON,+24V OFF
+0.5V ON,+24V OFF	/LAMP STOP	15	15	RECORDER+	+12V
0V ON, +12V OFF	/PEN DOWN	16	16	RECORDER-	+12V ON, 0V OFF(IF..)
0V ON, +12V OFF	/FORWARD	17	17	/FORCE PROG.	0V ON, +12V OFF
+12V ON, 0V OFF	>MIN	18	18	/>MAX	0V ON, +12V OFF
0V ON, +12V OFF	/RESET	19	19	/AUTO	0V ON, +12V OFF
0V ON, +12V OFF	/RUN	20	20	/STOP	0V ON, +12V OFF
ABOUT +2.90V	SPEED Y (H)	21	21	SPEED Z (V)	ABOUT +2.90V
+12V ON, 0V OFF	DETECT. FOR.	22	22	DETEC. BACK	+12V ON, 0V OFF
+12V ON, 0V OFF	DETECT. UP	23	23	DETEC. DOWN	+12V ON, 0V OFF
	MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	AB. +3.7VGO, -22VBACK
	MOTOR- Z (V)	25	25	MOTOR- Z (V)	
	MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	AB. +6.5VGO, -22VBACK
	MOTOR- Y (H)	27	27	MOTOR- Y (H)	
ABOUT +5.80V	TACHY+ Y (H)	28	28	TACHY- Z (V)	ABOUT +2.90V
	+12 VOLTS	29	29	+12 VOLTS	+0.2V, -0.2V
	+24 VOLTS	30	30	+24 VOLTS	+2.0V, -2.0V
	GND DIGITAL	31	31	GND DIGITAL	
	GND DIGITAL	32	32	GND DIGITAL	
	A			C	VOLTAGE IN (..) FOR 200 N

DIGITAL

C S E M NEUCHATEL

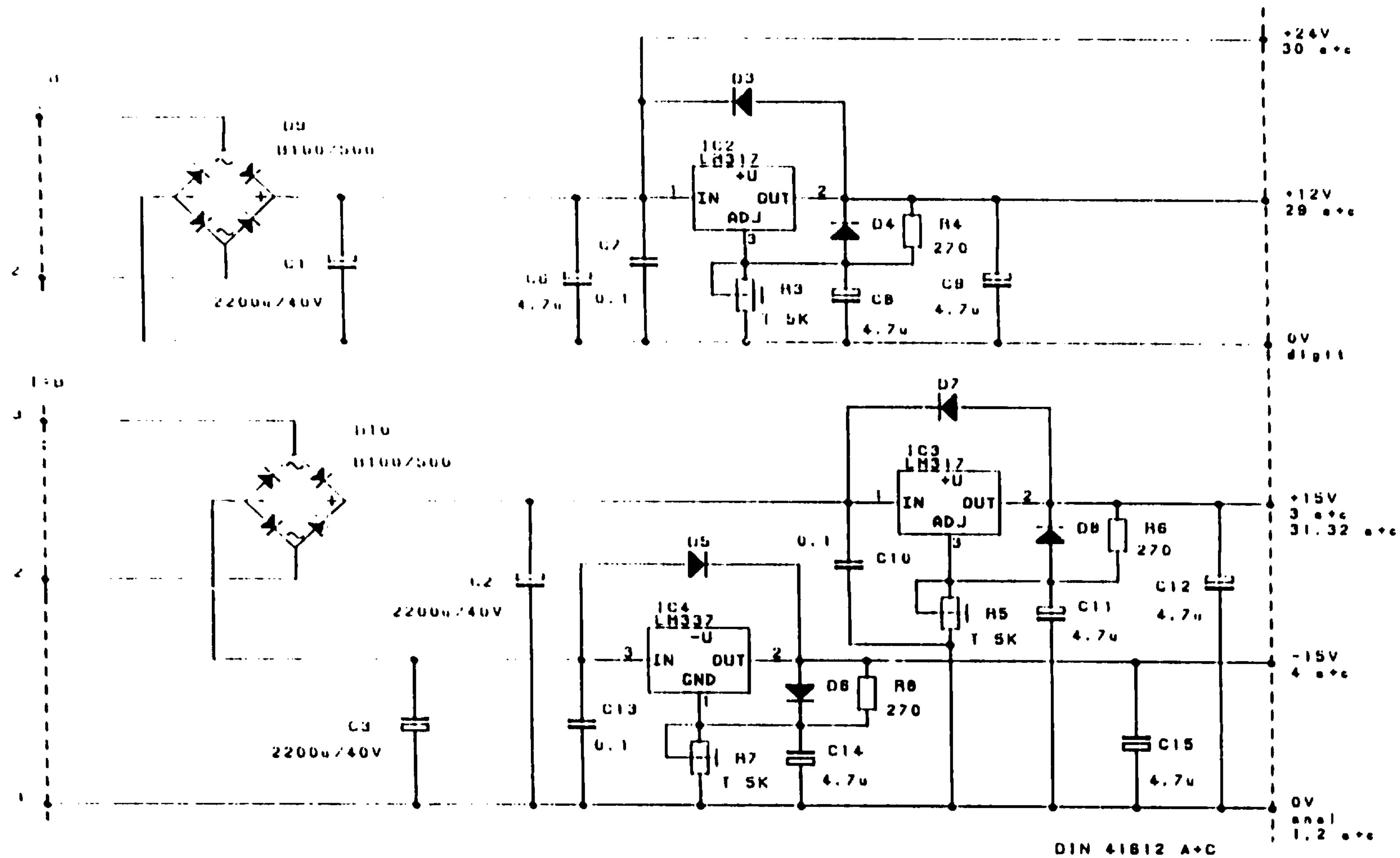
Title

BUS

Size Document Number REV

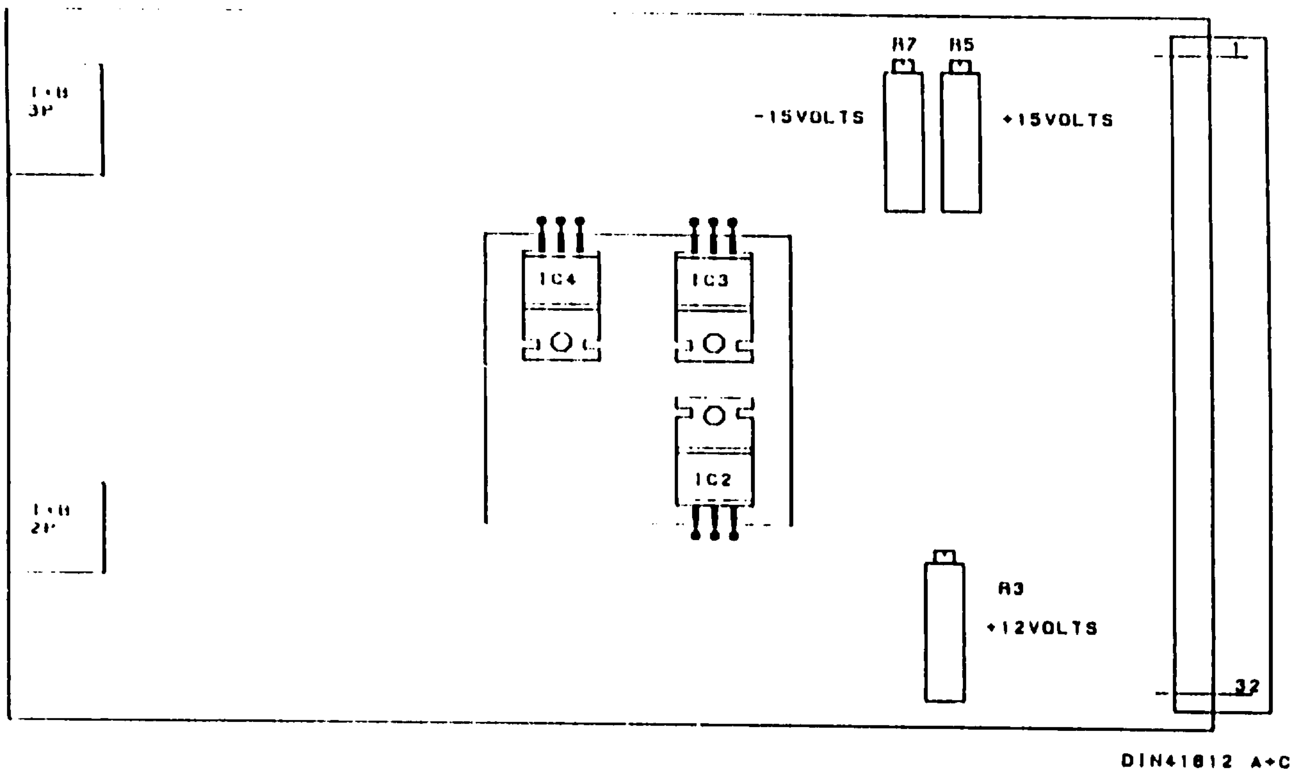
E 54.1408.09 1

Date: January 5, 1990 Sheet 1 of 1



CSEM

C S E M NEUCHATEL		
Title: PCB 8.SUPPLY, Electrical circuit		
Size: A	Document Number: 54.1413	REV: 1
Date: November 25, 1988	Sheet 1 of 1	



C S E M NEUCHATEL		
Title: PCB 6. SUPPLY		
Size: A	Document Number: 54.1414	REV: 1
Date: November 25, 1988	Sheet 1 of 1	

SCRATCH-TESTER CSEM
DIN41612 A+C

ANALOG

A			C	
GND ANALOG	1	1	GND ANALOG	
GND ANALOG	2	2	GND ANALOG	
+15 VOLTS	3	3	+15 VOLTS	+0.2V -0.2V
-15 VOLTS	4	4	-15 VOLTS	+0.2V -0.2V
MIN	5	5	MAX	
	6	6		
	7	7	FN/2	
FN	8	8		
FT	9	9	u*	
AE	10	10	AE'	
	11	11		
	12	12	/200N	
	13	13		
/PEN OFF	14	14	/LAMP RUN	
/LAMP STOP	15	15	RECORDER+	
/PEN DOWN	16	16	RECORDER-	
/FORWARD	17	17	/FORCE PROG.	
>MIN	18	18	/>MAX	
/RESET	19	19	/AUTO	
/RUN	20	20	/STOP	
SPEED Y (H)	21	21	SPEED Z (V)	
DETECT. FOR.	22	22	DETEC. BACK	
DETECT. UP	23	23	DETEC. DOWN	
MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	
MOTOR- Z (V)	25	25	MOTOR- Z (V)	
MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	
MOTOR- Y (H)	27	27	MOTOR- Y (H)	
TACHY+ Y (H)	28	28	TACHY- Z (V)	
+12 VOLTS	29	29	+12 VOLTS	+0.2V. -0.2V
+24 VOLTS	30	30	+24 VOLTS	+2.0V. -2.0V
GND DIGITAL	31	31	GND DIGITAL	
GND DIGITAL	32	32	GND DIGITAL	

A C

VOLTAGE IN (..) FOR 200 N

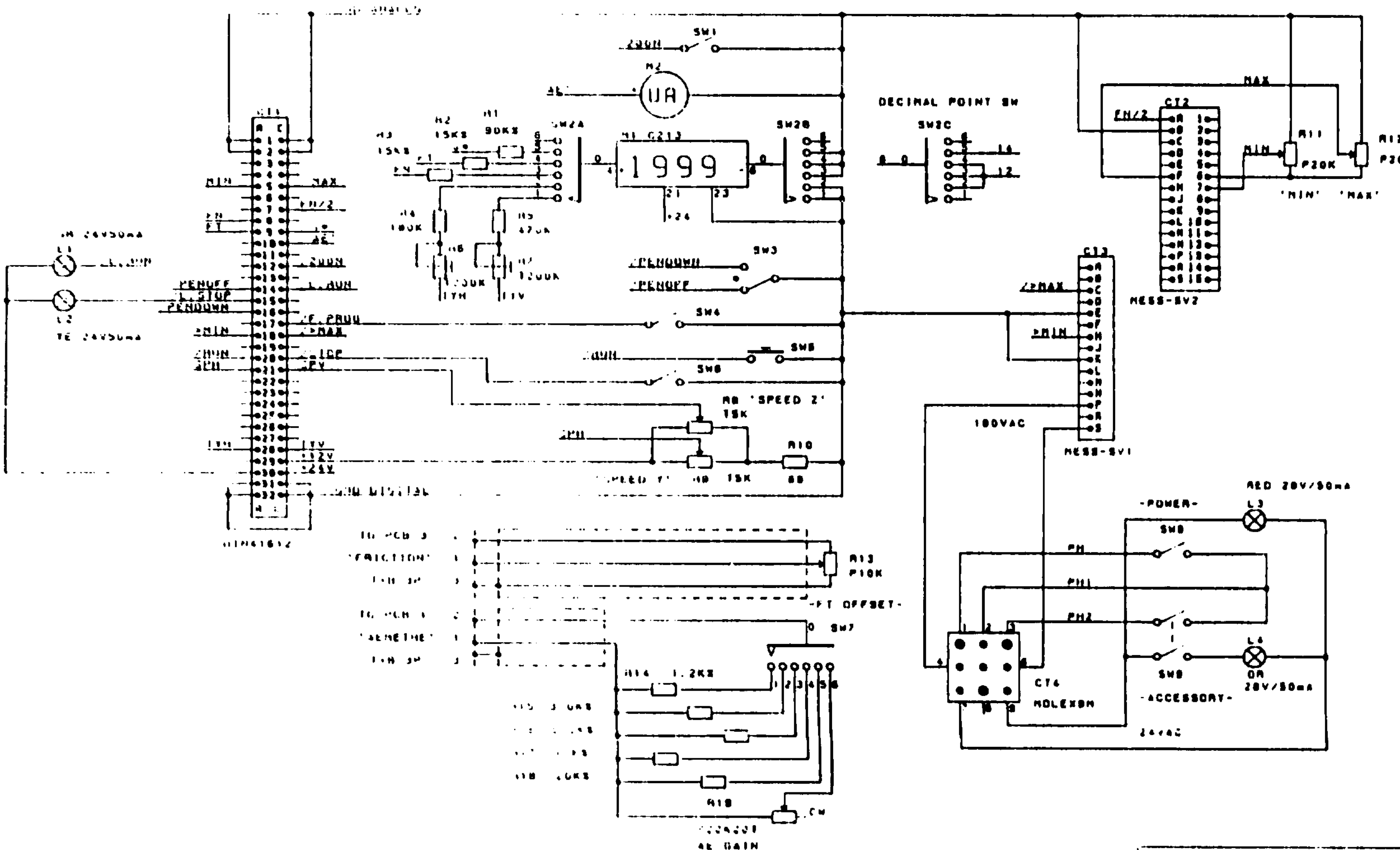
DIGITAL

C S E M NEUCHATEL

Title: BUS

Size: E — Document Number: 54.1413.14 — REV: 1

Date: January 5, 1990 Sheet [illegible] of [illegible]



C S E M NEUCHATEL

Title: FRONT PANEL, Electrical circuit

Size	Document Number	REV
B	54.1410	1

Date: February 1, 1988 Sheet 1 of 1

SCRATCH-TESTER CSEM
DIN41612 A+C

ANALOG

	A			C	
	GND ANALOG	1	1	GND ANALOG	
	GND ANALOG	2	2	GND ANALOG	
	+15 VOLTS	3	3	+15 VOLTS	
	-15 VOLTS	4	4	-15 VOLTS	
0.0 TO +5.0V	MIN	5	5	MAX	+5.0V TO 0.0V
		6	6		
		7	7	FN/2	
	FN	8	8		
	FT	9	9	v*	
	AE	10	10	AE'	INTERNAL USE
		11	11		
		12	12	/200N	0V ON,+15V OFF
		13	13		
0V ON,+1.2V OFF(IF..)	/PEN OFF	14	14	/LAMP RUN	+0.5V ON,+24V OFF
+0.5V ON,+24V OFF	/LAMP STOP	15	15	RECORDER+	
0V ON, +12V OFF	/PEN DOWN	16	16	RECORDER-	
	/FORWARD	17	17	/FORCE PROG.	0V ON, +12V OFF
+12V ON, 0V OFF	>MIN	18	18	/>MAX	0V ON, +12V OFF
	/RESET	19	19	AUTO	
0V ON, +12V OFF	/RUN	20	20	STOP	0V ON, +12V OFF
	SPEED Y (H)	21	21	SPEED Z (V)	
	DETECT. FOR.	22	22	DETEC. BACK	
	DETECT. UP	23	23	DETEC. DOWN	
	MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	
	MOTOR- Z (V)	25	25	MOTOR- Z (V)	
	MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	
	MOTOR- Y (H)	27	27	MOTOR- Y (H)	
	TACHY+ Y (H)	28	28	TACHY+ Z (V)	
	+12 VOLTS	29	29	+12 VOLTS	
	+24 VOLTS	30	30	+24 VOLTS	
	GND DIGITAL	31	31	GND DIGITAL	
	GND DIGITAL	32	32	GND DIGITAL	
	A			C	VOLTAGE IN (..) FOR 200 N

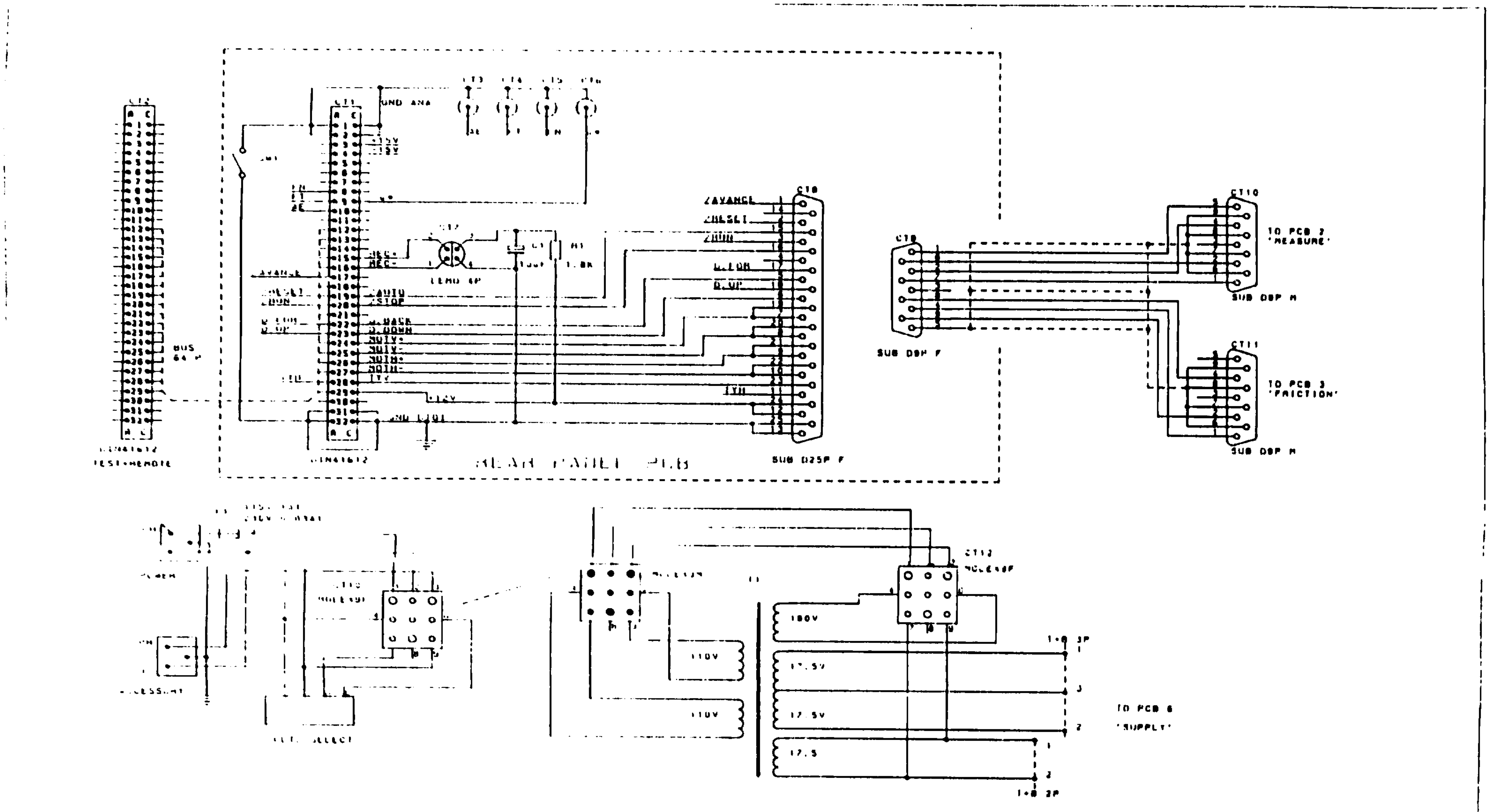
DIGITAL

C S E M NEUCHATEL

Title
BUS

Size Document Number REV
E 54.1410 1

Date: January 3, 1990 Sheet of



C S E M NEUCHATEL		
Title	REAR PANEL, Electrical circuit	
Size: B	Document Number: 54.1411	REV: 1
Date: November 24, 1988	Sheet 1 of 1	

SCRATCH-TESTER CSEM
DIN41612 A+C

ANALOG

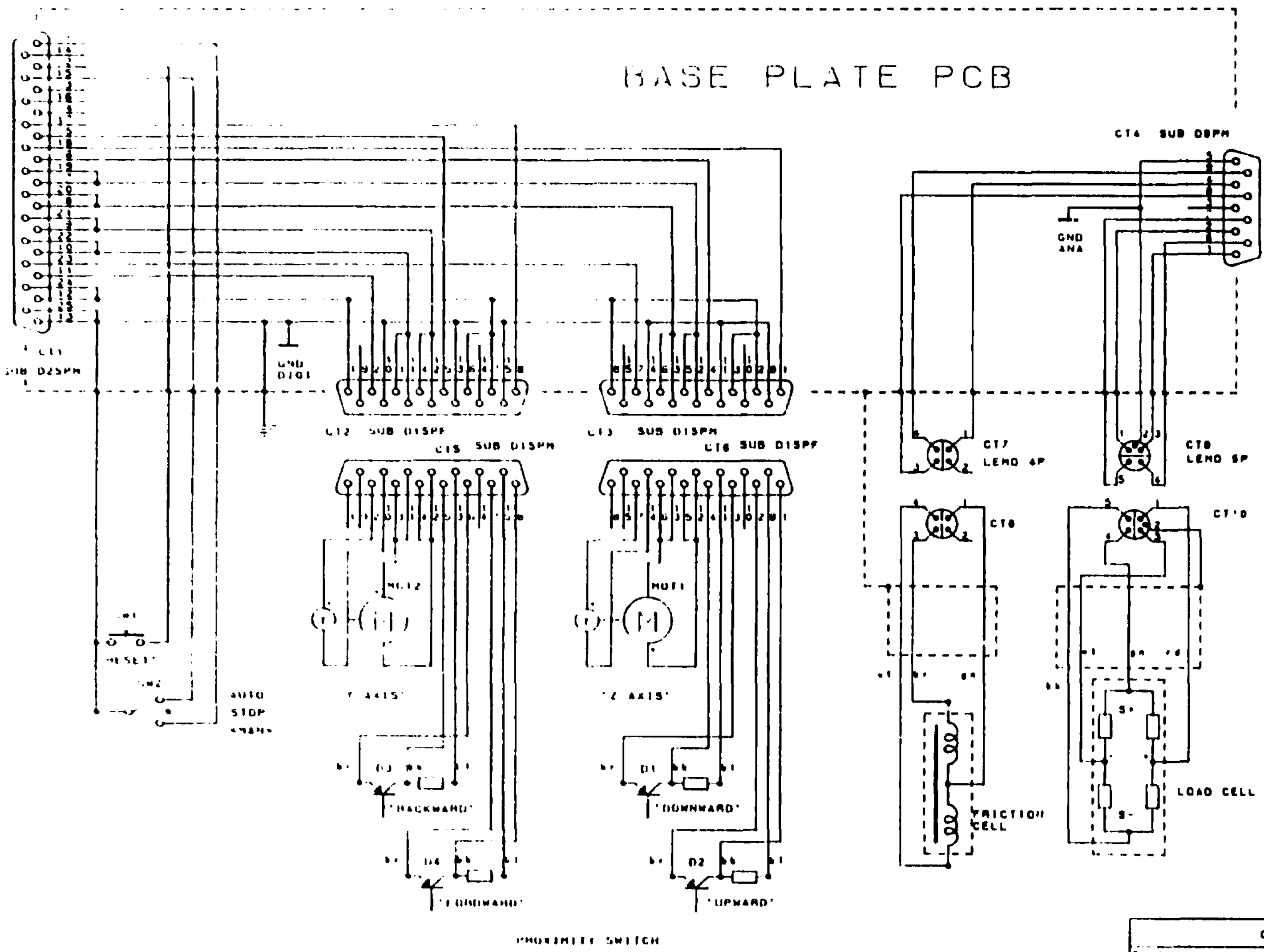
A			C
GND ANALOG	1	1	GND ANALOG
GND ANALOG	2	2	GND ANALOG
+15 VOLTS	3	3	+15 VOLTS
-15 VOLTS	4	4	-15 VOLTS
MIN	5	5	MAX
	6	6	
	7	7	FN/2
FN	8	8	
FT	9	9	V*
AE	10	10	AE*
	11	11	
	12	12	/200N
DIGITAL			
	13	13	
/PEN OFF	14	14	/LAMP RUN
/LAMP STOP	15	15	RECORDER+
/PEN DOWN	16	16	RECORDER-
/FORWARD	17	17	/FORCE PROG.
>MIN	18	18	/>MAX
/RESET	19	19	/AUTO
/RUN	20	20	/STOP
SPEED Y (H)	21	21	SPEED Z (V)
DETECT. FOR.	22	22	DETEC. BACK
DETECT. UP	23	23	DETEC. DOWN
MOTOR+ Z (V)	24	24	MOTOR+ Z (V)
MOTOR- Z (V)	25	25	MOTOR- Z (V)
MOTOR+ Y (H)	26	26	MOTOR+ Y (H)
MOTOR- Y (H)	27	27	MOTOR- Y (H)
TACHY+ Y (H)	28	28	TACHY- Z (V)
+12 VOLTS	29	29	+12 VOLTS
+24 VOLTS	30	30	+24 VOLTS
GND DIGITAL	31	31	GND DIGITAL
GND DIGITAL	32	32	GND DIGITAL

RECORDER+: +12V

RECORDER-: +12V ON, 0V OFF(IF..)

VOLTAGE IN (..) FOR 200 N

C S E M NEUCHATEL		
Title: BUS		
Size: E	Document Number: 54.1411	REV: 1
Date: January 3, 1990	Sheet	of



C S E M NEUCHATEL

Title: WIRING OF MECHANICAL PARTS

Size	Document Number	REV
B	54.1412	1

Date: November 25, 1988 Sheet 1 of 1

SCRATCH-TESTER CSEM
DIN41612 A+C

ANALOG

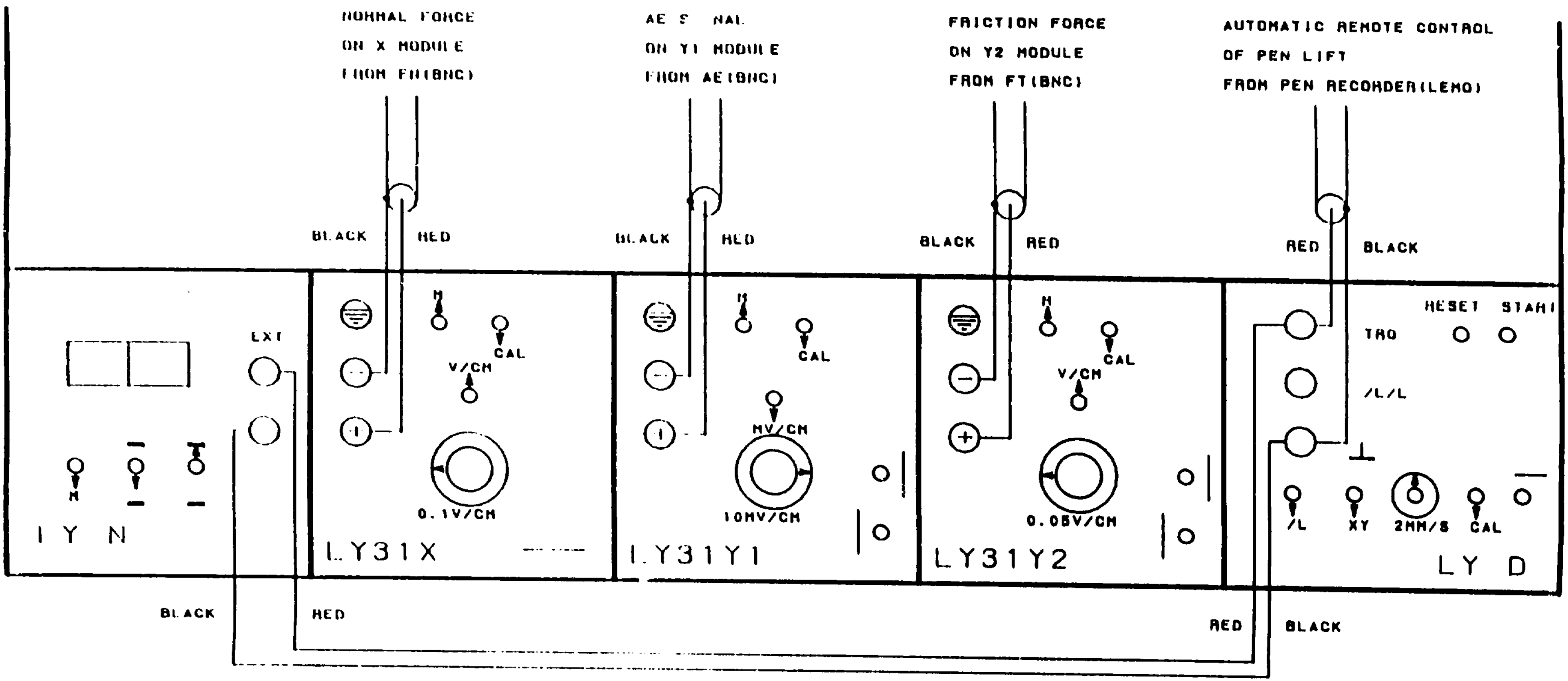
	A			C	
	GND ANALOG	1	1	GND ANALOG	
	GND ANALOG	2	2	GND ANALOG	
	+15 VOLTS	3	3	+15 VOLTS	
	-15 VOLTS	4	4	-15 VOLTS	
	MIN	5	5	MAX	
		6	6		
		7	7	FN/2	
	FN	8	8		
	FT	9	9	u*	
	AE	10	10	AE*	
		11	11		
		12	12	/200N	
		13	13		
	/PEN OFF	14	14	/LAMP RUN	
	/LAMP STOP	15	15	RECORDER+	
	/PEN DOWN	16	16	RECORDER-	
	/FORWARD	17	17	/FORCE PROG.	
	>MIN	18	18	/>MAX	
0V ON, +12V OFF	/RESET	19	19	/AUTO	0V ON, +12V OFF
	/RUN	20	20	/STOP	
	SPEED Y (H)	21	21	SPEED Z (V)	
+12V ON, 0V OFF	DETECT. FOR.	22	22	DETEC. BACK	+12V ON, 0V OFF
+12V ON, 0V OFF	DETECT. UP	23	23	DETEC. DOWN	+12V ON, 0V OFF
	MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	AB. +3.7VGO, -22VBACK
	MOTOR- Z (V)	25	25	MOTOR- Z (V)	
	MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	AB. +6.5VGO, -22VBACK
	MOTOR- Y (H)	27	27	MOTOR- Y (H)	
ABOUT -5.80V	TACHY+ Y (H)	28	28	TACHY- Z (V)	ABOUT +2.90V
	+12 VOLTS	29	29	+12 VOLTS	
	+24 VOLTS	30	30	+24 VOLTS	
	GND DIGITAL	31	31	GND DIGITAL	
	GND DIGITAL	32	32	GND DIGITAL	
	A			C	

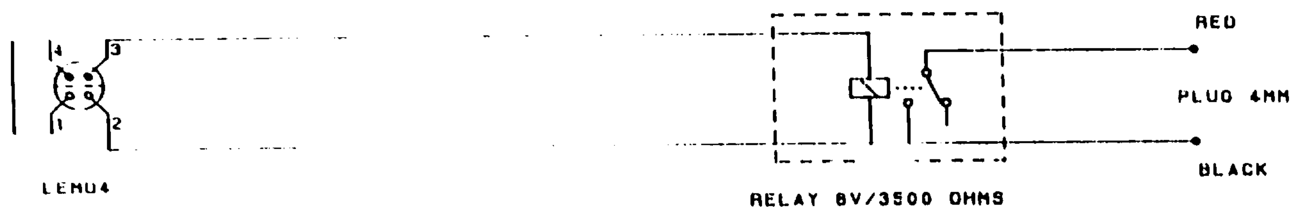
VOLTAGE IN (..) FOR 200 N

DIGITAL

C S E M NE[illegible]EL	
Title: BUS	
Size: E — Document Number: 54.1412	REV: 1
Date: [illegible] 1990 Sheet of	

WIRING OF LYNSEIS 18100 RECORDER





CSEM

C S E M NEUCHATEL		
Title: PEN DRIVER		
Size: A	Document Number: 54.1420	REV: 1
Date: February 1, 1989	Sheet 1 of 1	

INTERFACE PC TO SCRATCH-TESTER

PCB1 : INTERFACE

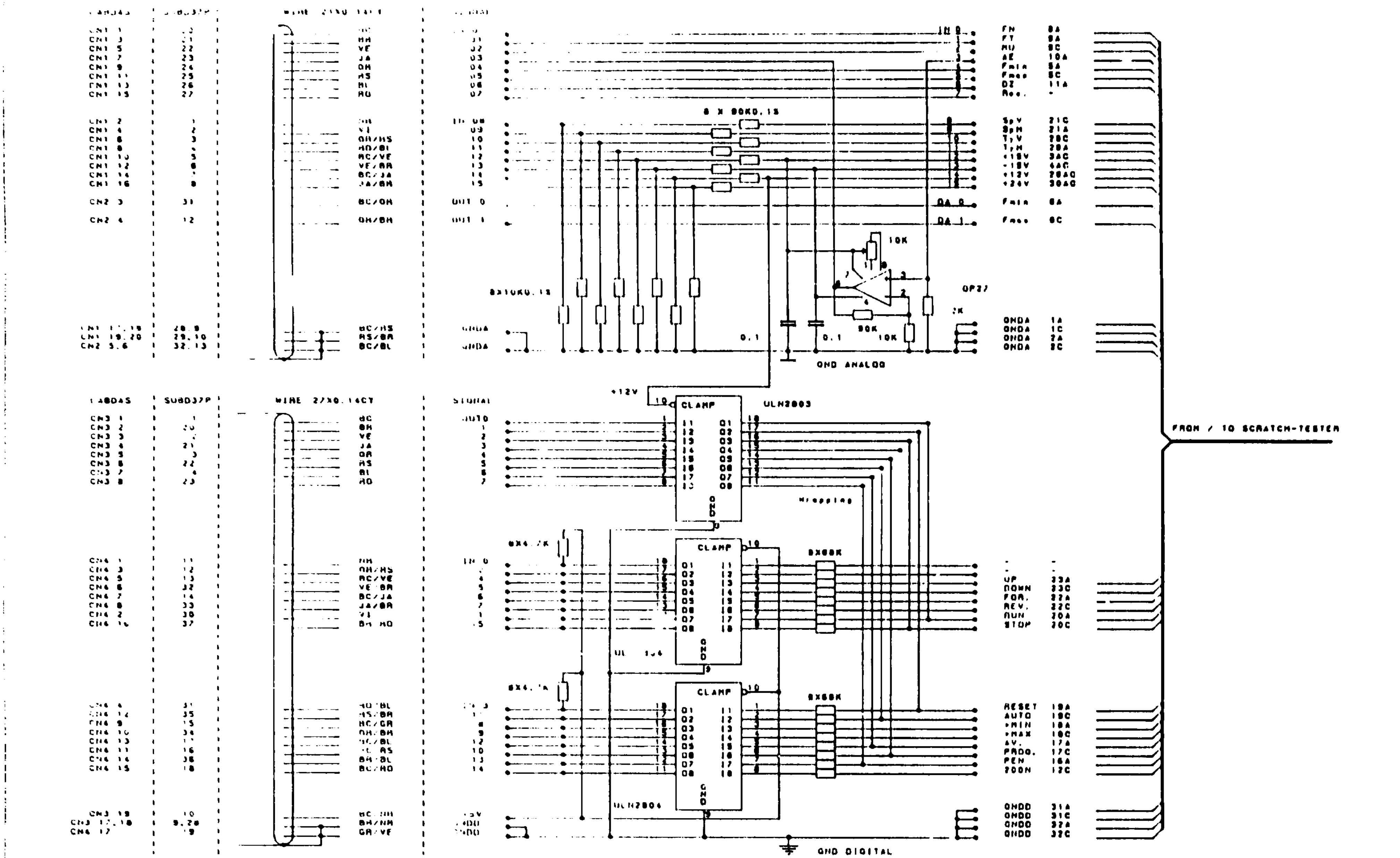
PCL718: IN/OUT ATTRIBUTION

: DATA ACQUISITION CARD FOR PC

: SWITCHES POSITION

: LOCKING CLIP

: WIRING,
CONTROL UNIT-INTERFACE-PC



C S E M NEUCHATEL

Title: INTERFACE SCRATCH-TESTER TO PC

Size	Document Number	REV
B	54.080	

Date: March 20, 1990 Sheet

REVETEST-PC IN/OUT A/D FS = 5VOLTS

DIGITAL IN/OUT AEX10 2.44MV/BIT

IN/OUT	AD.	128	64	32	16	8	4	2	1
IN 1	B+3	/REV	/FOR	/DOWN	/UP	RESET		RUN	
IN 2	B+11	STOP	ZOOM	PEN	AVAN.	AUTO	PROG	>MAX	/>MIN
OUT 1	B+3	PEN	AVAN.	AUTO	PROG		STOP	RESET	RUN
OUT 2	B+11								

ANALOG IN

CHANEL	SIGNAL	DIV.	PLEINE ECHELLE UNITE		PLEINE ECHELLE (MV)	PLEINE ECHELLE (BIT)	RESOLUTION (UNIT/BIT)	FACTEUR BIN TO UNIT
0	FN	1/1	N	200.0	5000	2048	0.1	0.0977
1	FT	1/1	N	200.0	5000	2048	0.1	0.0977
2	MU	1/1	N/N	1.00	1000	409.6	0.0025	0.00244
3	AE	1/1	%	100	2000	819.2	0.12	0.122
4	FMIN	1/1	N	100/200	5000	2048	0.05/0.1	0.0488 /0.0977
5	FMAX	1/1	N	100/200	5000	2048	0.05/0.1	0.0488 /0.0977
6	DZ	1/1	muM	-	-	-	-	-
7	-	1/1	-	-	-	-	-	-
8	SV	1/10	N/'	→ 100 ← E700	295 E2065	120.9 846.3	0.83	0.827
9	SH	1/10	mm/'	→ 10.0 ← E40.0	295 E1180	120.9 483.6	0.083	0.0827
10	TV	1/10	V	→ 2.95 ← E20.7	295 E2065	120.9 846.3	0.025	0.0244
11	TH	1/10	V	→ 5.90 ← E23.6	590 E2360	241.8 967.2	0.025	0.0244
12	+15V	1/10	V	+15.0	+1500	614.8	0.025	0.0244
13	-15V	1/10	V	-15.0	-1500	614.8	0.025	0.0244
14	+12V	1/10	V	+12.0	+1200	491.8	0.025	0.0244
15	+24V	1/10	V	+24.0	+2400	983.6	0.025	0.0244

ANALOG OUT

CHANEL	SIGNAL	PLEINE ECHELLE UNITE	PLEINE ECHELLE (UNIT)	PLEINE ECHELLE (MV)	PLEINE ECHELLE (BIT)	RESOLUTION (MV)	RESOLUTION (BIT)	FACTEUR
0	FMIN							
1	FMAX							

C S E M NEUCHATEL

Title: A/D VOLT'S RESOLUTION

Size	Document Number	REV
E	54.000.X	2

Date: May 2, 1990 Sheet 1 of 1

CHAPTER 1 GENERAL INFORMATION

1-1 Introduction to The PCL-718

PCL-718 is a high performance, high speed, multi-function data acquisition card for the IBM PC/XT/AT or compatibles. The high-end specifications of this full size card and complete software support from third-party vendors make it ideal for wide range applications in the industrial and laboratory environment, like data acquisition, process control, automatic testing and factory automation.

The key features of this interface control card include:

* Switch selectable 16 single-ended or 8 differential analog input channels.

* An industrial standard 12 Bit successive approximation converter (HI-674A) to convert analog inputs. The maximum A/D sampling rate is 60 KHz in DMA mode. With the Option 001 which supplies a faster A/D converter (HI-774), PCL-718 can accomplish 100 KHz sampling rate in DMA mode.

* Switch selectable versatile analog input ranges.
  Bipolar: +/- 0.5V, +/- 1V, +/- 2.5V, +/- 5V, +/- 10V.
  Unipolar: +1V, +2V, +5V, +10V.

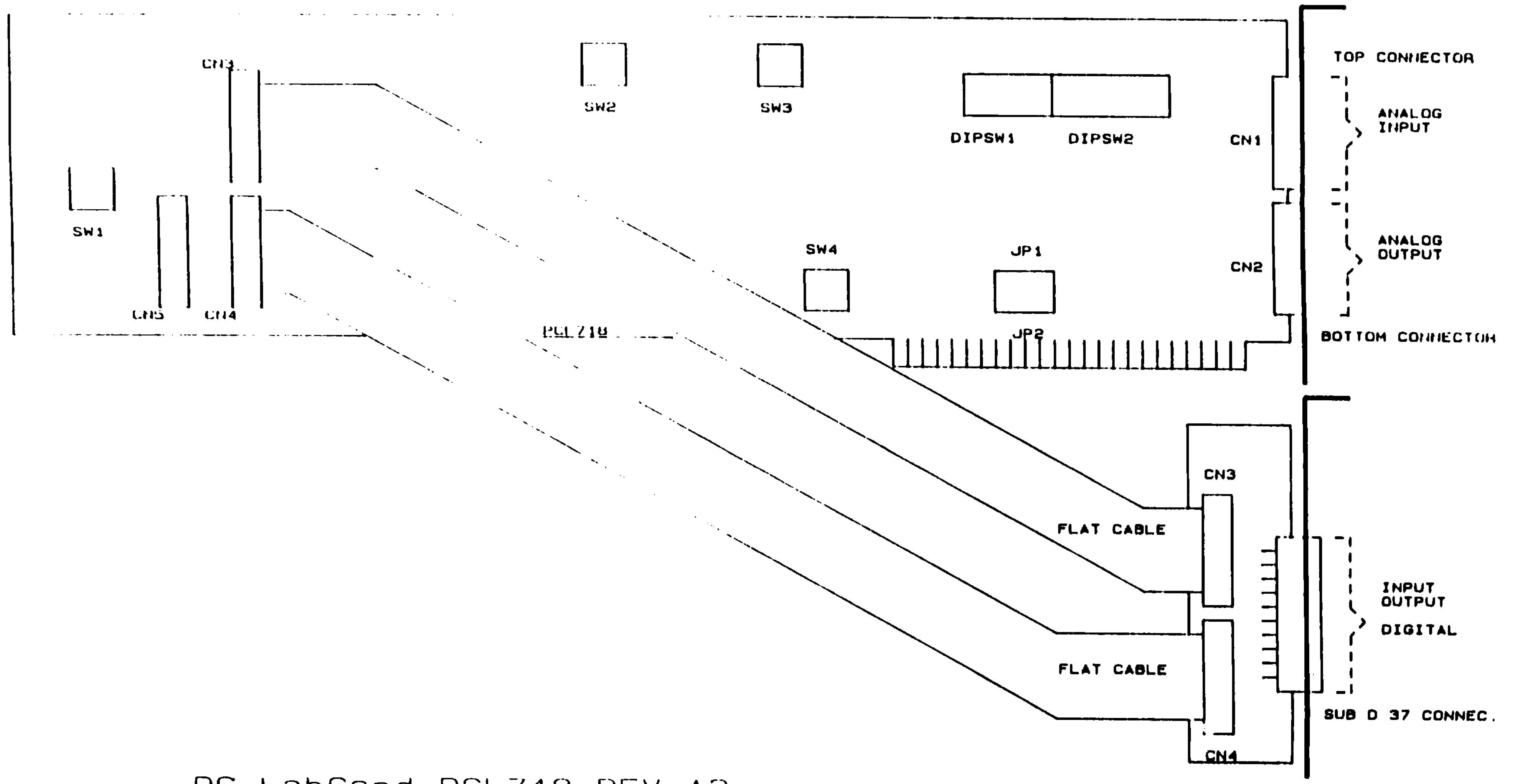
* Provide three A/D trigger modes: Software trigger, Programmable pacer trigger and external trigger pulse trigger.

* A/D converted data can be transferred by program control, interrupt handler routine or DMA transfer.

* An INTEL 8254-2 Programmable Timer/Counter provides pacer output (trigger pulse) at the rate of 2.5 MHz to 71 minutes/pulse to the A/D. The timer time base is switch selectable 10 MHz or 1 MHz. One 16-bit counter channel is reserved for user configurable applications.

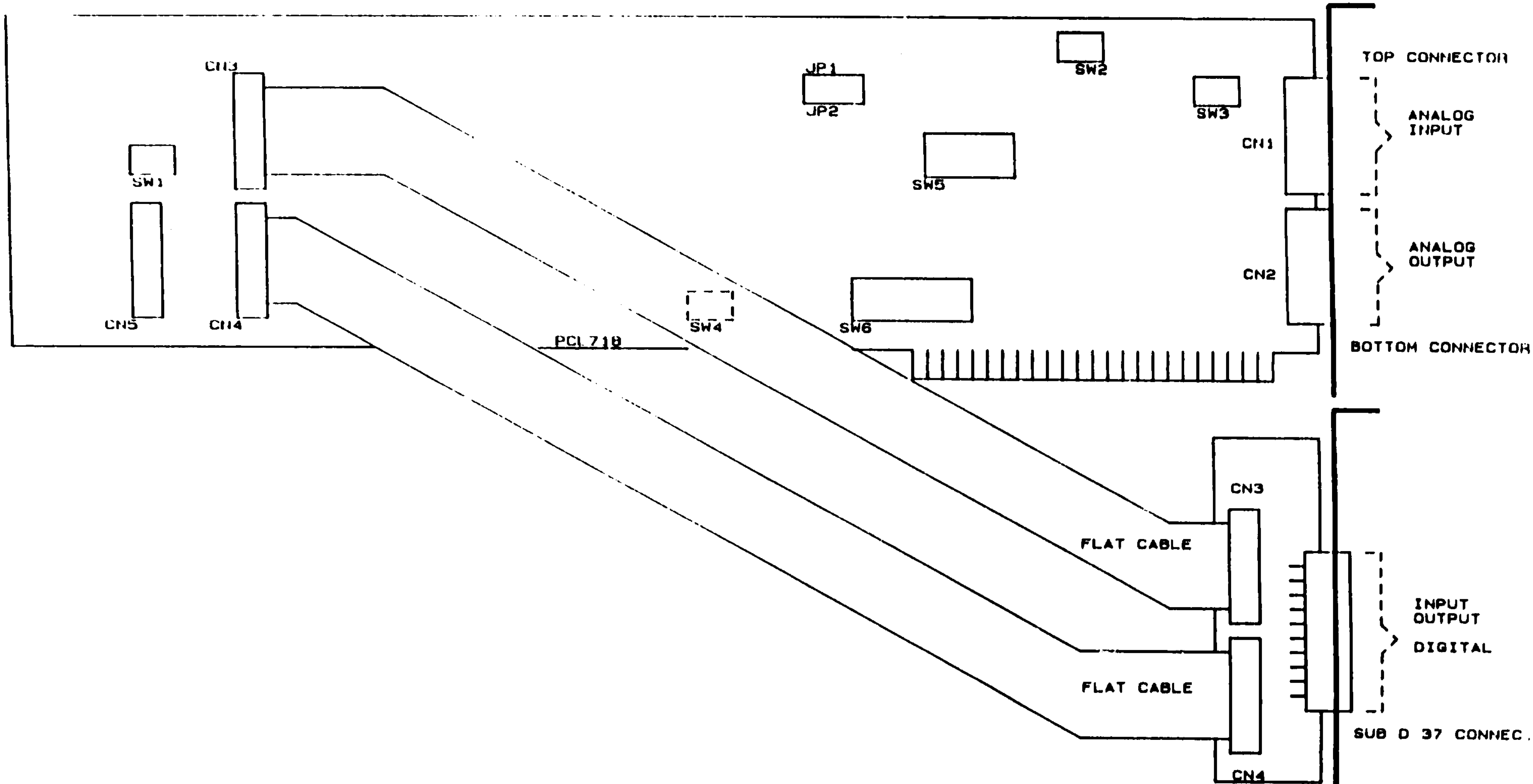
* Two 12 bit monolithic multiplying D/A output channels. Output range of 0 to -5V can be created by using the on-board -5V reference. This precision reference is derived from the A/D converter reference. External AC or DC reference can also be used to generate other D/A output ranges.

* TTL/DTL compatible 16 digital input and 16 digital output channels.



PC-LabCard PCL718 REV A3

C S E M NEUCHATEL		
Title IN/OUT/ANALOG/DIGITAL BOARD PCL718		
Size A	Document Number PAGE 4	REV 1
Date: June 26, 1991	Sheet 1 of 2	



PC-LabCard PCL718 REV B1

CSEM

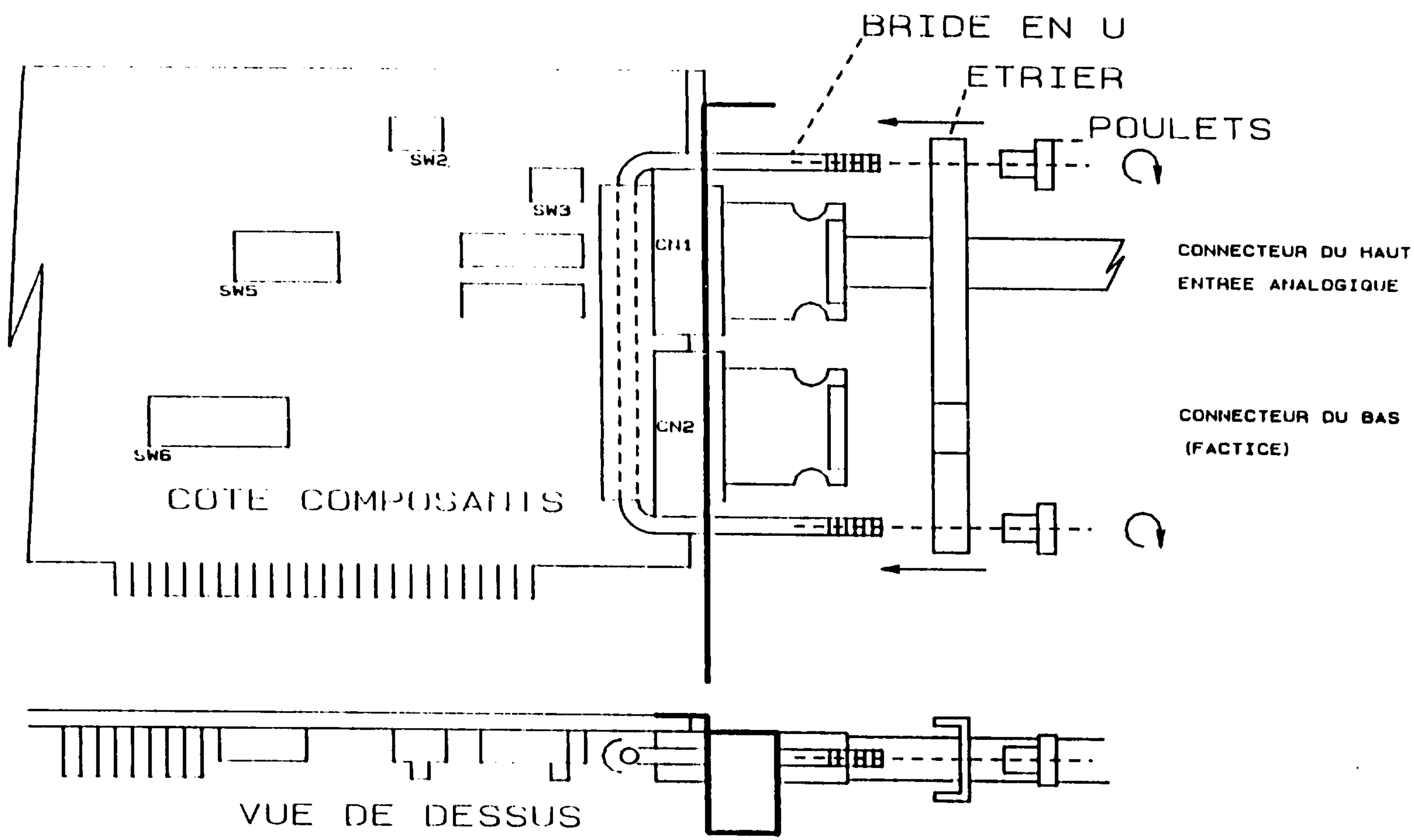
C S E M NEUCHATEL		
Title IN/OUT/ANALOG/DIGITAL BOARD PCL718		
Size A	Document Number PAGE 5	REV 1
Date: June 27, 1991	Sheet 1 of 2	

Configuration des commutateurs de la carte d'acquisition PCL 718 revision A3

	1	2	3	4	5	6	7	8
DIPSW1	off	on	off	off	off	off		
DIPSW2	off	off	on	on	on	on	on	on
SW1	1 MHZ							
SW2	BIP							
SW3	16CH							
SW4	DRQ3							
JP1	-5V(REF)							
JP2	-5V(REF)							

Configuration des commutateurs de la carte d'acquisition PCL 718 revision B1

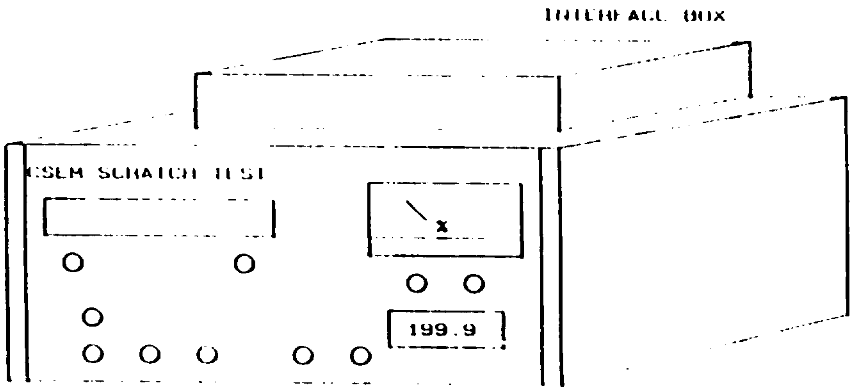
	1	2	3	4	5	6	7	8
SW1	1 MHZ							
SW2	BIP							
SW3	16CH							
SW4	DRQ3							
SW5	off	on	off	off	off	off		
SW6	off	off	on	on	on	on	on	on
JP1	-5V(REF)							
JP2	-5V(REF)							



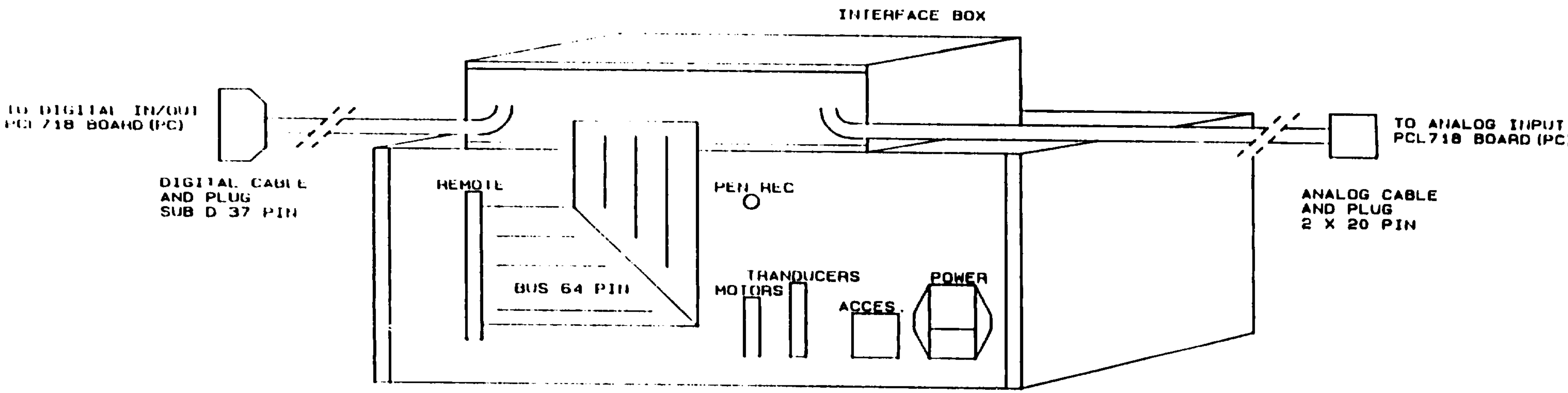
PC-LabCard PCL718 REV A3 & B1

C S E M NEUCHATEL			
Title: IN/OUT/ANALOG/DIGITAL BOARD PCL718			
Size: A	Document Number: PAGE 7		REV: 1
Date: June 26, 1991	Sheet 1 of 1		

SCRATCH-TEST CONTROL UNIT AND INTERFACE BOX WIRING



FRONT VIEW



REAR VIEW

C S E M NEUCHATEL		
Title	WIRING OF INTERFACE	
Size A	Document Number PAGE 8	REV 1
Date: June 27, 1991	Sheet 1 of 1	

CSEM - REVETEST®

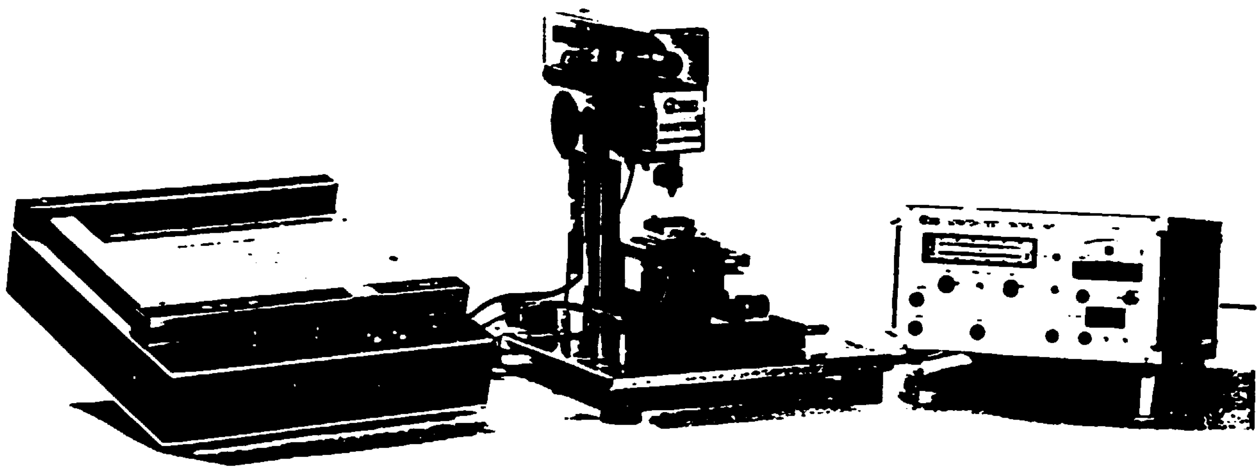
Automatic Scratch-Tester

DIRECTIONS FOR USE

S/N : 16/297

CSEM, Rue Breguet 2, CH - 2007 NEUCHATEL (Switzerland)
TEL +41 38 24 01 61 TELEX 952 655 CSEM TELEFAX +41 38 25 40 78

CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE S.A.
– Recherche et Développement –



The REVETEST - Scratch-Tester - developed by CSEM is an automatic instrument which enables the measurement of the mechanical strength - adhesion and intrinsic cohesion - of hard and brittle coatings obtained by chemical vapor deposition (CVD) or physical vapor deposition (PVD) on softer and tougher substrates.

The test consists in scratching the surface of a coated substrate with a rounded diamond point. The load applied on the point increases continuously as it scratches along the surface and a piezoelectric accelerometer detects the acoustic emission produced as the coating is being damaged. The apparatus also enables the scratching test to be performed under constant load.

The intensity of the acoustic emission depends on the nature of the damage: levelling of asperities, cracking, chipping (cohesive failure), flaking (adhesive failure) of the coating, etc. The acoustic emission signal, recorded as a function of the load applied on the diamond point, is a characteristic of the tested sample. The analysis of the obtained graph provides qualitative and quantitative information on the mechanical strength of the coating.

TABLE OF CONTENTS

1 GENERAL RECOMMENDATIONS

Please carefully read the present instructions before proceeding to any change. Before leaving CSEM the equipment has been adjusted for testing 1/2" (12,7 mm) square inserts.

- The measuring system needs approx. ½ hour for warming up, i.e. the CONTROL UNIT should not be switched off for short measurement interruptions.

- The input of the Acoustic Emission (AE) measurement system (42) is very sensitive and must be protected against high voltages. Such high voltages can be observed in statically charged cables. For this reason the connection cable should be discharged by a short-circuit before being connected to the AE detector input (2). For the connection of the AE detector to the CONTROL UNIT, only the appropriate supplied cable should be used.

- Every time the equipment is switched on (25), the diamond support rod should be tapped slightly with a metallic tool until the AE meter (35) shows a deflection.

- The calibration of the AE-signal has been made using CSEM's instrument as a standard. The reference calibration value is set to 1.2 (standard AE sensitivity). It is strongly recommended to use this value if AE-signal intensities have to be compared. The AE detector (Fig. 3) should never be dismounted, otherwise the reference calibration may be lost.

- The AE-signal can be plotted on an xy recorder. Normally any xy recorder with an input impedance Ri > 5 kOhm and a sensitivity range S > 1 mV/cm can be used.

- The scratching tip should always be used in the same position(s), to be set initially by the user: depending on the wear rate (which is a function of the coating material) the scratching tip should be replaced - or 180° turned - after a few tens to some hundred tests.

- For the warranty to apply fully, CSEM recommends not to change the settings inside the CONTROL UNIT. The possible adjustments are specified in section 4.

- An electrical component has been included in the CONTROL UNIT to protect the mechanical system if the proximity switches fail. This element switches the motor power supply off as soon as the torque increases abruptly (current exceeds approx. 350 mA). If this occurs, switch POWER (25) off and wait approx. 5 minutes before starting anew. If the failure still occurs, consult first section 9.

2 DESCRIPTION

(Unfold the double size pages at the end of this booklet to refer to the corresponding figures.)

SCRATCHING MACHINE (Fig. 1 and 2)

1. Scratching tip
2. AE detector
3. Load cell
4. Load cell spirit level
5. Point lift command rod
6. Load spring
7. Scratching head vertical locking handle
8. Load driving motor
9. Sample table driving motor (y-axis)
10. Sample table displacement indicator
11. X-axis stage displacement knob (1 turn = 1 mm)
12. X-axis locking handle (optional)
13. Sample table
14. Hand-wheel for vertical adjustment of scratching head.
15. Proximity switch for setting sample table end-of-stroke
16. RESET switch
17. Sample table displacement switch (y-axis)
18. Connector board

AE Detector (Fig. 3)

Point lift command rod (Fig. 4)

19. Adjustment screw for lifting scratching head
20. Spring setting mark
21. Locking nut
22. Stopper
23. Lever
24. Spring

CONTROL UNIT front panel (Fig. 5)

25. POWER switch

26. ACCESSORY power switch

27. RUN switch (light on)

28. STOP switch (light on)

29. Switch for mode selection of applied load:

    Const: load increases until selected force is reached

    Prog : load increases with constant speed

30. Min: adjustment of minimum load limit

31. Max: adjustment of maximum load limit

32. Normal force display instrument:

    Upper display: Min and Max load limits
    Lower display: instantaneous applied force

33. RANGE switch for load display instrument: 100/200 N

34. Chart recorder PEN lift remote control

35. Acoustic emission (AE) meter

36. Selector and trimmer for setting AE signal sensitivity

37. FUNCTION selector (Vz, Vy, Fn, Ft, μ*)

    Units: Vz in N/min
    Vy in mm/min
    Fn, Ft in N
    μ*: ratio Ft/Fn

38. Function digital display

39. Trimmer for tangential force OFFSET adjustment

40. Trimmer for SETting the speed of the sample table driving motor

41. Trimmer for SETting the speed of load driving motor.

CONTROL UNIT rear panel (Fig. 6)

42. AE-DETECTOR cable

43. Friction coefficient μ* output (to recorder)

44. Normal force Fn output (to recorder)

45. PEN-lift remote control output (to recorder)

46. Input power plug, voltage selector and fuse

47. ACCESSORY power outlet

48. TRANSDUCERS input

49. Power output for electrical MOTORS

50. AE signal output (to recorder)

51. Tangential force Ft output (to recorder)

52. REMOTE control connector

3 DIRECTIONS FOR USE

3.1 Electrical connections

The CSEM-REVETEST is delivered with all the necessary connection cables. After inspection of the CONTROL UNIT rear panel (Fig. 6) and the SCRATCHING MACHINE (Fig. 2), connect the motors (49) and transducers (48) cables to the connector board of the REVETEST (18). Check that connectors are strongly fixed to protect the instrument from short-circuits.

Connect AE cable (42) to the AE detector (Fig. 3): AE plug is sensitive to grease and should therefore be cleaned with a solvent (freon, etc.) before connection to the AE detector input. For other recommendations also see § 1.0.

If required, connect the Fn (44) and AE (50) outputs (Ft and μ* in option) to an xy recorder by means of the appropriate cables.

For the remote control connection of your recorder, see § 3.2.

The power cable of the recorder (or microscope light in option) can be connected to the ACCESSORY socket (47).

Before switching POWER (25) on, verify the input voltage on the selector (46).

3.2 Recorder

3.2.1 Recommendations

For a standard use of this AUTOMATIC SCRATCH-TESTER, only an xy recorder is necessary. CSEM offers two recorder models: BBC SE 790 and Linseis LY 1700.

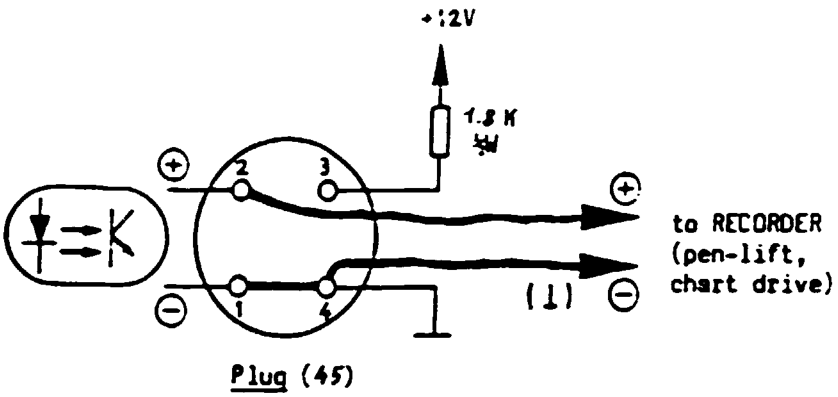
For recording the friction parameter, provided in option, CSEM offers a double way xyy recorder, Linseis LY 18100.

If your recorder is different from those proposed above, verify its remote control mode before connecting it to the CONTROL UNIT: CSEM will not warrant any damage in case of incorrect connection.

3.2.2 Pen lift, chart drive remote control

Before leaving CSEM, the cable for pen lift command is connected for a voltage controlled input (+12 DC V) of the recorder. Any modification has to be executed by the user according to one of the following schematics:

a. Short-circuit controlled input: (BBC SE 790)



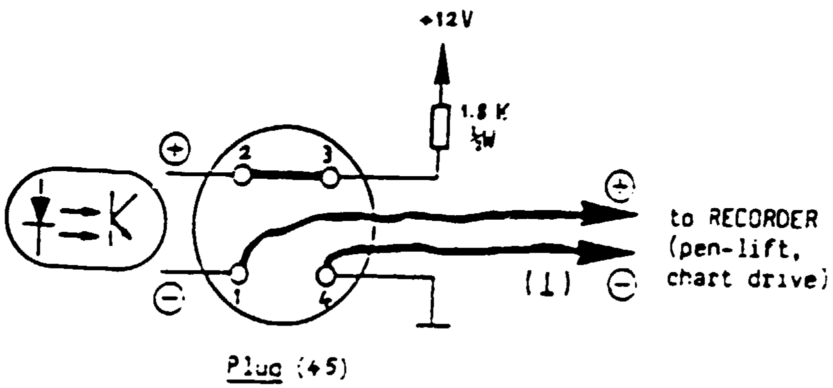
Max. ratings :

$U_{max} \simeq 12VDC$ *

$I_{max} \leq 30mA$

*depending on recorder control input impedance

b. Voltage controlled input: (Linseis LY 1700 and LY 18100)



Max. ratings :

$U_{max} \simeq 12VDC$ *

$I_{max} \leq 30mA$

*depending on recorder control input impedance

3.3 Point lift command rod adjustment

The aim of this adjustment is to prevent the applied load from jumping suddenly from zero to some finite value at the beginning of the test and also to protect the load cell against a destructive shock.

Before leaving CSEM, the point lift command rod (5), (Fig. 1) has been carefully adjusted, but readjustment may be necessary after transport. For this, proceed as follows: (see Fig. 4) .

1. Scratching tip up (light RUN (27) must be off), unscrew the tightening nut (21).

2. Turn (5) so that the stopper (22) stands at about 1 mm from the transmitting force lever (23).

3. Tighten the nut (21).

4. Control this little gap by moving the lever (23) and after several scratches proceed to a finer adjustment if necessary.

4 ADJUSTMENTS

Before leaving CSEM, the following careful adjustments have been made. The user can adjust these parameters according to his own specifications, although these values are considered as standards (10 mm/min; 100 N/min).

4.1 Sample table length-of-stroke

The displacement of the sample table is limited by two end-of-stroke switches. They should always be in a functional position ! Only the forward proximity switch (15), mounted into a screw, is adjustable.

Before delivery, the scratching length is set to 10,00 mm ± 0,02 mm (for 1/2" inserts). Using screw (15), the stroke can be adjusted to a maximum of 22 mm.

4.2 Sample table and loading speeds

As explained above, these speeds are calibrated for a standard application. Using trimmers (40) and (41) with the function selector (37) on the corresponding position, the user can adjust Vy and Vz into the range indicated in § 8.1.

4.3 Rise of the scratching head

Depending on the common user or the type of REVETEST (model with microscope), it may be necessary to adjust the effort needed to rise the scratching head. This is done by means of screw (19), (Fig. 4): with the scratching head at its upmost position, slacken the hand-wheel (14): the scratching head must move down by about one cm.

5 SCRATCHING PROCEDURE

When the instrument is being installed, the sample table must be placed in the horizontal position using a spirit level instrument and the four adjustable rubber feet.

Note that the spirit level (4) on the lever serves to verify the horizontality of the load cell when the applied force is about 50 N

The SCRATCHING MACHINE has been adjusted with a pre-determined spring position. Before start up, check this setting with the mark (20) (Fig. 4).

After warming up, the scratching tip support rod must be tapped slightly with a metallic tool until the AE meter (35) shows a deflection.

5.1 Usual scratching procedure

1) Fix the sample to the holder under the scratching tip. For testing other samples than ½" square inserts, pins must be placed at the adequate position on the sample holder.

2) Loosen the scratching head by unscrewing (7) and adjust the height by means of (14) so that the tip stands 1 to 2 mm above the surface of the sample. Tighten (7) again and initialize the position on the displacement indicator (10).

3) On the CONTROL UNIT, select the AE sensitivity with (36) (the "1.2" position is the standard amplification of the acoustic signal) and select the normal force scale range 100/200 N with (33).

4) Using switch (29), select the mode of the applied force:

   Prog.: the load increases regularly with the sample displacement (standard value: 10 N/mm).
   Const: the load increases until selected force (30) is reached and remains constant.

5) Using knob (30), select the minimum force required at the beginning of the scratch and its maximum limit with knob (31).

6) If needed, connect a xy recorder to the CONTROL UNIT and set switch (34) to the correct position for its pen-lift remote control (on "Auto", the pen will go down as soon as the minimum force limit (30) is reached).

7) To run the scratch, depress STOP (28) (light off), verify that switch (17) is on "AUTO RETURN" and press RUN (27): the green light will stay on until the end of the test.

The scratching tip will first go down until it touches the sample. Then the applied Fn force immediately starts to increase linearly with time and sample table motion starts when the minimum selected force is reached. The instantaneous value of Fn is displayed on (32) and also on (38) if the selector (37) is on Fn position. Scratching goes on until the maximum limit (31) is reached or "RESET" switch (16) is pressed. The scratching tip is thus unloaded and lifted from the sample surface. When the sample is free, the table moves back to its original position at full speed.

As soon as the light RUN (27) is off, the equipment is ready for a new test. If it is to be performed on the same sample, turn (11) to change the test location: a minimum spacing of 0.5 mm between two scratches is recommended. It mainly depends on the deformation of the substrate and the extent of cracking in the coating.

5.2 AE determination of the critical load

The AE detection device is used to determine the critical load when testing hard coatings which fail in a brittle manner. The occurence of such failures gives rise to an important signal which is shown on the AE meter (35) and which can be recorded on an xy recorder. The intensity of the AE-signal depends on the coating type. Selector and trimmer (36) enable the adjustment of the sensitivity of AE detection, in a range of 0.0 to 20.0, corresponding to a sensitivity variation of more than 30 dB (> 30x). During final control of the apparatus, the AE is calibrated in position 1.2 using the instrument at CSEM as a reference.

Note that a change of input sensitivity of the xy recorder is not identical to a change of the AE measurement sensitivity by (36)! While the first signal modification will result only in different signal heights on the chart, the second sensitivity change will contribute more or less to the detection of low-energy AE-signals. The best results will be obtained when the AE meter deflects to a mean value of approximately 50 % when scratches beyond the critical load are produced.

6 CONTROL OF SCRATCHING TIP

In order to ensure that the results of the test remain comparable, it is important to periodically check that the tip of the diamond is not damaged. The diamond tip should always remain smoothly rounded with a radius of curvature equal to the nominal value. The tip of the diamond can be examined by one of the following ways :

a) Examination under a stereoscopic microscope (recommended magnification : 50 x).

b) Examination with an electronic microscope (S.E.M.). In this case, a thin gold film should be deposited on the diamond tip before introducing it into the microscope (see pictures next pages).

c) A few scratches should be made on a soft, uncoated material (e.g. annealed copper) and the shape of the scratches should be measured using a profilometer (e.g. Talysurf).

It must be emphasized here that the diamond tip will inevitably wear, particularly when testing hard coatings.

The wear tolerances are to be determined by the user since the wear rate of a tip is greatly dependent on the materials being tested. The diamond should always be mounted in the same position. If an important wear of the diamond is observed, it can be turned by 180° and a new series of scratches can be made. It is advised to have a standard sample which can be used to regularly check the condition of the diamond tip. At defined intervals (for example 20 to 30 scratches) two to three scratches should be made on this standard sample to observe any variation of the critical load as a function of the diamond wear ([1]).

New diamonds may be obtained from CSEM. In this case, the diamond tip radius and the cone angle should be indicated in the purchase order and a diamond holder should be sent to the supplier.

If coating failures are not accompanied by an Acoustic Emission, the critical load has to be determined by inspecting the scratches visually.

When in doubt about the operation of the AE detection system, check it by slightly tapping the diamond support rod (e.g. with a metallic tool) until the AE meter (35) shows a deflection.

([1]) "Adhesion testing by the scratch test method"
PAS, YTa and HEH, Thin Solid Films 154 (1987)

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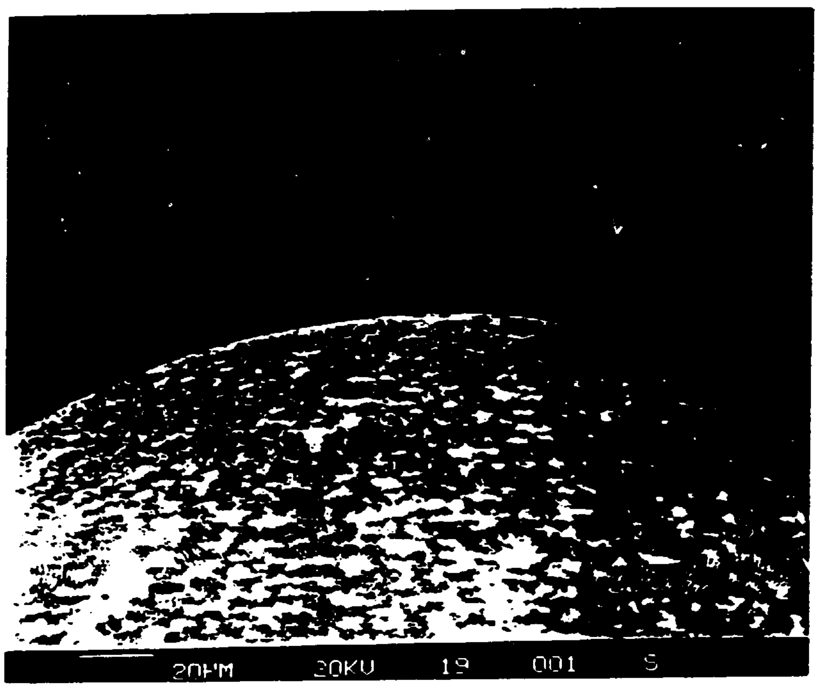
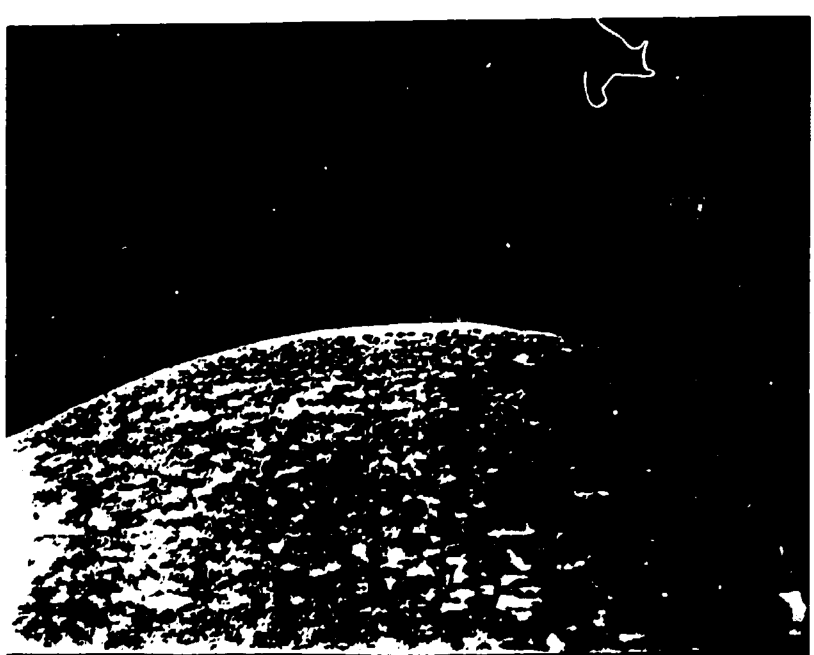
TIP RADIUS CONTROL (magnification 500 x)

RCD/2. R 0.2 mm

Diamond No 219





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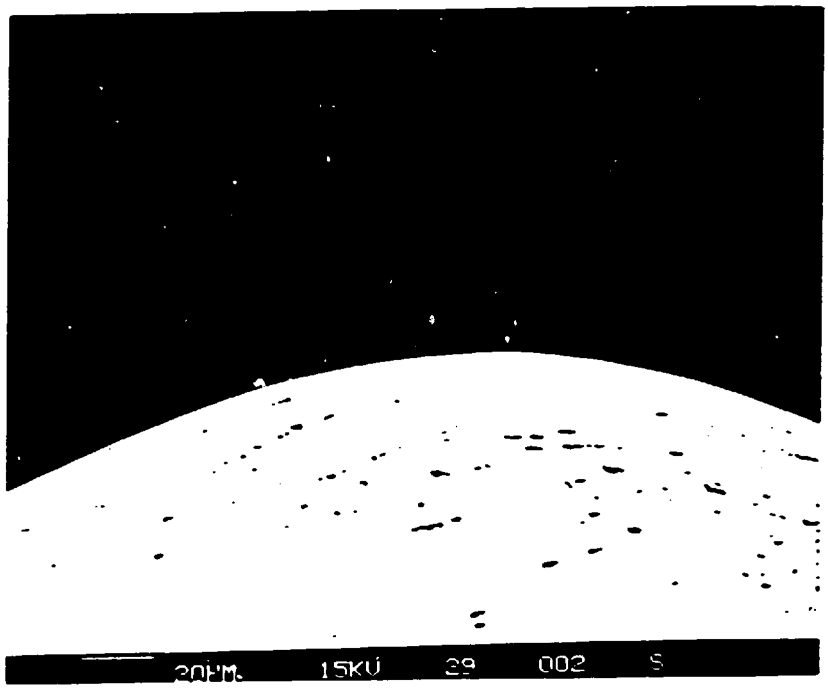
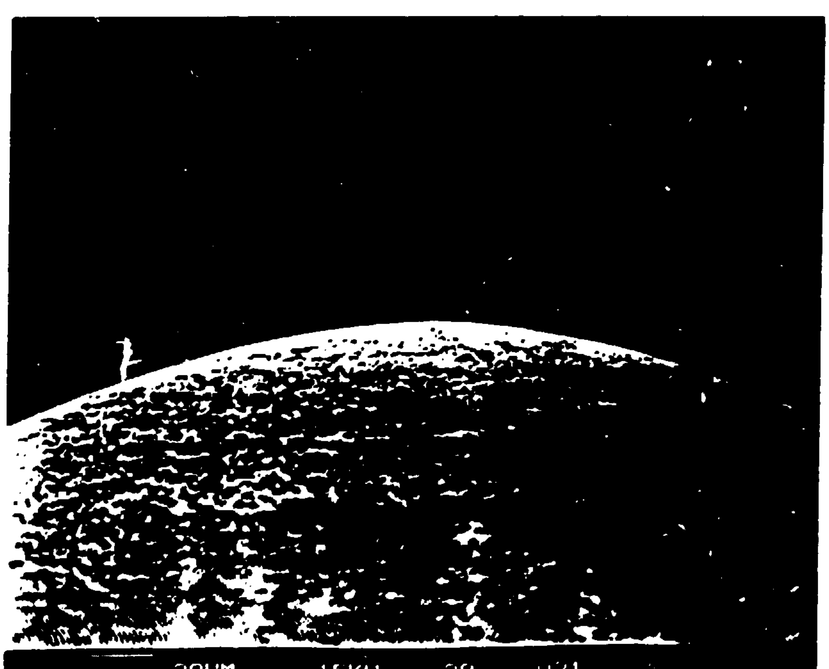
TIP RADIUS CONTROL (magnification 500 x)

RCD/2. R 0.2 mm

Diamond No 229





7 MAINTENANCE

The CSEM instrument is built solidly and does not require any special maintenance. It is however recommended to store it in a dust-free place and to keep the sliding parts clean. Should it prove necessary, the latter may be lightly lubricated with a fine, conventional oil.

For the replacement of any of the parts, please contact our local representative or CSEM under the following address:

CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE SA
Division Matériaux et Micromécanique (Dépt. Appareils)
2, rue A.-L. Breguet, Case postale 41
CH-2007 **Neuchâtel**

TEL (++41) 38 205 111 / TELEX 952 655 CSM / TELEFAX (++41) 38 205 640

8 SPECIFICATIONS

8.1 General features

1. Power supply: 115/230 AC V, 50/60 Hz
   Maximum power consumption: 24 W (58 W with microscope light)
   Fuse: 115 V - T 1 A
   230 V - T 0.63 A

2. Translational table speed:
   range : 2 < dy/dt < 35 mm/min
   calibrated value: 10.0 ± 0.1 mm/min

3. Loading rate:
   range : 20 < dz/dt < 400 N/min
   calibrated value: 100 ± 1 N/min

4. Normal force range: 1 to 200 N (do not work below 1 N)

5. Positioning of the sample:

   a) In the direction of the scratch,
      y: motorized (maximum displacement range: 22 mm)

   b) Perpendicular to the direction of the scratch,
      x: manual (maximum displacement range: 75 mm)

6. Standard sample holder: (width x depth): 49 mm x 33 mm

7. Dimensions: (width x height x depth) in mm

   - SCRATCHING MACHINE: 400 x 460 x 505

   - CONTROL UNIT : 340 x 190 x 490

8. Weights: - SCRATCHING MACHINE: 62.5 kg
   - CONTROL UNIT : 7.5 kg

8.2 Load measurement system

a) Transducer:

Precision Load Cell

Manufacturer: Vibro-Meter AG, Fribourg/Switzerland

Type & Specifications: see Test Chart (next page)

Bridge supply: 10.000 V rms/5 kHz

Output signal: 20.505 mV at 20 kg

1.025 mV/kg

1.045 mV/10 N

b) Amplifier:

Precision Strain Gauge Module (oscillator/demodulator)

Manufacturer: Sangamo / Switzerland

Power supply: ± 15V

Output signal: 5 V @200 N (25 mV/N)

c) Reference values: (warm-up time 2½ hr)

Load		Output [mV]	
[kg]	[N]	Amplifier (calcul.)	(measur.)
1.019	10	250	245
2.038	20	500	496
4.077	40	1000	998
6.116	60	1500	1501
8.155	80	2000	2003
10.194	100	2500	2502
12.232	120	3000	3005
14.271	140	3500	3507
16.310	160	4000	4008
18.349	180	4500	4505
20.387	200	5000	5008

vibro-meter ag

PRÜFKARTE
TEST CHART

Typ / Type BLC-305-0,03	S/N 28034
Mod. Status	
Art. Nr / Part No	
Nennwert / Nominal value	20 kg
Max. Belastung / Max. load	150 %
Empfindlichkeit / Sensitivity	2,0505 mV/V
Speisespannung / Excitation	10 V DC/AC
Eigenfrequenz / Natural frequency	
Linearität / Linearity	< 0,015 %
Hysterese / Hysteresis	< 0,015 %
Impedanz / Impedance	INP: 415 Ω OUT: 350 Ω
Isolationswiderstand / Insulation resistance	> 5 x 10^3 MΩ
Temperaturbereich / Temperature range	− 30^0 + 70^0C
Kopplungsfehler / Coupling influence	
Prüfvorschrift Nr / Test Specification Nr	
Bemerkungen / Remarks	

Zero return (30 min.) 0,0075 %

Datum / Date	[illegible] 1990
Geprüft durch / Tested by	VM-P 88 — VM-QE 02
Vibro-Meter AG Fribourg/Schweiz	

8.3 Acoustic emission measurement system

a) Acoustic emission (AE) detector

Resonant AE detector

Manufacturer: Brüel & Kjaer/Denmark

Type 8313 S/N 146.1583

200 kHz

b) AE preamplifier

Manufacturer: Brüel & Kjaer/Denmark

Type 2637 S/N 146.5965

Octave band width filter: 200 kHz

Amplification: 40 dB

c) AE amplifier

Large bandwidth amplifier: ~ 50 - 400 kHz

Amplification: 0 - 20 dB

d) AE signal converter

Averaging capacity: C = 22 uF (C9 on PCB 1)

Integration time constant: T ~ 1 sec.

Brüel & Kjær DK-2850 NÆRUM, DANEMARK Telefon + 45 2 800500 Telex 37316 bruka dk

2. OPERATION OF AE TRANSDUCERS

2.1. ENVIRONMENT

2.1.1. Temperature

The two Resonance Transducers Types 8313 and 8314 have an operating and storage temperature range from —70°C to +250°C. Because the Broad-Band Transducer Type 8312 contains electronic components its operating range is limited to temperatures between —10°C and +55°C, however the transducer will not be damaged when stored in ambient temperatures between —25°C and +85°C.

Although ambient air temperatures may lie within the allowable limits the transducers should not be attached to surfaces having temperatures outside the limits. In these cases the transducer may be attached to the measuring point via a waveguide, that is a metallic rod of suitable length to reduce the temperature at the attachment point. Good coupling is very important, refer to section 2.2

The sensitivity calibration of the transducers is performed at room temperature, at other temperatures the sensitivity can be expected to vary in accordance with the curve in Fig 2.1

Coaxial cables supplied with the Resonance Transducers Types 8313 and 8314 can withstand temperatures up to 260°C while the multi-conductor cable supplied with the Broad-Band Transducer Type 8312 should not be subjected to temperatures in excess of 100°C.

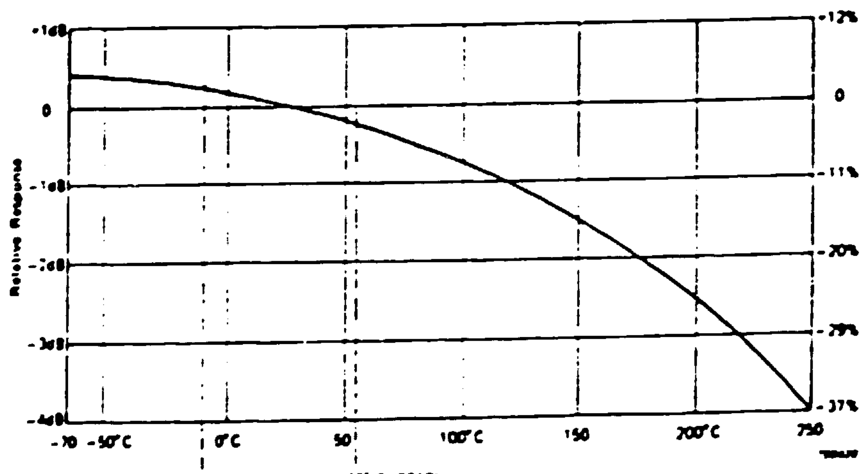


Fig 2.1. Typical temperature response curves of the AE transducers

2.1.2. Humidity

B & K AE transducers have epoxy sealed housings and are therefore impervious to moisture. However the cable connectors only offer superficial protection and require extra protection when the transducer is to be used in wet environments. For short-term exposure sufficient protection is gained by dipping the transducer socket and the cable plug into silicon grease before the connector is assembled. Where exposure to high humidity levels or direct immersion in liquids is expected, the whole connector should be encapsulated in an acid free room-temperature vulcanising silicon rubber compound.

Special cables are required for long-term immersion and for immersion to depths in excess of a few meters.

2.1.3. Shock and Vibration

Resonance Transducers Types 8313 and 8314 can tolerate shocks of up to 20000 m/s^2 (2000 g) without damage when they are firmly attached to a flat surface but it should be borne in mind that the base of the transducers is a ceramic material which can break if maltreated. Point and edge impacts which could occur when dropped onto a hard surface should therefore be avoided.

Broad-Band Transducer Type 8312 has a shock and vibration limit 1000 m/s^2 (100 g) which can easily be exceeded as result of careless handling. Structural vibration on objects likely to be monitored for acoustic emissions will rarely approach these levels.

2.1.4. Nuclear Radiation

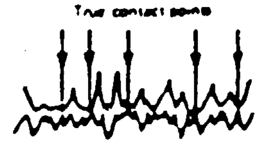
AE Transducer Type 8312 which contains electronic components, will operate satisfactorily under gamma radiation up to accumulated doses of 100 kRad. Resonance Transducers Types 8313 and 8314 and their associated cables will operate satisfactorily under gamma radiation up to accumulated doses of 2 M Rad.

2.2. MOUNTING OF TRANSDUCERS

The stress waves constituting the AE signal are minutely small when one considers them in terms of mechanical stress waves which must be transfered to the transducer for detection. Intimate contact between the measurement surface and the transducer is therefore imperative if the AE signal is to be detected at all. Fortunately this is not so difficult in practice when using a coupling medium.

2.2.1. Coupling Media

There are no known proprietary brands of AE coupling medium but it has been found that many viscous or semi-fluid substances seem to work satisfactorily. The coupling medium fills up the valleys in the surface texture of the measurement surface and the transducer base and in effect provides a surface-to-surface contact rather than a random contact between peaks in a rough surface. This is illustrated in Fig 2 2.



We use a highly viscous (700—1000 cps at 60°C) substance known as Dow resin No 276—V9 made by the firm Dow Chemicals This is satisfactory for use up to about 120°C The liquids and jellies used as couplants for ultrasonic transducers are also applicable

Satisfactory results have also been obtained with lubricating grease Silicon grease gives good results and is particularly valuable for use with the resonance transducers which may be used up to 250°C

Whichever substance is used it should be applied in a thin layer only so that the transducer can be pressed down in it to obtain actual contact between the transducer and measuring surface

The measuring surface should be prepared by grinding with a fine abrasive to remove paint, mill scale etc before mounting the AE transducer

2.2.2. Note regarding Broad-Band Transducer Type 8312

The contact sole in the base of Transducer Type 8312 projects approximately 0.3 mm (0.012") beyond the lower surface of the transducer to ensure good coupling to the surface With a light preload of a few N, the diaphragm, in the centre of which the contact sole is mounted, will deflect slightly The use of a coupling medium is also advisable for good coupling to this transducer

2.2.3. Transducer Clamps

To ensure that perfect coupling is maintained throughout AE measurements, some form of clamping arrangement for the transducer is required. On magnetic surfaces permanent magnets provide a convenient means of attaching the clamp B & K magnets UA 0070 available in packs of six are especially convenient as they have a 10-32 NF attachment stud (In countries where UNF threads are not common remember to order 10-32 UNF thread tap QA 0029 and a quantity of 10-32 UNF nuts (YM 0414) with the magnets)

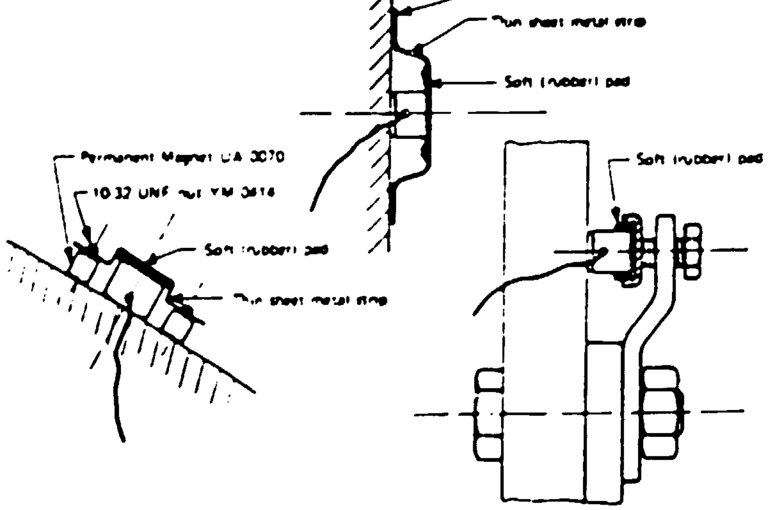


Fig 2.3 Some typical clamping arrangements for holding the AE transducers in light contact with the measurement surface A coupling medium should always be used between the transducer and the measurement surface

On non-magnetic surfaces and for permanent monitoring applications the clamping arrangement or the transducer can be fixed by epoxy adhesive or via adjacent screw fasteners. See Fig 2.3. which shows some typical clamping arrangements. It is not necessary to apply more than a few N force to the transducer.

The simplest clamping method will usually be evident when the user is confronted with a specific measuring situation. In many situations spring clips, plastic tape or rubber bands will give satisfactory results.

Note: In the case of transducer Types 8313 and 8314 the use of a rubber pad between the clamp and the transducer will, in addition to holding the transducer in place, maintain the electrical insulation from measuring surface (The transducer soles are made from an insulating ceramic material).

2.3. CONNECTION OF TRANSDUCERS TO PREAMPLIFIERS / AMPLIFIERS

2.3.1. Resonance Transducers Types 8313 and 8314

The output signal from AE transducers has very low amplitude and power and should therefore be fed to Preamplifier Type 2637 which has high input impedance, low output impedance and 40 dB amplification so that the signal is suitable for transmission to measuring and analysis instrumentation.

B & K coaxial connector sockets are used on these transducers. They match the standard range of cables available for B & K accelerometers. A standard cable of 1.2 m length fitted with plugs both ends is supplied with each AE Transducer and this should be used alone, without extension, wherever possible so as to maintain the sensitivity stated on the transducer calibration chart.

For cable lengths longer than 1.2 m the signal will be attenuated, changing the sensitivity stated on the calibration chart as shown in Fig 2.4.

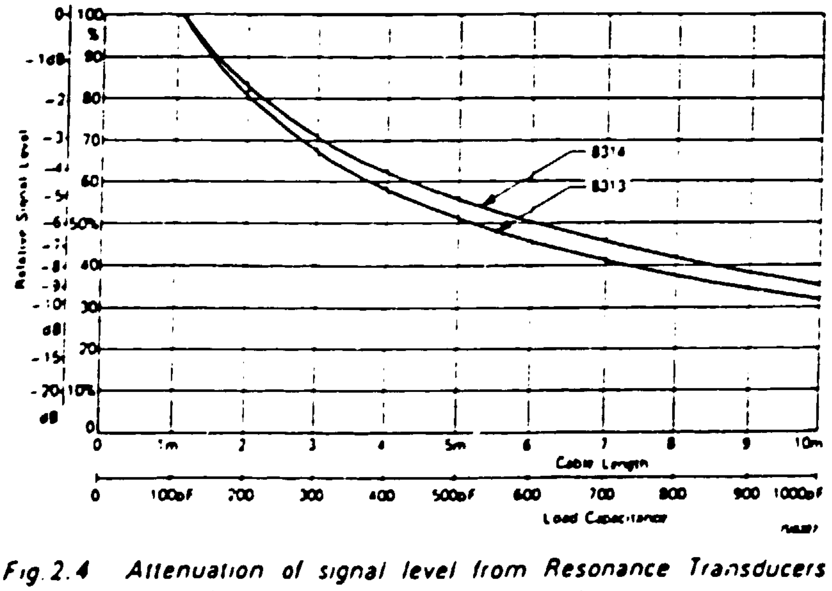


Fig. 2.4 Attenuation of signal level from Resonance Transducers Types 8313 and 8314 as a function of output cable length

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A.-L BREGUET 2, CASE POSTALE 41
CH-2000 NEUCHATEL 7, SUISSE

TÉL. 038 205 111
TÉLEX 952 655 CSM
TÉLÉFAX 038 205 640

CSEM-Revetest ®

Automatic Scratch-Tester

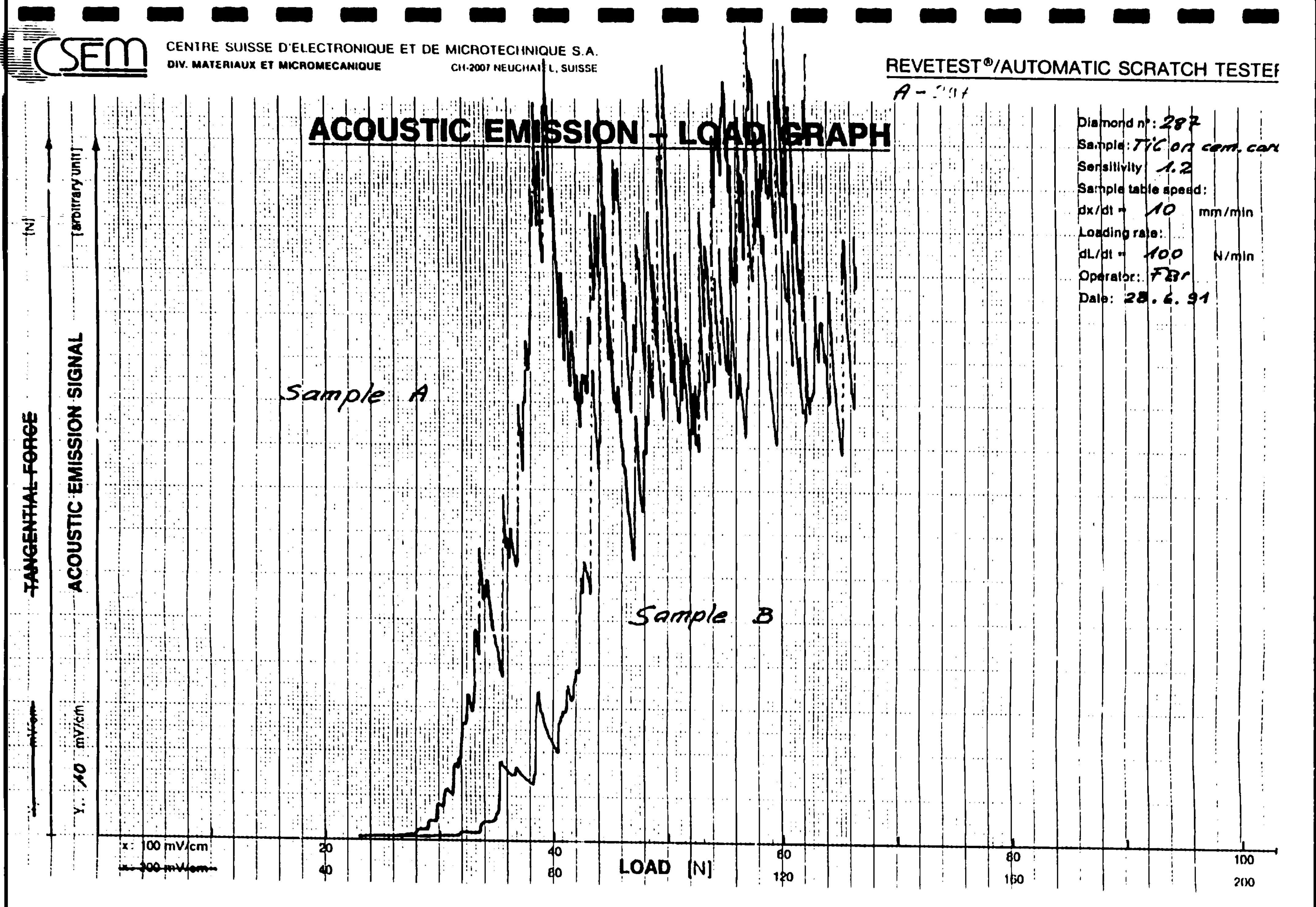
FINAL INSPECTION CHECK-LIST

(Instrument S/N A-[illegible])

Function check / calibration	Checked	Date	Observations
Table displacement length	✓	10.7.91	10 mm ± 0.02 mm
Table displacement speed	✓	10.7.91	5.71 V @ 10 mm min⁻¹
Lever balance adjustment	✓	10.7.91	
Loading rate speed	✓	10.7.91	2.99 V @ 100 N min⁻¹
Load calibration	✓	10.7.91	see values pg 15
Min. load value	✓	10.7.91	ca. +16 mV (≈0.6 N)
Holder friction control	✓	10.7.91	
Spring linearity control	✓	10.7.91	
Constant load control	✓	10.7.91	
AE-potentiometer linearity	✓	10.7.91	109 Ω ÷ 19'752 Ω
AE-response calibration	✓	10.7.91	1.2 ≙ 280 Ω
AE-signal control	✓	10.7.91	
Scratch-line linearity	✓	10.7.91	
Test certification chart	✓	10.7.91	
Mains fluctuation rejection	✓	10.7.91	220 VAC (± 12%)
Microscope image shift	✓	10.7.91	
X/Y-Recorder compatibility	—	—	
Friction force measurement	✓	10.7.91	with FR-Al 174

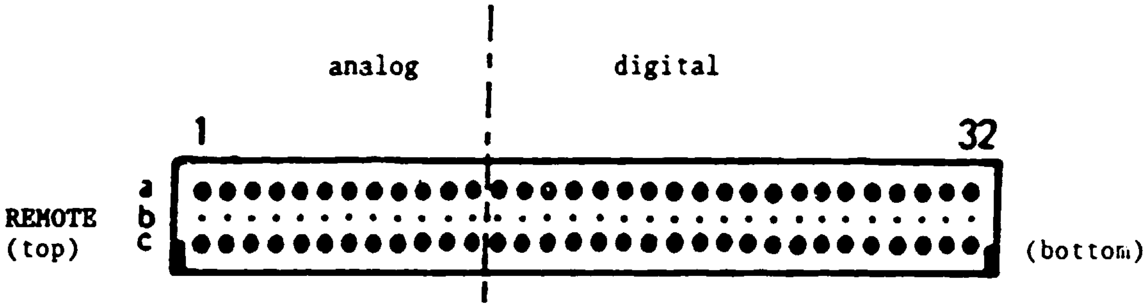
Neuchâtel, July 10, 1991.

checked by: TBrand



CSEM
CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE S.A.
DIV. MATERIAUX ET MICROMECANIQUE
CH-2007 NEUCHATEL, SUISSE
REVETEST®/AUTOMATIC SCRATCH TESTER
ACOUSTIC EMISSION - LOAD GRAPH
Diamond nº: 287
Sample: TiC on cem. carb.
Sensitivity: 1.2
Sample table speed:
dx/dt = 10 mm/min
Loading rate:
dL/dt = 100 N/min
Operator: FBr
Date: 28.6.91
Sample A
Sample B
TANGENTIAL FORCE [N]
ACOUSTIC EMISSION SIGNAL [arbitrary unit]
Y: 10 mV/cm
mV/cm
x: 100 mV/cm
x: 200 mV/cm
LOAD [N]
20
40
60
80
100
40
80
120
160
200

9 FUNCTION CONTROL WITH REMOTE CONNECTOR



DIN 41612 a + c

Pin		Standard value	Control element
1 2	} GND analog }		
3 4	} Power supply }	+ 15 V ± 0.2 V - 15 V ± 0.2 V	Trimpot R5/PCB 6 Trimpot R7/PCB 6
5a 5a	Minimum force limit Maximum force limit	0 V to + 2.5 V 0 V to + 2.5 V	Trimpot(30)/Front Panel Trimpot(31)/Front Panel
7c	Fn display instr. (32) Input signal	0 N: ± 3 mV (about) Full scale:+2500mV (100/200 N)	
8a	Load signal output	0 N: ± 3 mV (about) 200 N: -5000 mV	Trimpot "offset"/PCB2 Trimpot "Gain"/PCB2
9a	Ft signal output (option)	0 N: 0 V ± 5 mV 100 N: +2.5 V ±1 mV	Trimpot(39)/Front Panel Trimpot "Gain Ft"/PCB3
9c	µ* signal output (option)	0.0 V to 1.0 V (for µ* = 1)	Trimpot "Gain µ*"/PCB3
10a	AE signal output	0.0 V to 1.0 V	Selector and trimmer (36)/Front Panel
12c	Fn scale range selection	Scale 100 N: +15 V Scale 200 N: 0 V	Switch(33)/Front Panel

Pin		Standard value	Control element
6 7a 8c 11 12a 13	NC (Reserved)		
14a 16a	Pen off } Recorder pen } control Pen down }	0 V on +1.2 V off 0 V on +12 V off	}Switch(34) and }Contacter(32)/ }Front panel
14c 15a	Lamp RUN Lamp STOP	+0.5 V on +24 V off +0.5 V on +24 V off	Knob (27) Knob (28)
15c 16c	} Recorder remote control } signal	0 V / + 12 V (depending on the recorder input)	
17a	Sample table forward displacement	0 V on +12 V off	Switch(17) and contac- ter(32)/Front panel
17c	Progressive loading mode selection	0 V on +12 V off	Switch(29)/Front Panel
18a	Fn > min threshold	+12 V on 0 V off	
18c	Fn > max threshold	0 V on +12 V off	
19a	Reset	0 V on -12 V off	Knob(16)/Scratching machine
19c	Auto-return of the sample table	0 V on -12 V off	Switch(17)/Scratching machine
20a	RUN	0 V on +12 V off	Knob(27)/Front Panel
20c	STOP	0 V on -12 V off	Knob(28)/Front Panel
21a	Sample table speed adjus.	see Final Insp. Check-list	Trimmer(40)/Front Panel
21c	Load speed adjustment	see Final Insp. Check-list	Trimmer(41)/Front Panel
22a 22c 23a 23c	Proxim. switch "Forward" Proxim. switch "Backward" Proxim. switch "Upward" Proxim. switch "Downward"	} } } +12 V on 0 V off }	

Pin		Standard value	Control element
24/ 25	Loading motor drive	~ + 3.6 V Go ~ - 22.0 V Back	
26/ 27	Sample table motor drive	~ + 6.5 V Go ~ - 22.0 V Back	
28a	Sample table tachometer	see Final Insp. Check-list	
28c	Loading motor tachometer	see Final Insp. Check-list	
29	Power supply + 12 V	+ 12 V ± 0.2 V	Trimpot R3/PCB6
30	Power supply + 24 V	+ 24 V ± 2 V	Not adjustable
31 32	GND Digital		

Remarks:

- All voltage values shown in DC volts
- Values measured with battery-operated precision voltmeter
  - pins 1 to 12: against analog GND
  - pins 13 to 32: against digital GND (where not indicated by /)
- For instrument specific values, see "Final Inspection Check-list"

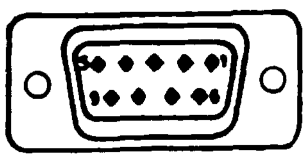
9.1 Supplementary Informations

1. **Power supply + 24 V**

   Not adjustable, level defined by a bridge rectifier (Type: B80 C 1500 M on PCB6)

2. **Transducer power supply**

   These sinusoidal signals (5 kHz frequency) have to be set to 10 V RMS (load cell) and 5 V RMS (Ft) with a convenient AC voltmeter (True RMS). Signals are available on the transducers output (48) or, more practically, on the 9 pole female subconnector D of the SCRATCHING MACHINE connector board (18).



9 pole subconnector D

Pin	
1	load cell - output
2	load cell + output
3	NC
4	tangential force signal
5	GND
6	supply + } load cell
7	supply - } " "
8	supply + } tangential force
9	supply - } " "

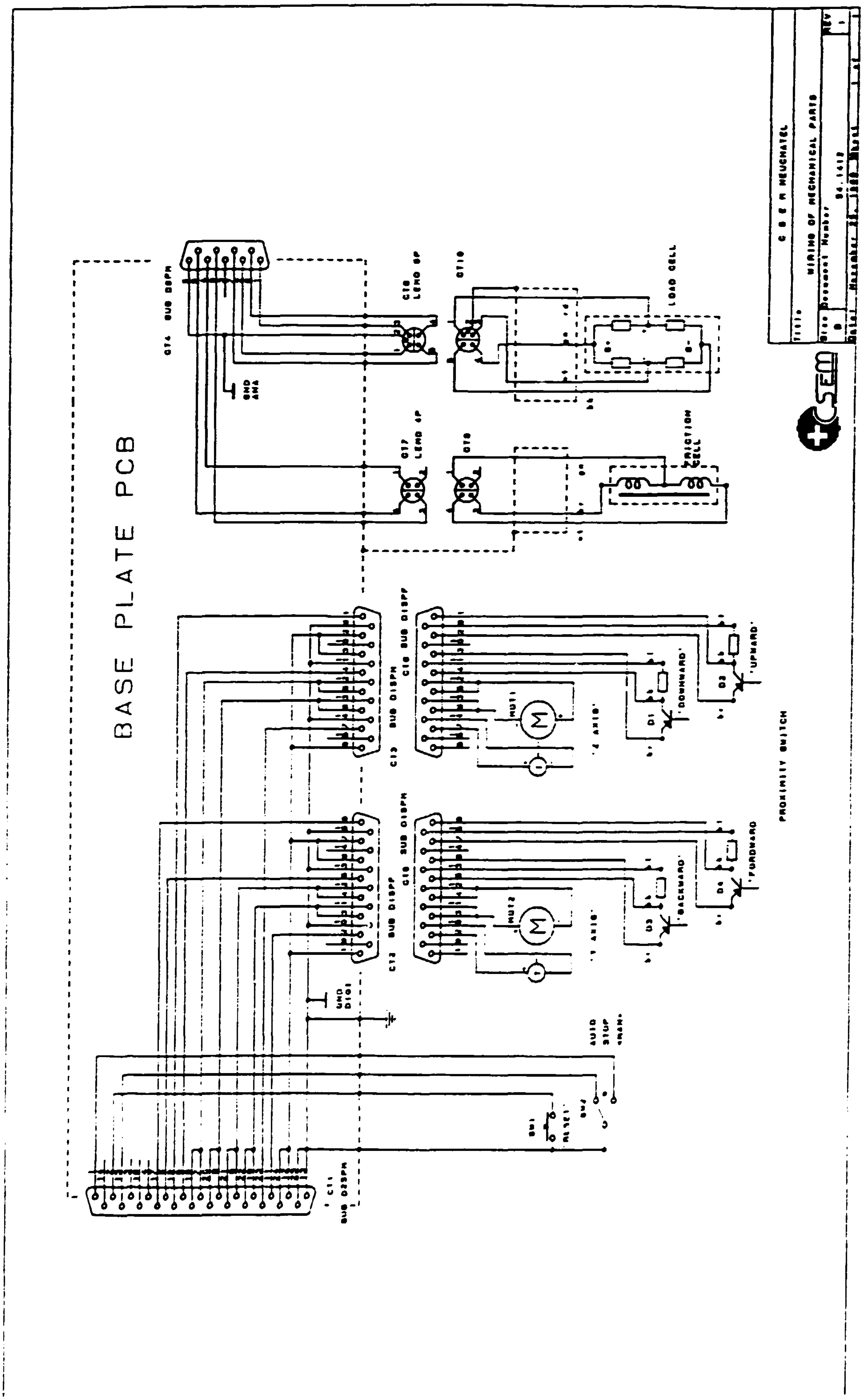
3. **Stroke limiter signals**

   The 4 stroke limiters (proximity switch type) show H-level (+ 12 V) when activated and L-level (0 V) when not: their function can be tested by bringing any metallic part (pincers. etc.) into contact with their extremity.

4. **Motor signals**

   To obtain a regular loading rate and sample displacement, the driving motor signals are enslaved according to their instantaneous rotational speeds: the tachometer output signal (pins 28) is compared with a regulated voltage level, adjusted with a trimmer on front panel ((40) and (41)). According to the difference between those two levels. the speed controller (TCA 365 op amp.) modifies the power supplied to the motor.

10 BOARDS AND DIAGRAMS


BASE PLATE PCB
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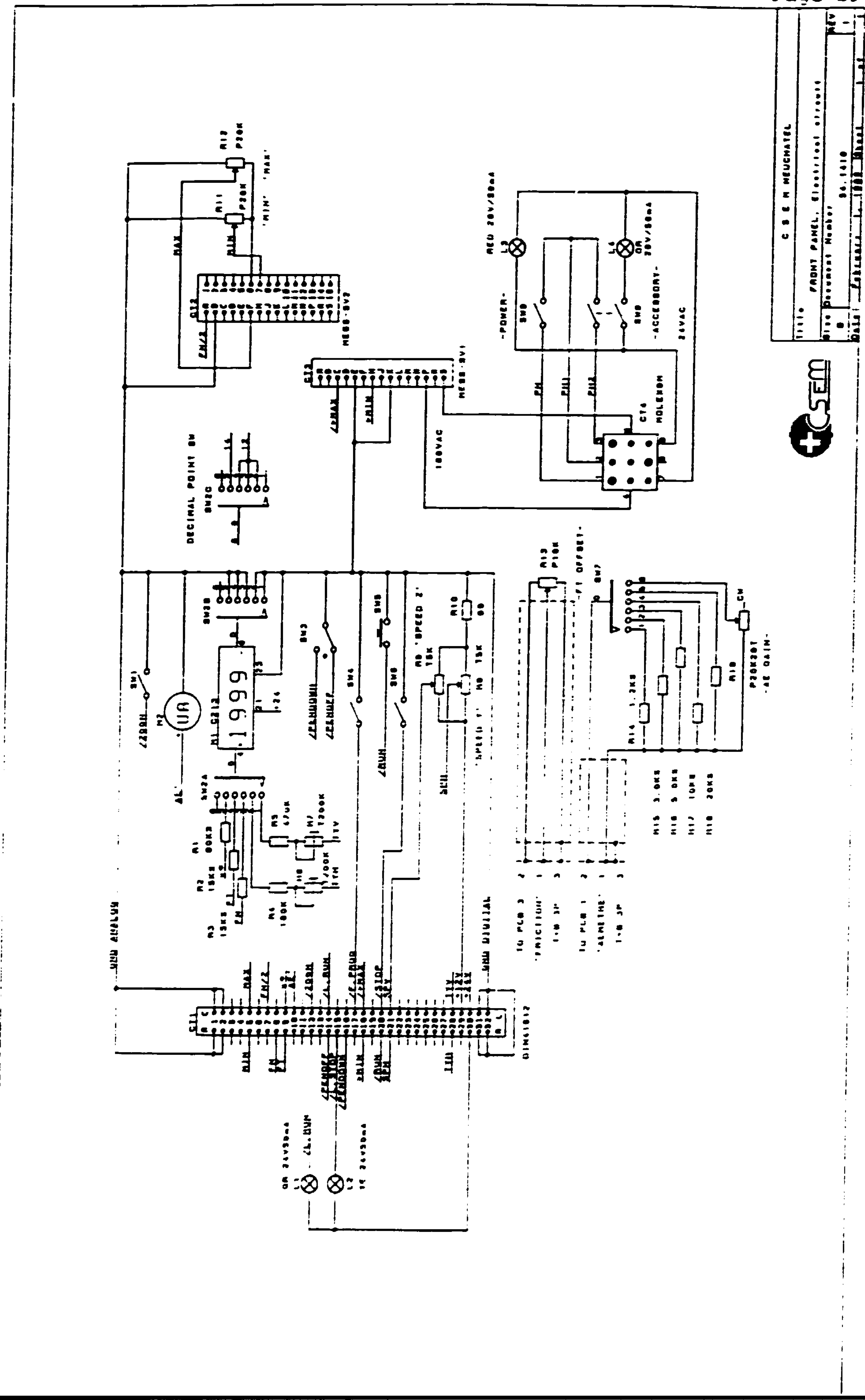
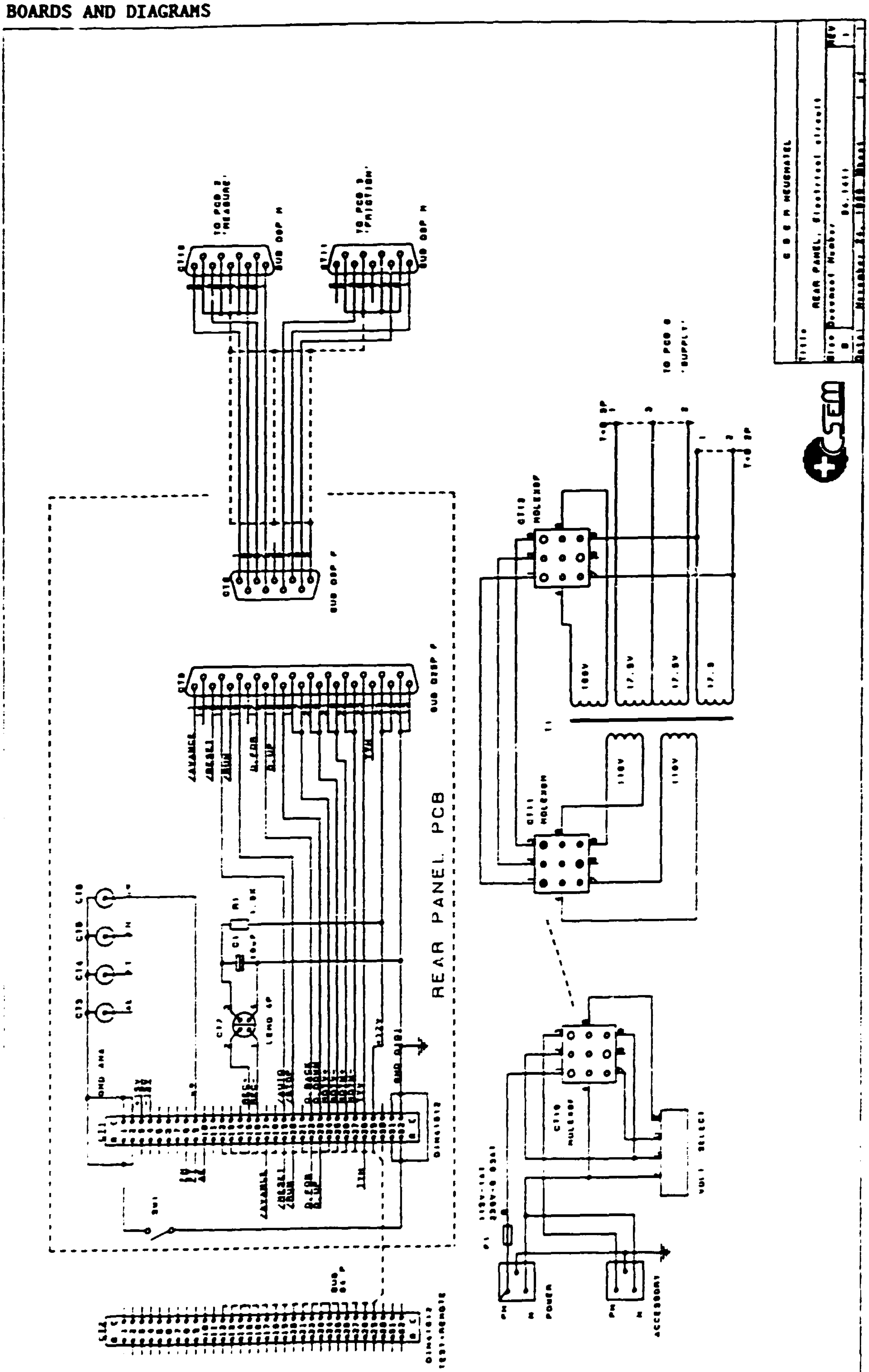
FRICTION CELL
PROXIMITY SWITCH
'UPWARD'
'DOWNWARD'
'BACKWARD'
'FORWARD'
WIRING OF MECHANICAL PARTS


C S E M NEUCHATEL
FRONT PANEL, Electrical circuits
DECIMAL POINT SW
-POWER-
-ACCESSORY-
24VAC
100VAC
GND ANALOG
GND DIGITAL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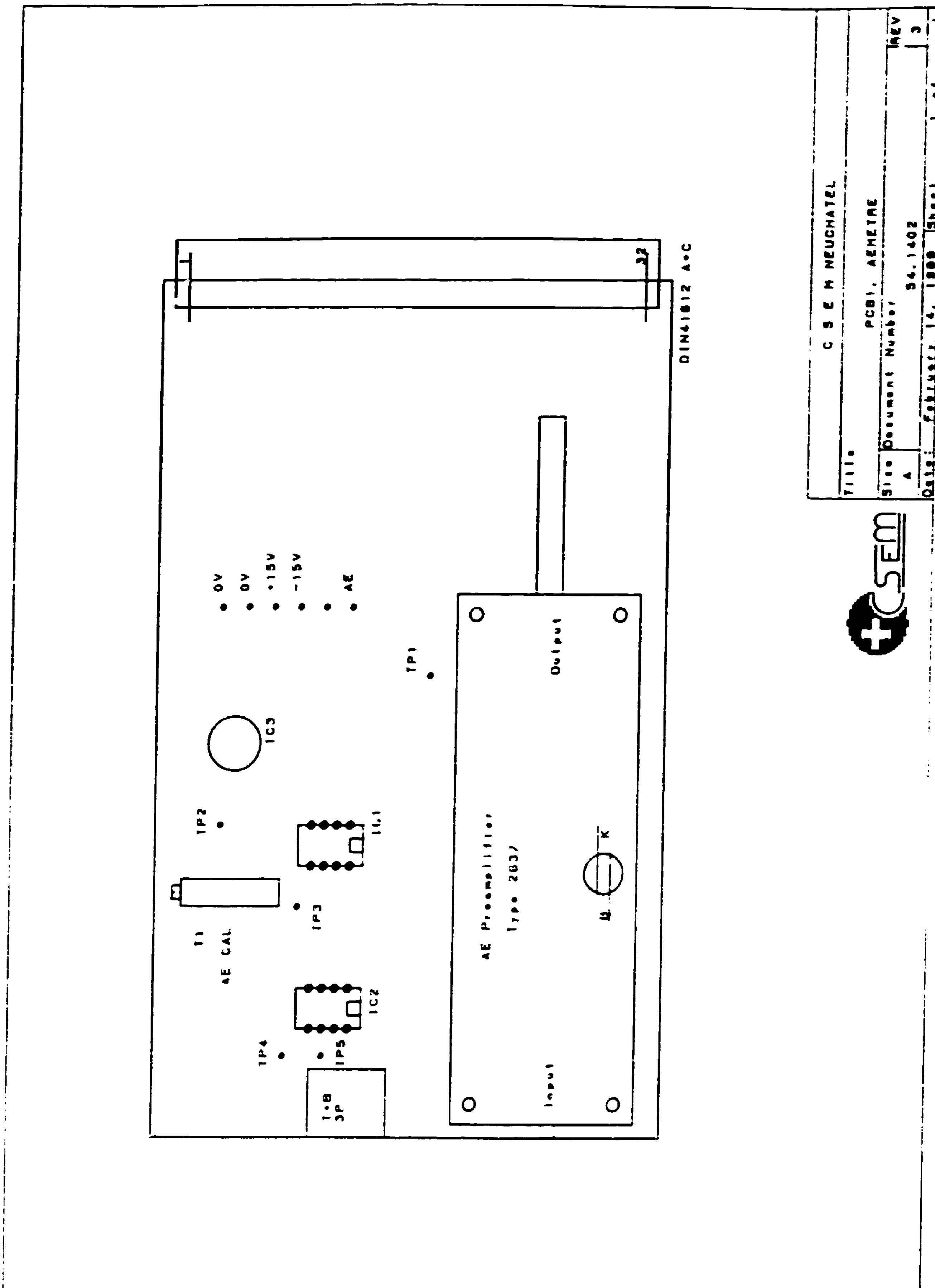
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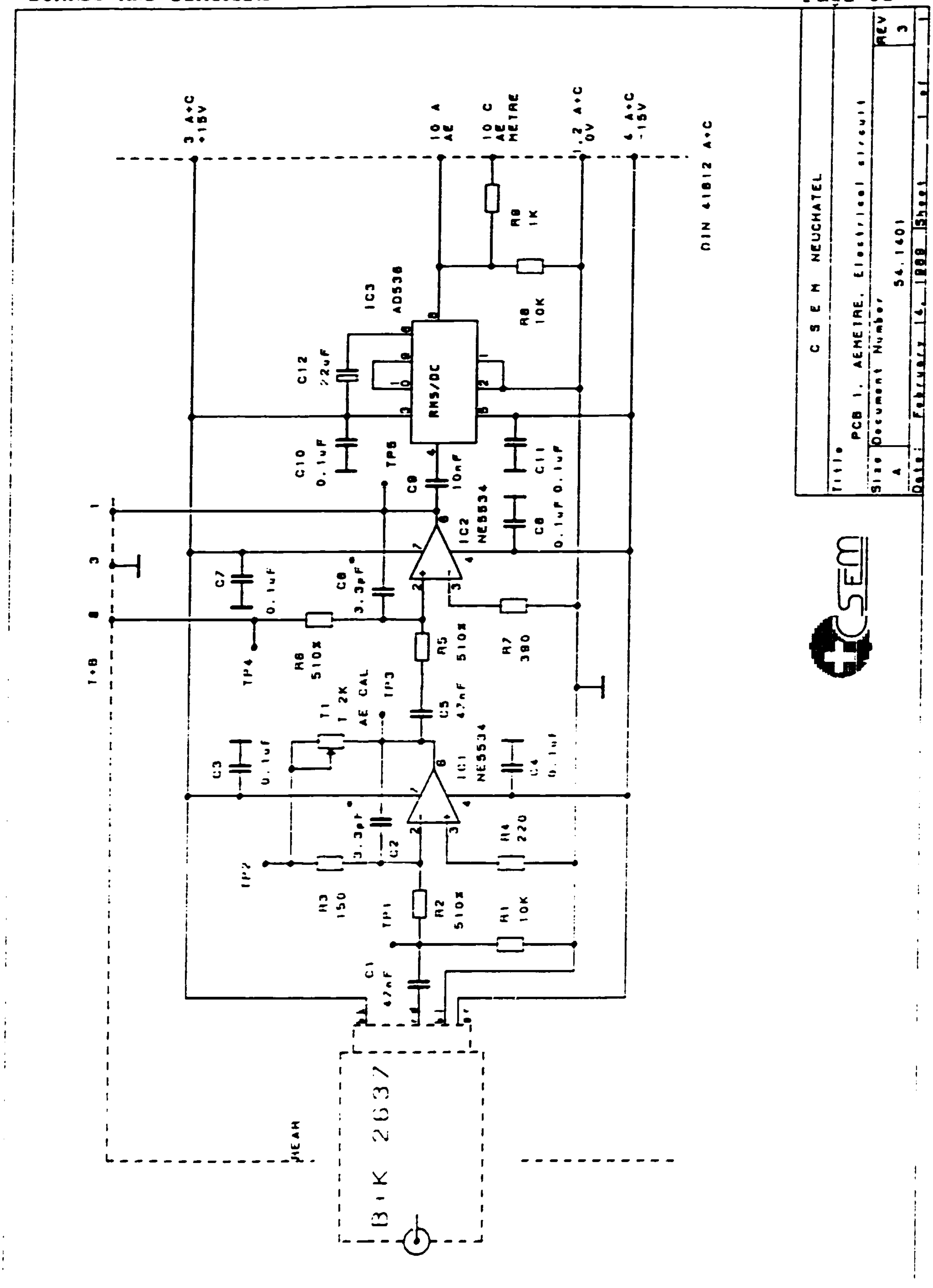
PCB1, AEMETRE
Size
A
Document Number
54.1402
REV
3
Date:
Sheet
DIN41612 A+C
0V
0V
+15V
-15V
AE
TP1
Output
IC3
TP2
TP3
T1
AE CAL
AE Preamplifier
Type 2037
K
IC2
TP4
TP5
Input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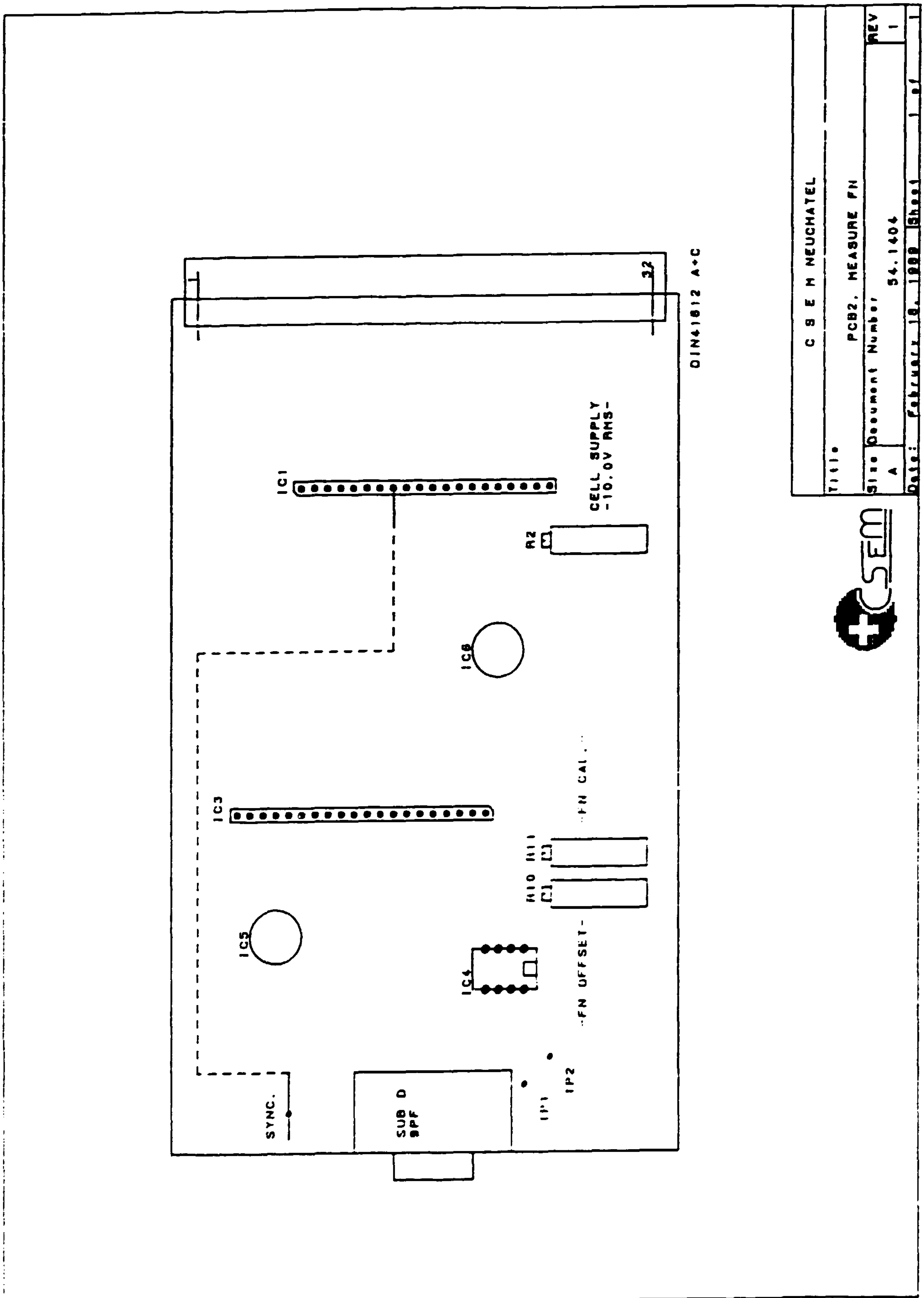
Size
A
Document Number
54.1401
REV
3
Date: February 14, 1988
Sheet 1 of 1
DIN 41612 A+C
3 A+C +15V
10 A AE
10 C AE METRE
12 A+C 0V
4 A+C -15V
IC3 AD536
RMS/DC
IC2 NE5534
IC1 NE5534
C12 22uF
C10 0.1uF
C11 0.1uF
C9 10nF
C8 0.1uF
C7 0.1uF
C6 3.3pF
C5 47nF
C4 0.1uF
C3 0.1uF
C2 3.3pF
C1 47nF
R9 1K
R8 10K
R7 390
R6 510K
R5 510K
R4 220
R3 150
R2 510K
R1 10K
T1 2K AE CAL
TP1
TP2
TP3
TP4
TP5
B+K 2637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Size
A
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Date:
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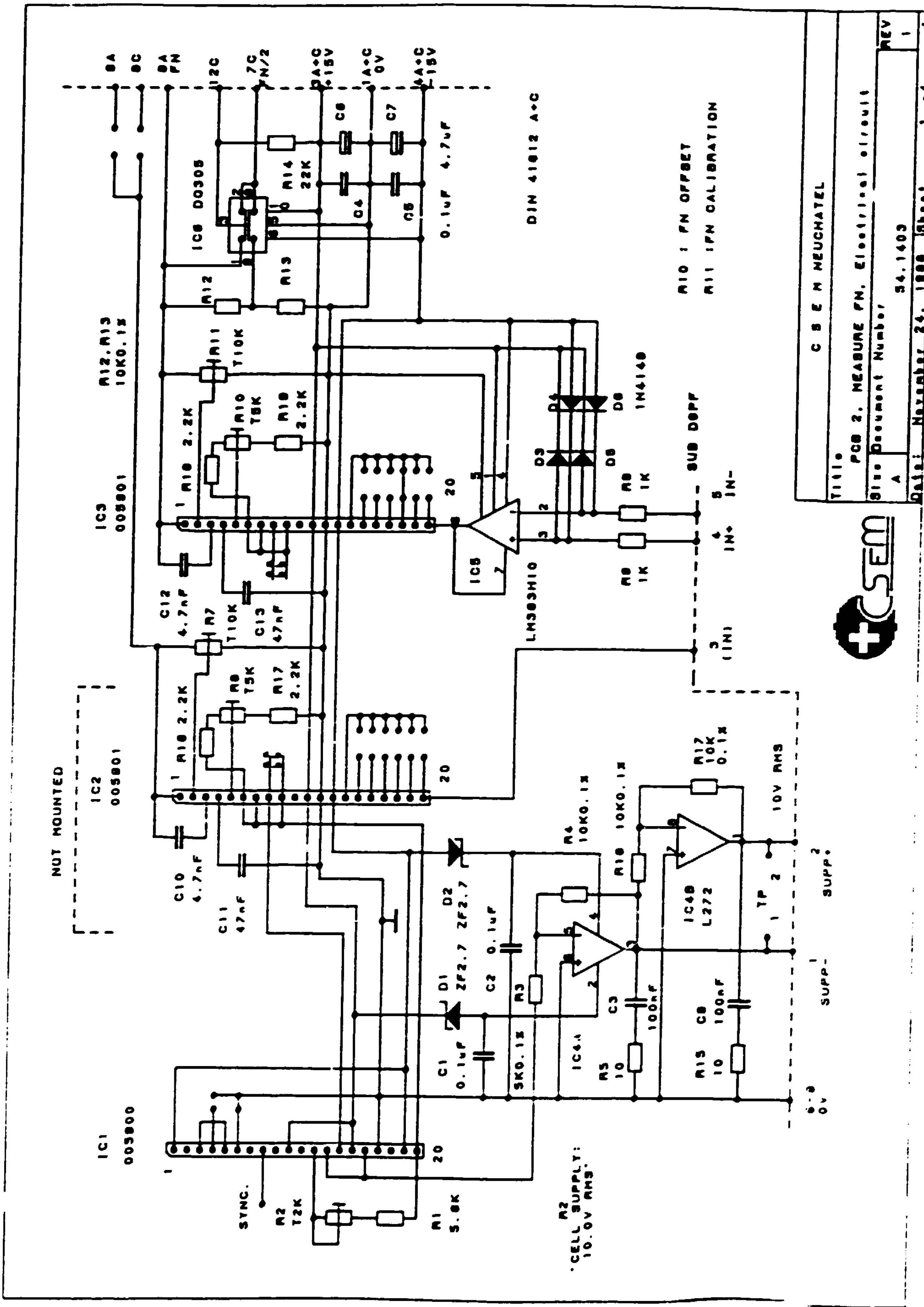
1 of
1
32
DIN41612 A+C
CELL SUPPLY
-10.0V RMS-
IC1
R2
IC6
IC3
-FN CAL.-
R10
R11
IC5
IC4
-FN OFFSET-
SYNC.
SUB D
9PF
IP1
IP2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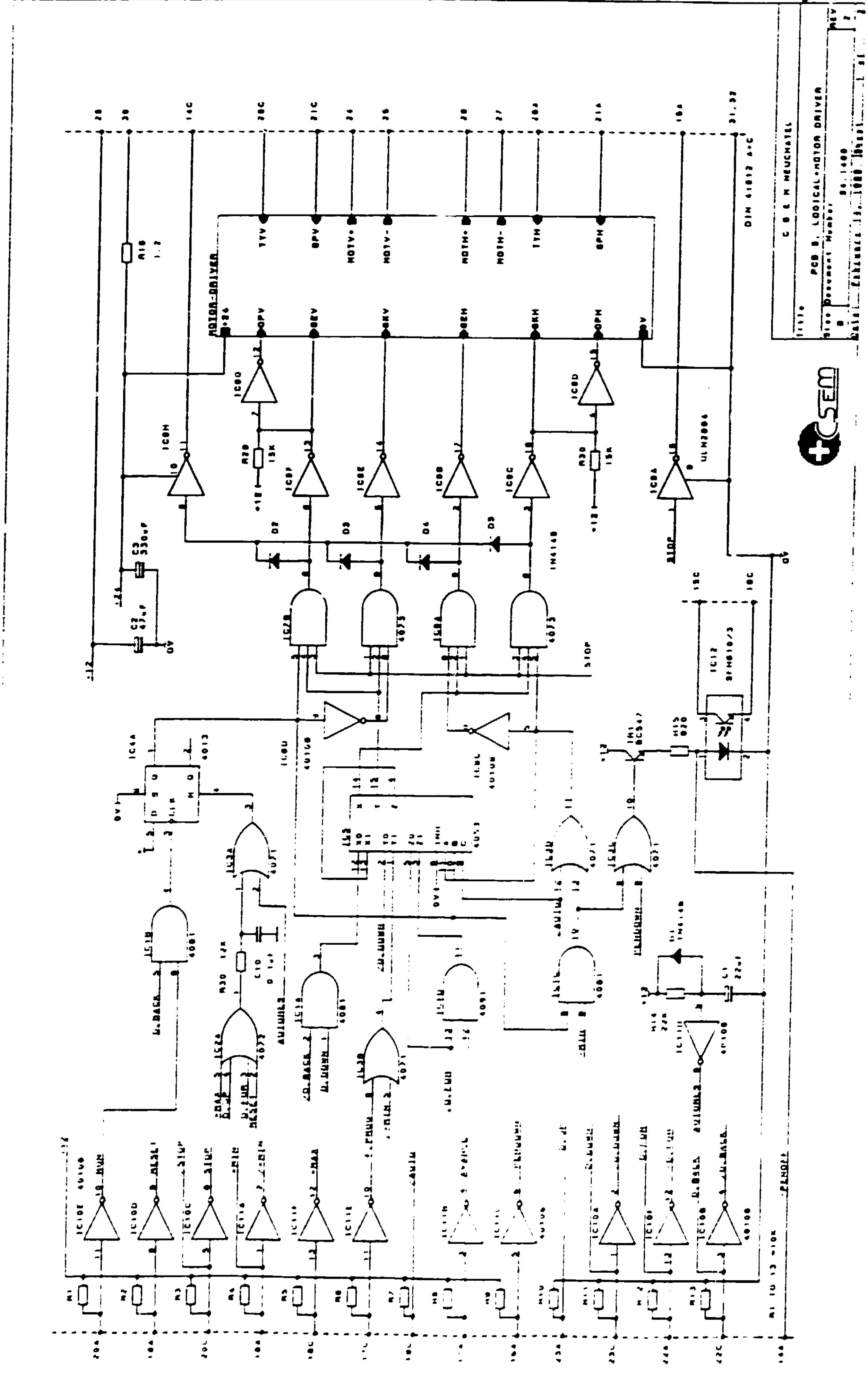
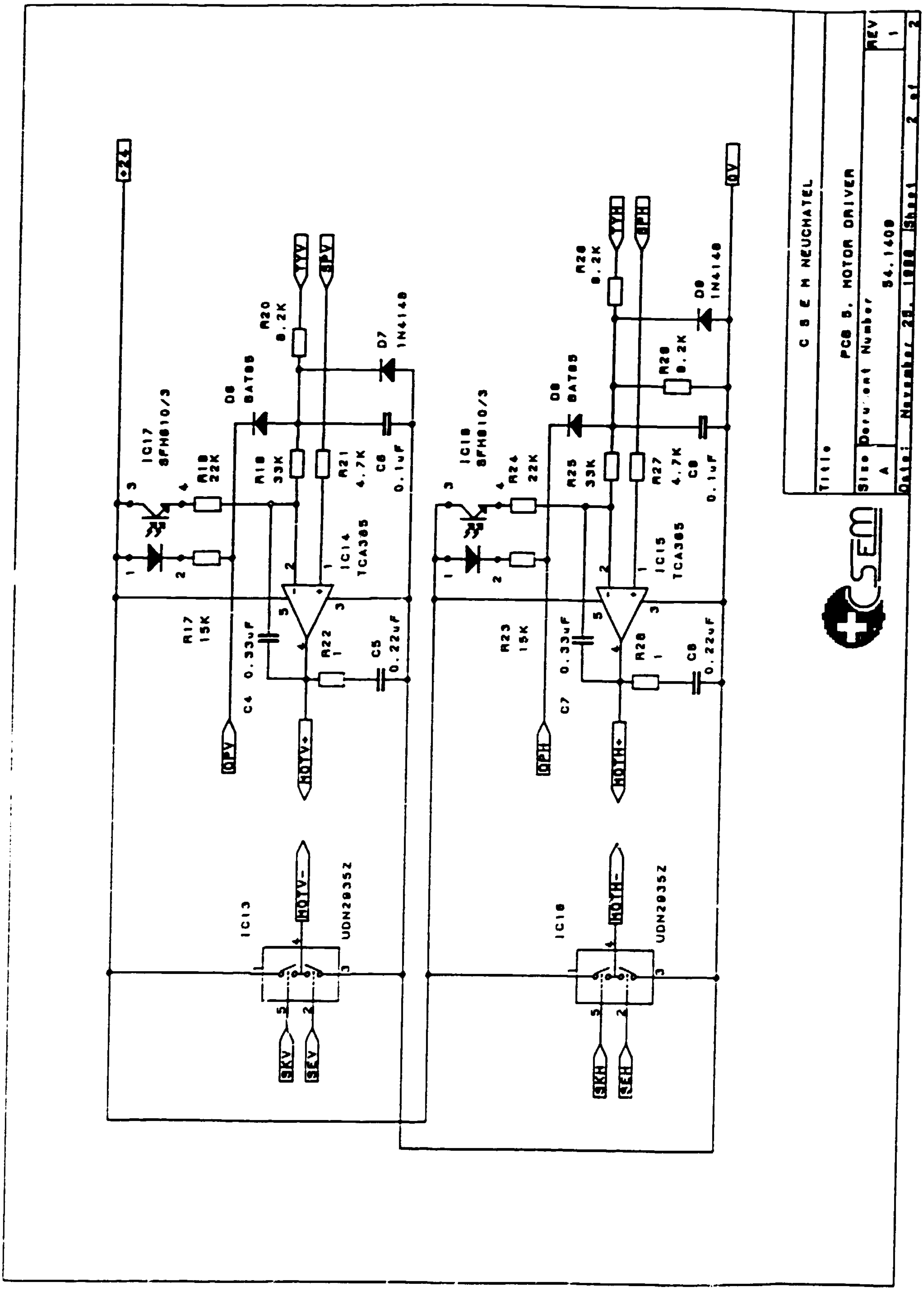
PCB 2, MEASURE FN, Electrical circuit
54.1403
DIN 41612 A+C
R10 : FN OFFSET
R11 : FN CALIBRATION
SUB D9PF
NOT MOUNTED
IC1 005800
IC2 005801
IC3 005801
IC6 D0305
LM393H10
1N4148
R12, R13 10K0.1%
IC4B L272
10V RMS
SYNC.
CELL SUPPLY: 10.0V RMS

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Size
A
Document Number
54.1400
REV
1
Date: November 25, 1988
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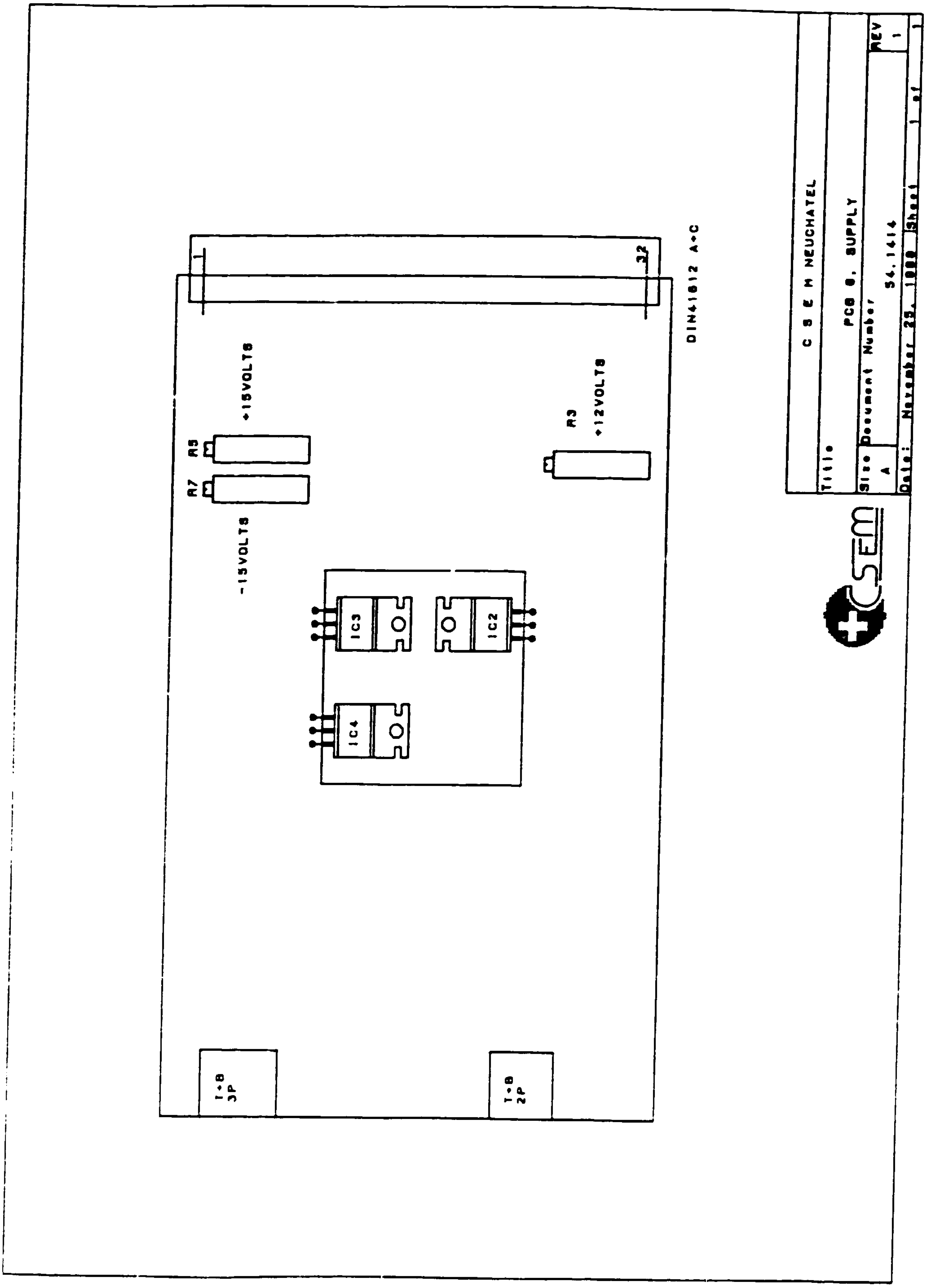
IC17
SFH610/3
IC18
SFH610/3
IC14
TCA365
IC15
TCA365
IC13
UDN2935Z
IC16
UDN2935Z
D6
BAT85
D8
BAT85
D7
1N4148
D9
1N4148
+24
0V
YYV
SPV
YYH
SPH
OPV
OPH
MOTV+
MOTV-
MOTH+
MOTH-
SKV
SEV
SKH
SEH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1
32
+15VOLTS
R5
R7
-15VOLTS
R3
+12VOLTS
IC3
IC2
IC4
I+B
3P
I+B
2P
Title
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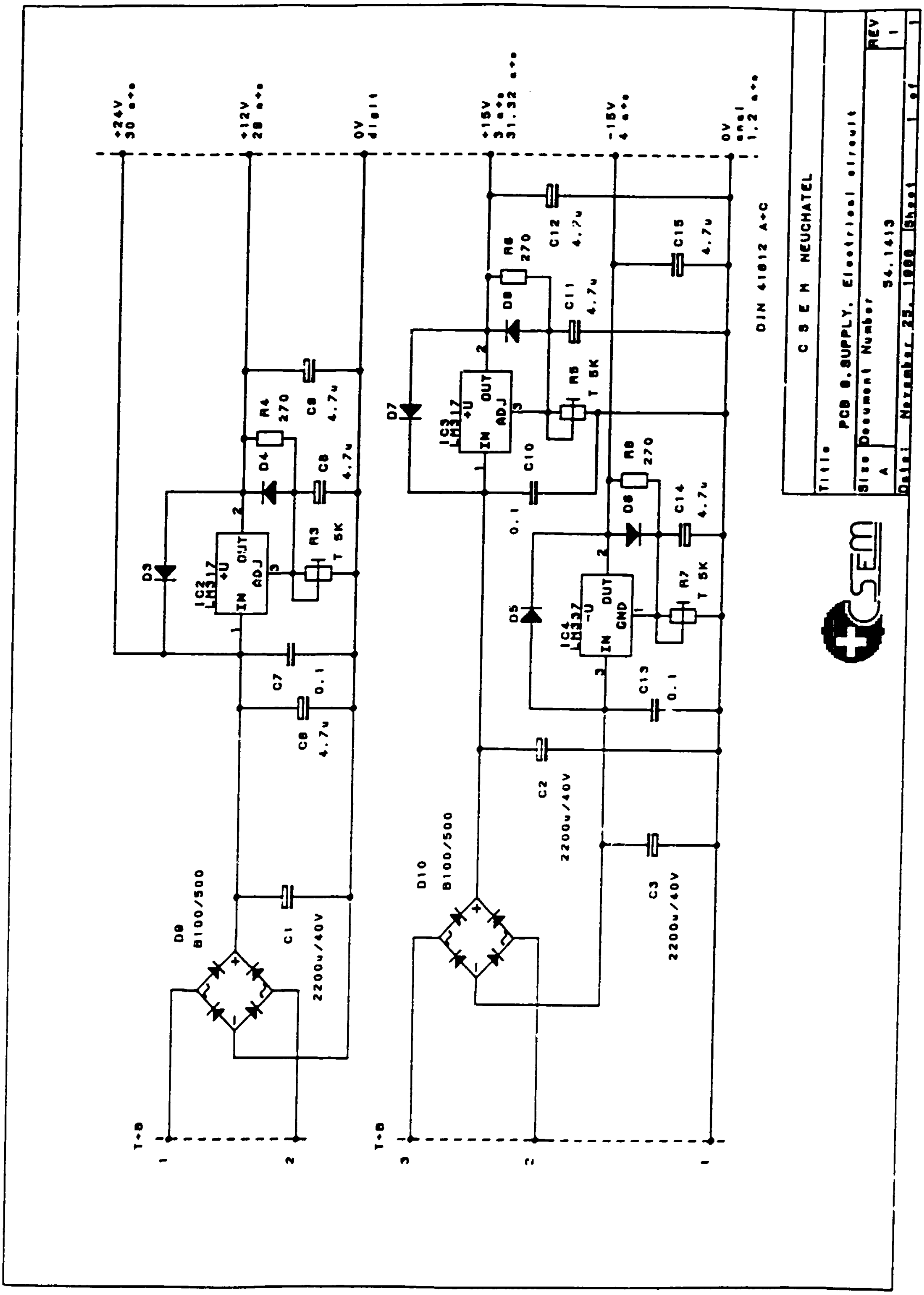
PCB 6. SUPPLY
Size
A
Document Number
54.1414
REV
1
Date: November 25, 1988
Sheet 1 of 1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DIN 41612 A+C
Title
Size
A
Document Number
54.1413
REV
1
Date: November 25, 1988
Sheet 1 of 1

SCRATCH-TESTER CSEM

	A			C		
	GND ANALOG	1	1	GND ANALOG		ANALOG
	GND ANALOG	2	2	GND ANALOG		
	+15 VOLTS	3	3	+15 VOLTS	+0.2V -0.2V	
	-15 VOLTS	4	4	-15 VOLTS	+0.2V -0.2V	
0.0 TO +5.0V	MIN	5	5	MAX	+5.0V TO 0.0V	
		6	6			
		7	7	FN/2	0.0 TO +2.5V	
0.0 TO +2.5V(5.0)	FN	8	8			
0.0 TO +2.5V(5.0)	FT	9	9	μ*	0 TO 1.0V(FOR μ =1)	
0.0 TO +1.0V	AE	10	10	AE'	INTERNAL USE	
		11	11			
		12	12	/200N	0V ON,+15V OFF	
		13	13			DIGITAL
0V ON,+1.2V OFF(IF..)	/PEN OFF	14	14	/LAMP RUN	+0.5V ON,+24V OFF	
+0.5V ON,+24V OFF	/LAMP STOP	15	15	RECORDER+	+12V	
0V ON, +12V OFF	/PEN DOWN	16	16	RECORDER-	+12V ON, 0V OFF(IF..)	
0V ON, +12V OFF	/FORWARD	17	17	/FORCE PROG.	0V ON, +12V OFF	
+12V ON, 0V OFF	>MIN	18	18	/>MAX	0V ON, +12V OFF	
0V ON, +12V OFF	/RESET	19	19	/AUTO	0V ON, +12V OFF	
0V ON, +12V OFF	/RUN	20	20	/STOP	0V ON, +12V OFF	
ABOUT +2.90V	SPEED Y (H)	21	21	SPEED Z (V)	ABOUT +2.90V	
+12V ON, 0V OFF	DETECT. FOR.	22	22	DETEC. BACK	+12V ON, 0V OFF	
+12V ON, 0V OFF	DETECT. UP	23	23	DETEC. DOWN	+12V ON, 0V OFF	
	MOTOR+ Z (V)	24	24	MOTOR+ Z (V)	AB.+3.7VGO,-22VBACK	
	MOTOR- Z (V)	25	25	MOTOR- Z (V)		
	MOTOR+ Y (H)	26	26	MOTOR+ Y (H)	AB.+6.5VGO,-22VBACK	
	MOTOR- Y (H)	27	27	MOTOR- Y (H)		
ABOUT +5.80V	TACHY+ Y (H)	28	28	TACHY- Z (V)	ABOUT +2.90V	
	+12 VOLTS	29	29	+12 VOLTS	+0.2V, -0.2V	
	+24 VOLTS	30	30	+24 VOLTS	+2.0V, -2.0V	
	GND DIGITAL	31	31	GND DIGITAL		
	GND DIGITAL	32	32	GND DIGITAL		
	A			C	VOLTAGE IN (..) FOR 200 N	

DIN41612 A+C

C S E M NEUCHATEL		
Title: BUS		
Size: E	Document Number: 54.1415	REV: 1
Date: November 29, 1988	Sheet 1 of 1	

11 INVENTORY

1 SCRATCHING MACHINE REVETEST S/N AMI 16/297

1 CONTROL UNIT SCRATCH-TESTER S/N AMI 16/297

1 resonant AE detector BRUEL & KJAER type 8313 S/N 146'1583

1 load cell VIBRO-METER type BLC-305-0,03 S/N 28034

2 diamonds ROCKWELL C, cone angle of 120°,
tip radius 0,2 mm. Nos 219; 229

1 standard sample holder

1 cable for power supply

1 cable for resonant AE detector

1 cable for connection of SCRATCHING MACHINE motors

1 cable for transducers

1 cable for AE signal output to the recorder

1 cable for force signal output to the recorder

1 cable for pen-lift command of the recorder

1 plug for accessory

1 screw driver

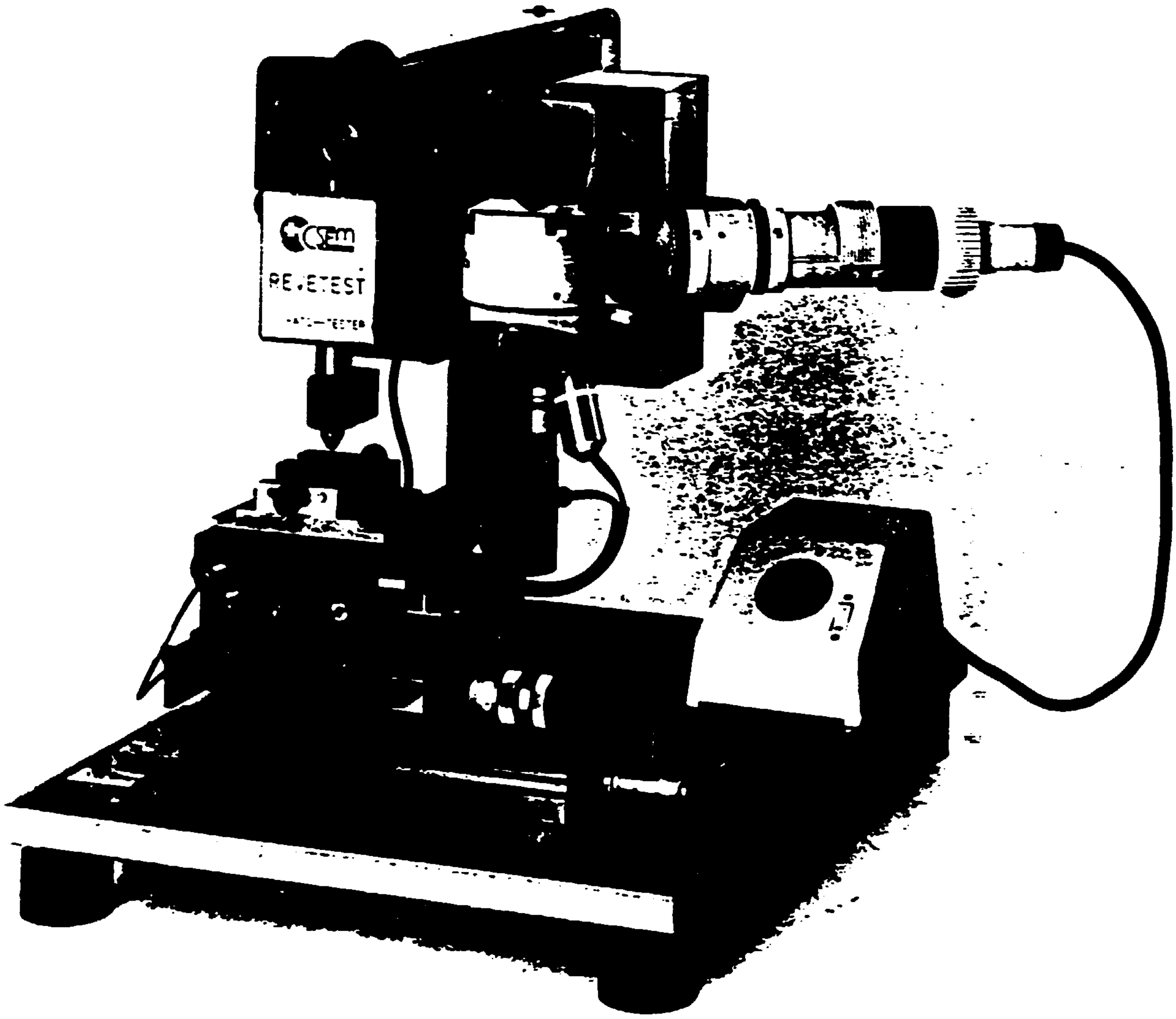
5 hex/Allen wrenches

1 plastic protection cover

1 instruction manual in English

12 OPTIONAL MATERIAL

CSEM-REVETEST / MICROSCOPE EQUIPMENT



The addition of a measurement microscope to the CSEM-REVETEST allows:

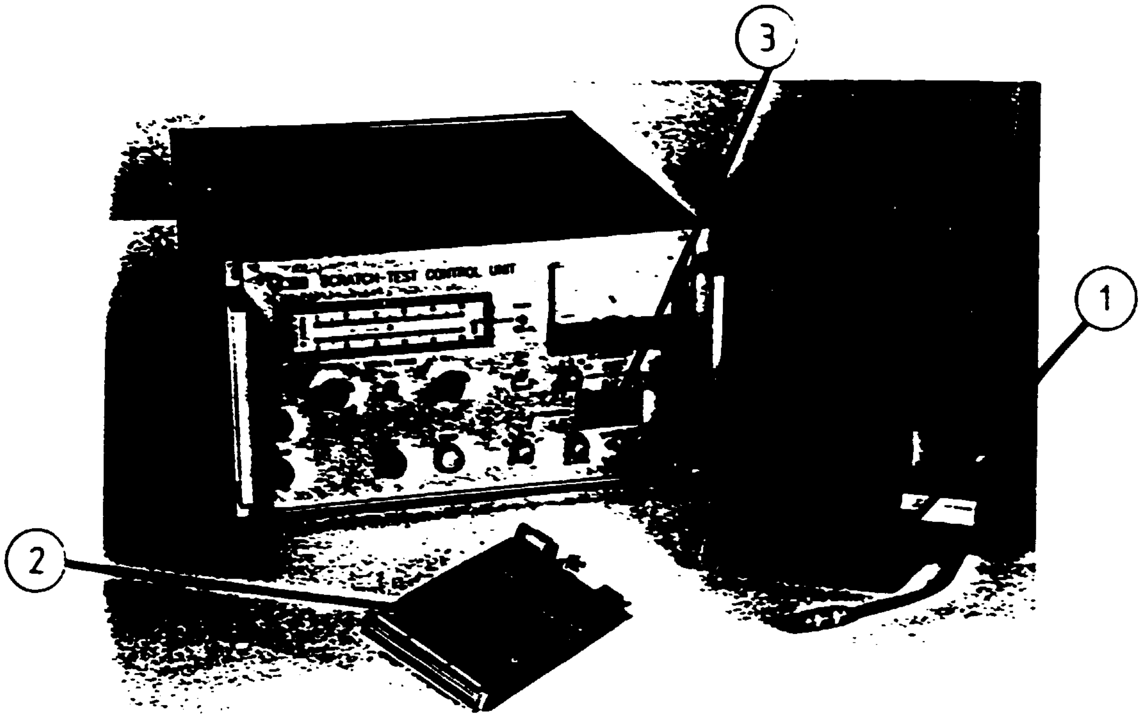
1) The location where the scratch will be performed to be chosen with precision by means of a visual observation.

2) The scratch to be observed after the test without removing the sample from its support table.

3) The scratch distance up to the first coating damage occurrence to up to be measured by microscope. By taking into account the loading rate and the sample displacement speed, the distance can be related to load (critical load). This technique allows testing of samples which do not produce acoustic emission. When testing hard and brittle coatings, this technique allows the critical load values obtained by acoustic emission and those obtained by optical microscopy to be compared.

CSEM-REVETEST

DEVICE FOR FRICTION PARAMETER DETERMINATION



This accessory enables measurement of the tangential force Ft and of the scratching coefficient µ* during the test. It can be adapted on the CSEM-AUTOMATIC SCRATCH-TESTER without any modification.

The accessory is composed of:

(1) A measurement table combined with a work base

(2) A friction measurement board connected to the SCRATCH-TEST CONTROL UNIT.

Tangential force Ft or scratching coefficient µ* can be displayed on the CONTROL UNIT (3) and can also be recorded simultaneously with the AE-signal on a xyly2 recorder.

13 REFERENCE FIGURES

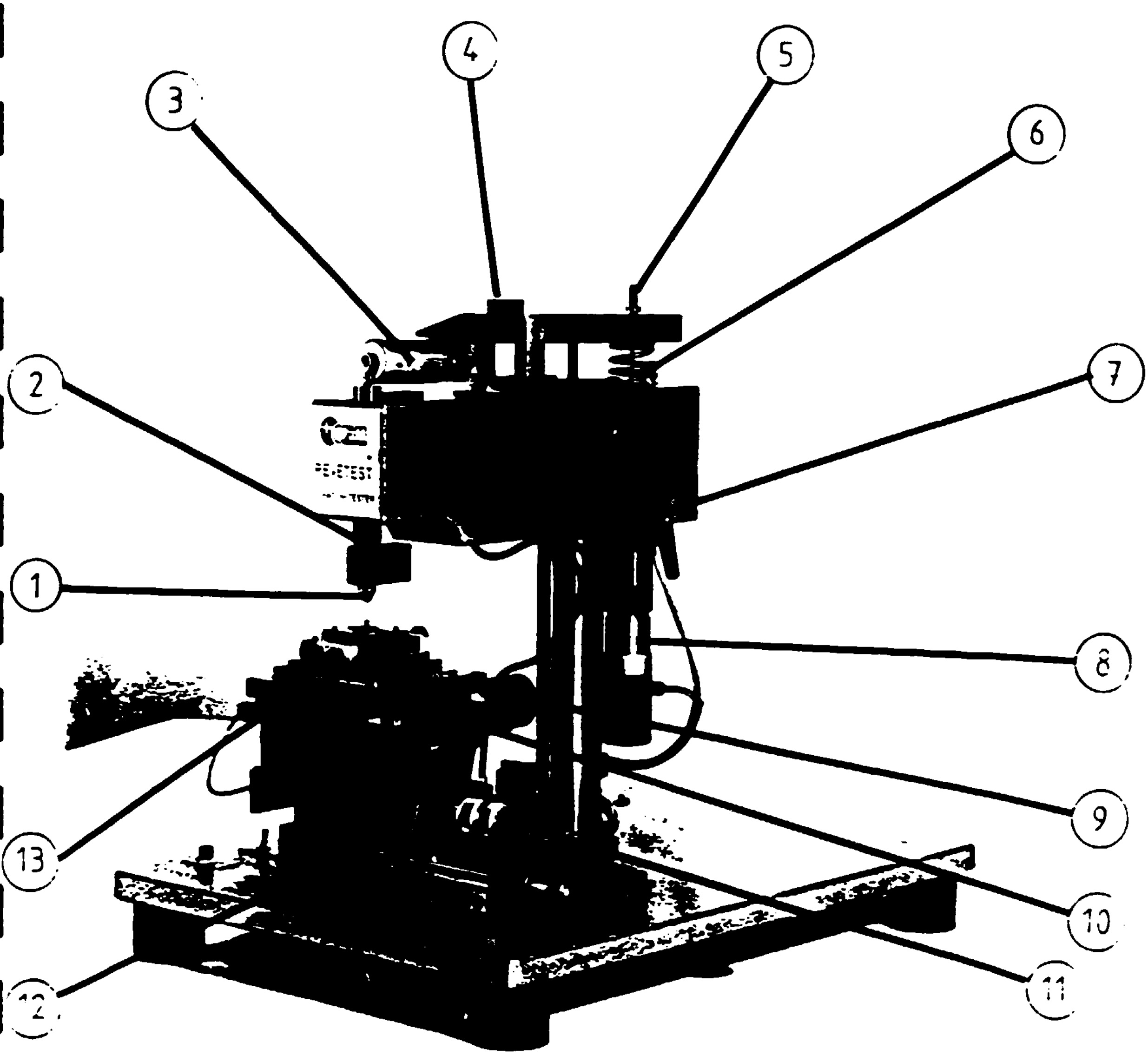


Fig. 1 : SCRATCHING MACHINE

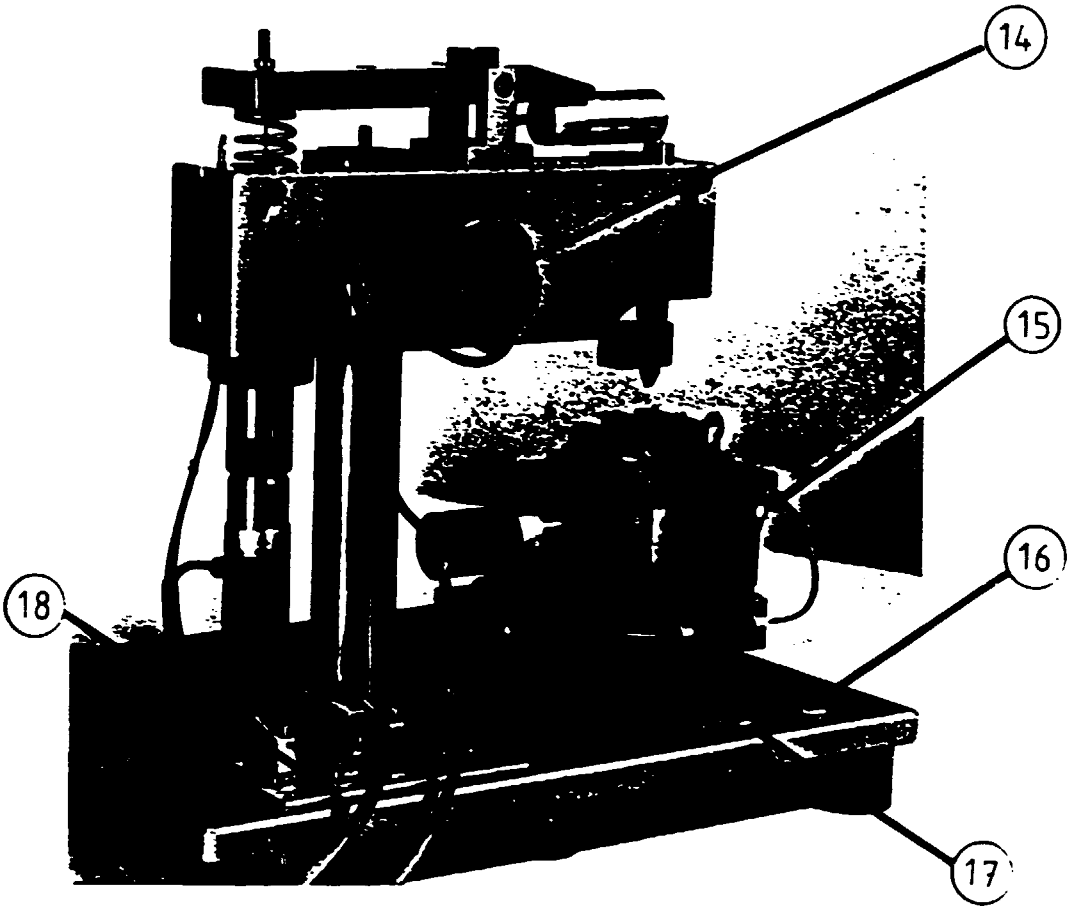


Fig. 2 : SCRATCHING MACHINE

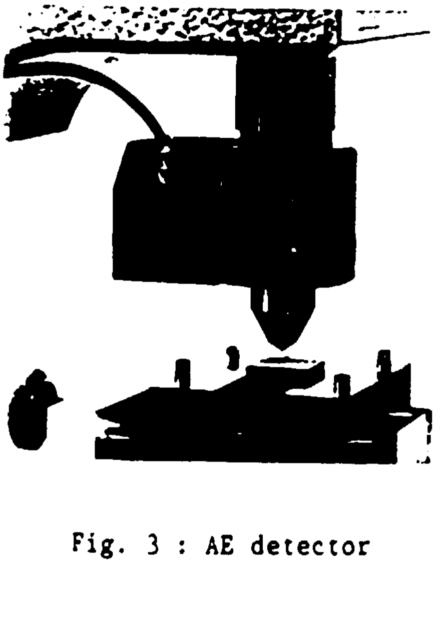


Fig. 3 : AE detector

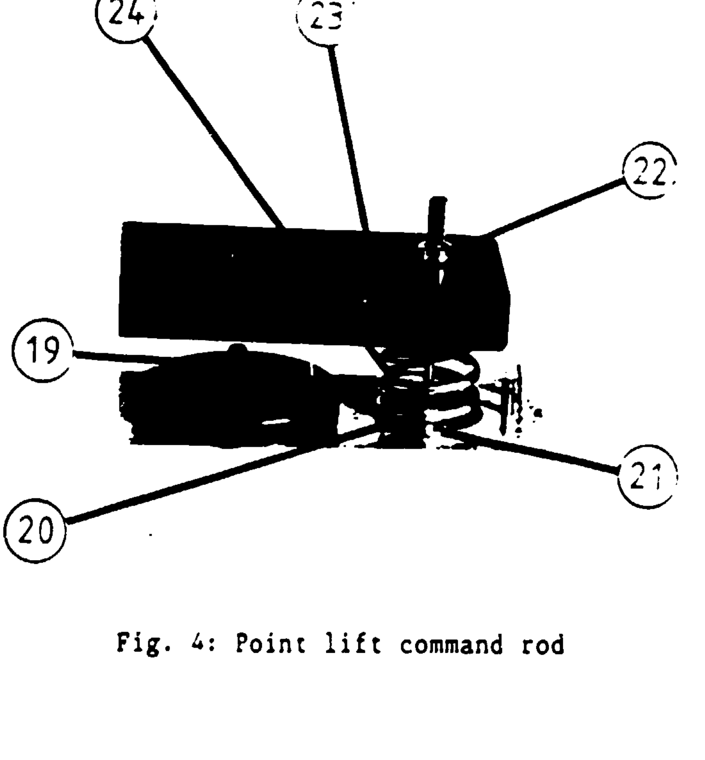


Fig. 4: Point lift command rod

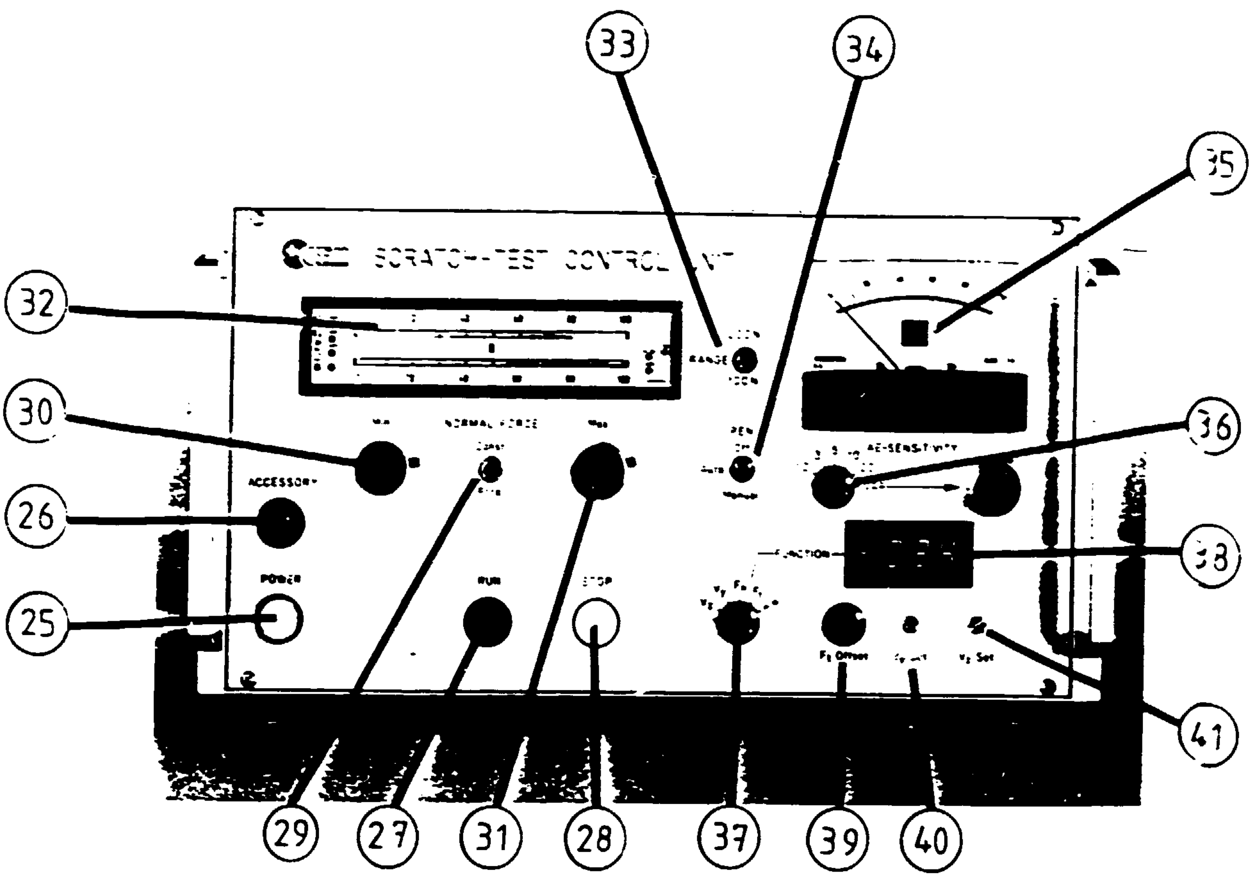


Fig. 5 : CONTROL UNIT front panel

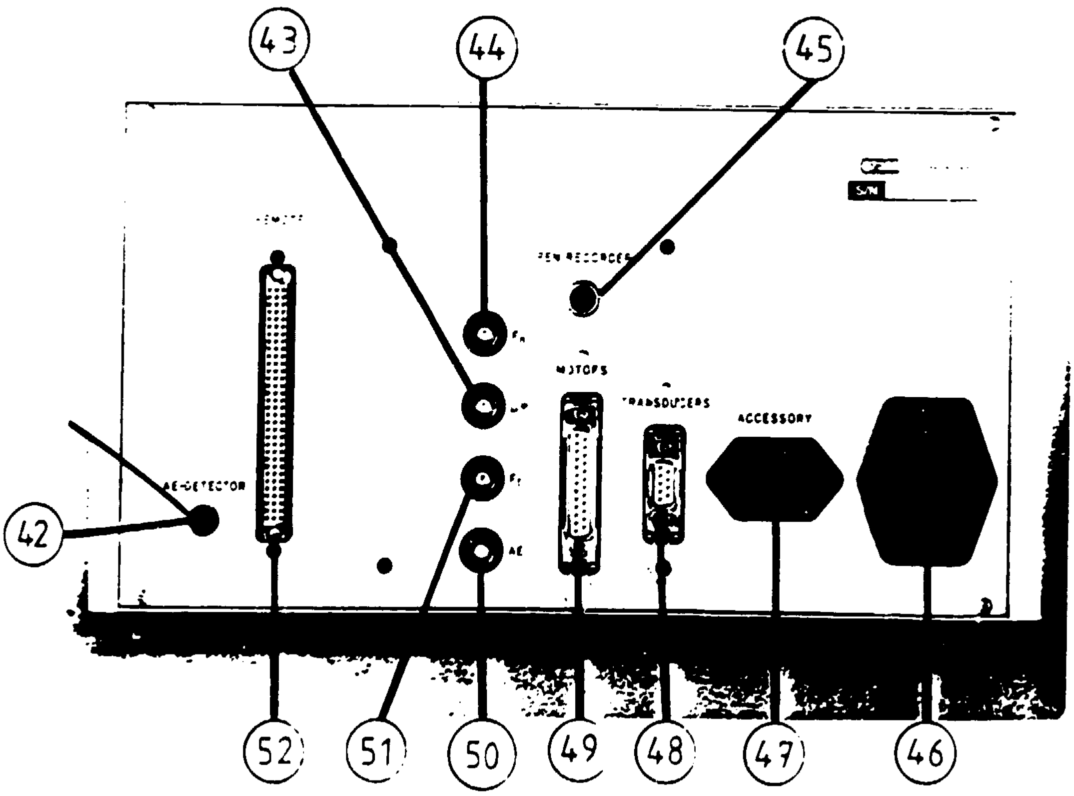


Fig. 6 : CONTROL UNIT rear panel

APPENDIX ....

CSEM - REVETEST®

Measurement Microscope Equipment

DIRECTIONS FOR USE

CSEM, Rue Breguet 2, CH - 2007 NEUCHATEL (Switzerland)
TEL +41 38 24 01 61 TELEX 952 555 CSEM TELEFAX +41 38 25 40 78

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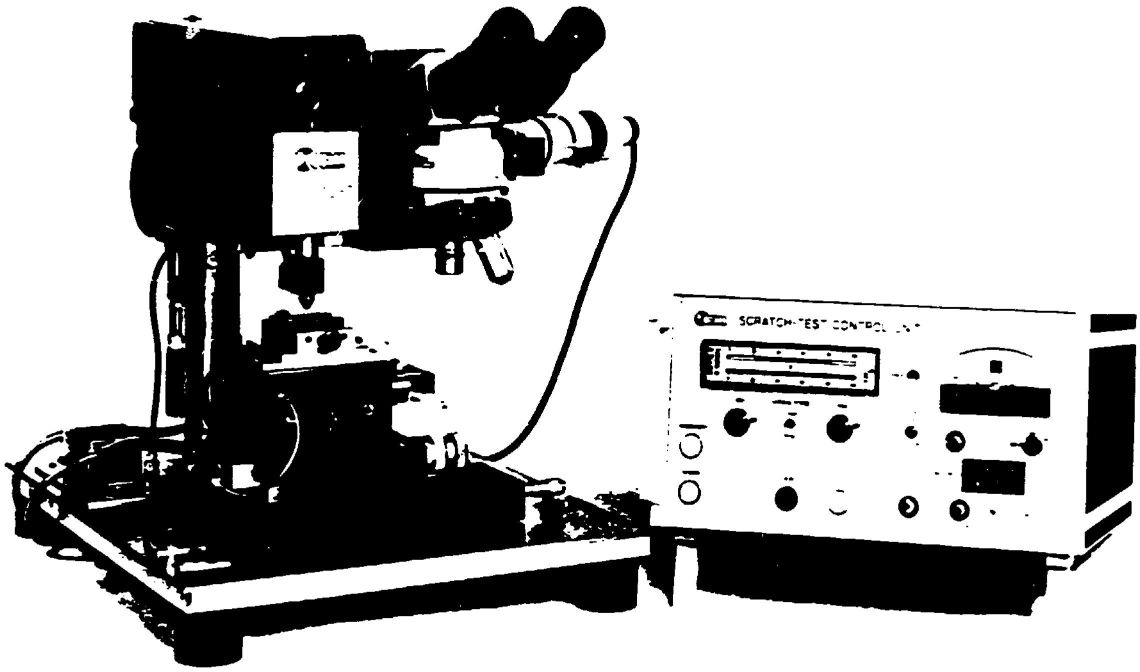
REVETEST / MICROSCOPE EQUIPMENT



1 INTRODUCTION

The addition of a measurement microscope to the CSEM-REVETEST allows:

1) The location where the scratch will be performed to be chosen with precision by means of a visual observation.

2) The scratch to be observed after the test without removing the sample from its support table.

3) The scratch distance up to the first coating damage occurrence to be measured by microscope. By taking into account the loading rate and the sample displacement speed, the distance can be related to load (critical load). This technique allows testing of samples which do not produce acoustic emission. When testing hard and brittle coatings, this technique allows the critical load values obtained by acoustic emission to be compared with those obtained by optical microscopy.

2 DESCRIPTION

Please unfold page 7 to refer to the corresponding figures.

1. Microscope stand
2. Microscope
3. Sample table displacement indicator
4. X-axis translation stage (1 turn = 1 mm)
5. X-displacement micrometer screw for slide-way translation adjustment
6. X-axis locking handle of translation slide-way
7. Switch for sample table displacement (Y-axis)
8. Locking handle for Y-axis translation stage
9. Y-axis translation stage (1 turn = 1 mm)
10. Column cradle

3 ASSEMBLING THE MICROSCOPE

Before manipulating the microscope, please carefully read the instructions in the brochure of manufacturer. The mains plug of the illumination transformer is adapted for the ACCESSORY connector of the CONTROL UNIT; this allows remote switching of the sample illumination from the front panel.

4 INITIAL POSITION ADJUSTMENT

In order to identify the scratching location precisely, the microscope must be adjusted to obtain good visual correspondance between the "work position" and the "observation position" (see Fig. 3 and 4).

1. With the table in the "work position" and handle (6) locked, make a trial scratch on a firmly fixed sample. Switch (7) must be in the "AUTO-RETURN" position.

2. Unlock (6) and bring the table in the "observation position". Lock handle (6).

   Caution: when samples of complicated geometry and large dimensions are being tested, it might be necessary to raise the microscope before translating the table and before changing from one objective to the other.

3. Using a magnification of 200 x (objective HD 16/0,35), focus on the surface of the sample. Adjust screw (5) so that the table is positioned under the microscope with the scratch in the centre of the observation field. Adjust the y-direction by means of the translation stage (2) (see Fig. 2) so that the scratch start is situated in the middle of the observation field. Firmly lock handle (8).

5 SAMPLE OBSERVATION

Sample translation is monitored by switch (7) (see Fig. 4).

Position 1: "MANUAL-FORWARD": the last scratch can be observed through the microscope at the speed used during scratching in the "work position".

Position 2: "STOP": translation of the sample stops.

Position 3: "AUTO-RETURN": the sample moves backward at high speed.

6 CRITICAL LOAD DETERMINATION BY OBSERVATION

In the initial scratching position, set the displacement indicator (3) to zero. By means of switch (7) translate the sample until the first coating damage appears and locate it in the middle of the observation field. Read the covered distance on the displacement indicator. Knowing the loading rate dL/dt (100 N/min as delivered) and the table translation speed dy/dt (10 mm/min as delivered), the load increase per unit length is easily calculated (10 N/mm as delivered). The critical load is therefore directly related to the displacement indicated by the instrument.

7 PART LIST

Nikon binocular Epimicroscope, including :

- 1 modular focusing unit
- 1 binocular eye piece tube
- 2 oculars CFW-10x
- 1 crossline reticle
- 1 epi-illuminator with field and aperture diaphragm
- 1 diffusing filter
- 1 halogen lamp socket
- 1 transformer XN 220 V or 110 V
- 2 halogen bulbs 6 V / 10 W
- 1 quintuple noze piece
- 1 objective MTJ 60801 - 20x
- 1 objective MTH 60050 - 5x

Mechanical device mounted on the CSEM-REVETEST SCRATCHING MACHINE :

- 1 translation stage
- 1 special screw nut for lamp socket

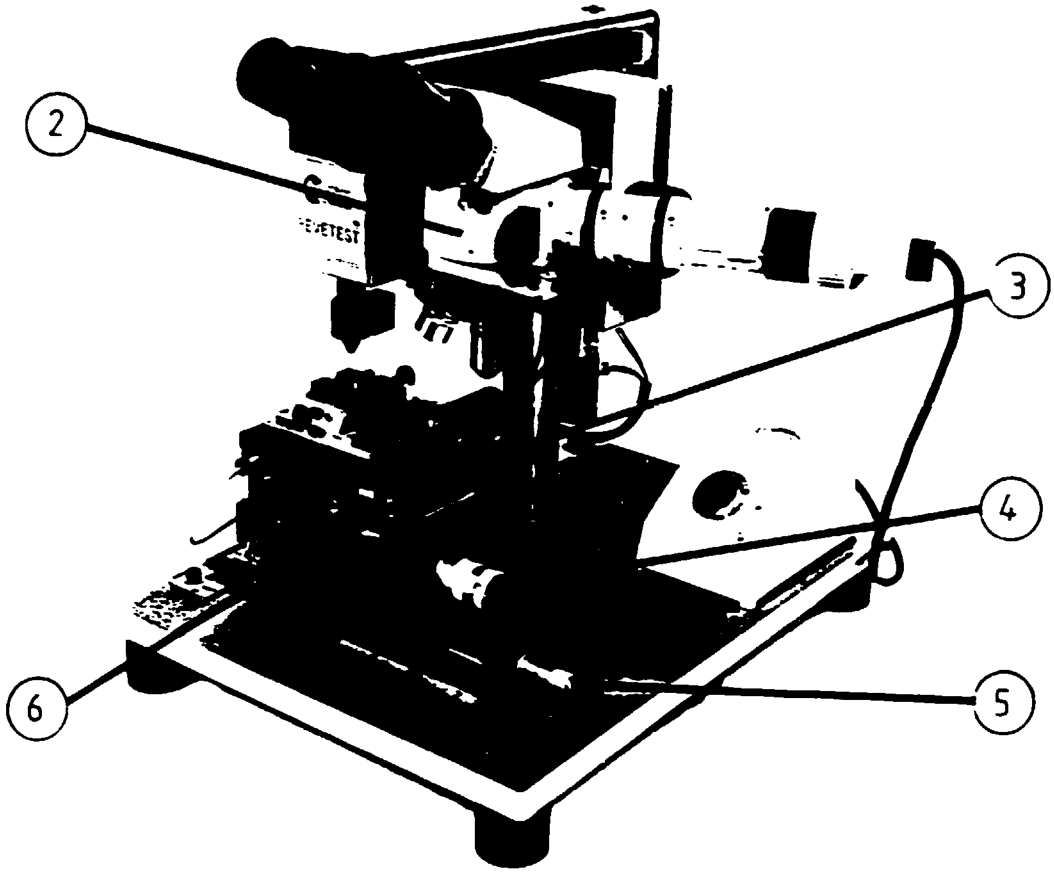


Fig. 1: General view

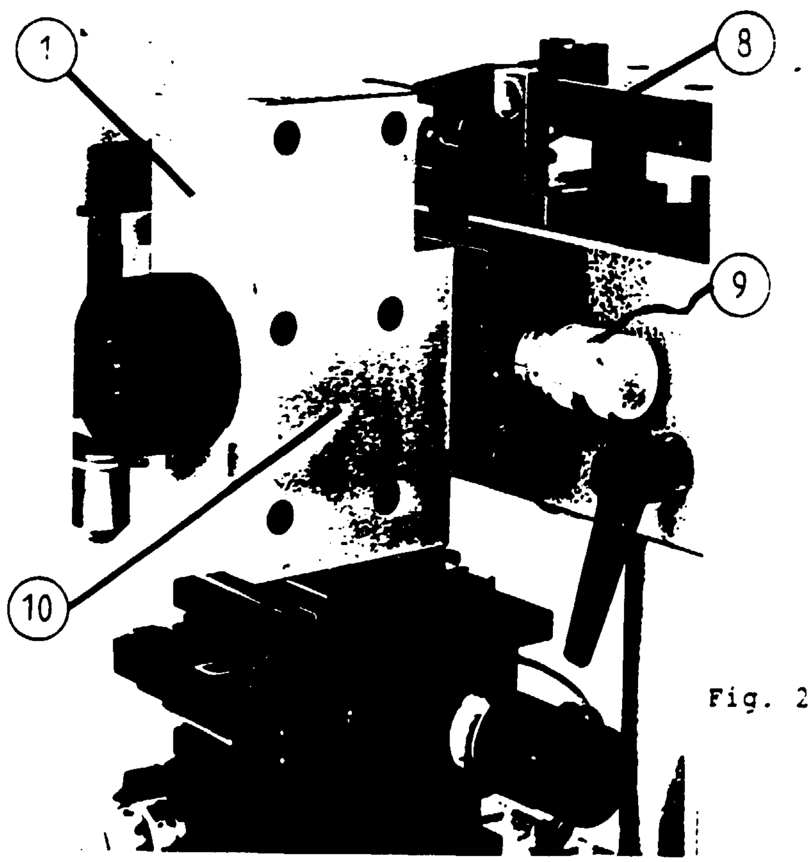


Fig. 2: Assembling of the microscope, adjustment

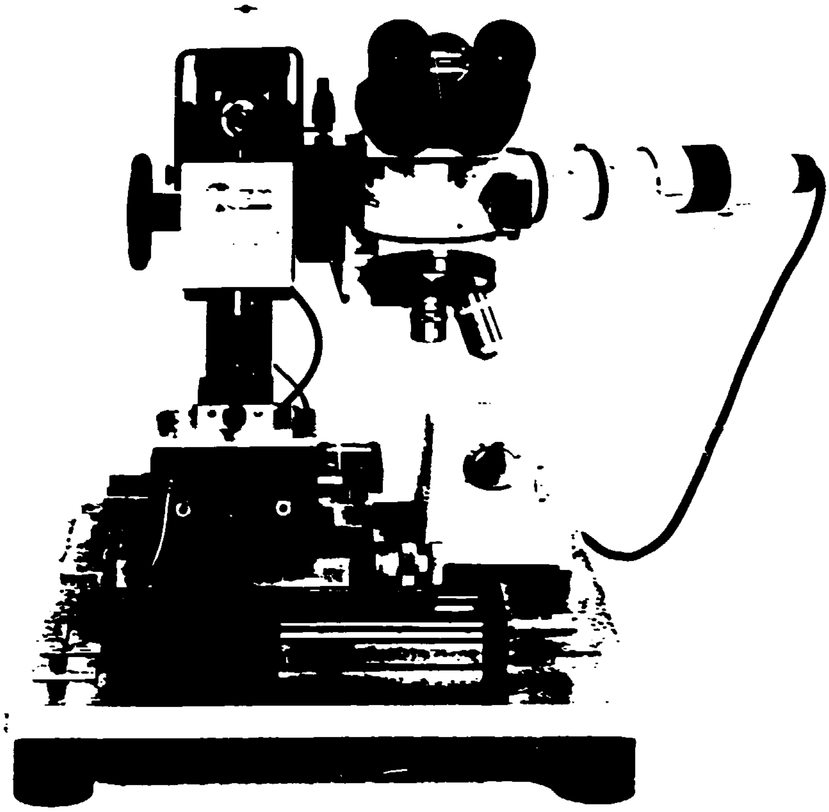


Fig. 3: Sample support table in "work position"

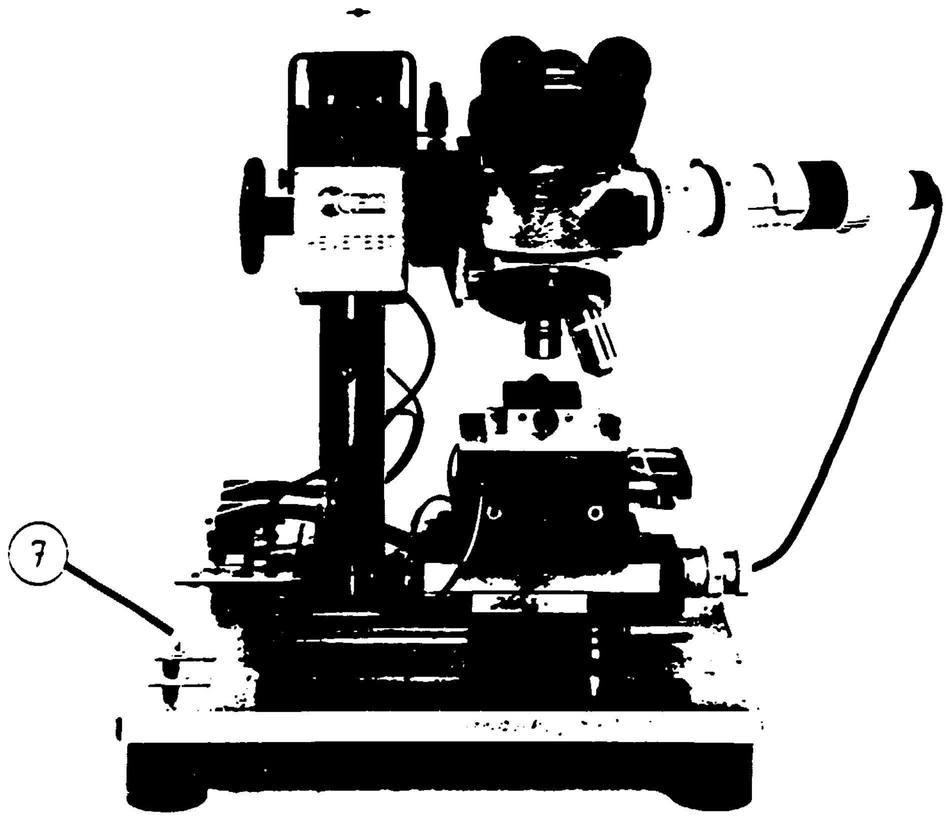


Fig.4: Sample support table in "observation position"

APPENDIX ....

CSEM - REVETEST ®

Device for Friction Parameter Determination

DIRECTIONS FOR USE

CSEM, Rue Breguet 2, CH - 2007 NEUCHATEL (Switzerland)
TEL +41 38 24 01 61 TELEX 952 655 CSEM TELEFAX +41 38 25 40 78

TABLE OF CONTENTS

1 INTRODUCTION

This accessory can be adapted on the CSEM-REVETEST SCRATCH-TESTER without any modification. It enables measurement of the tangential force Ft and of the scratching coefficient μ^* during the test, as shown in figure 1.

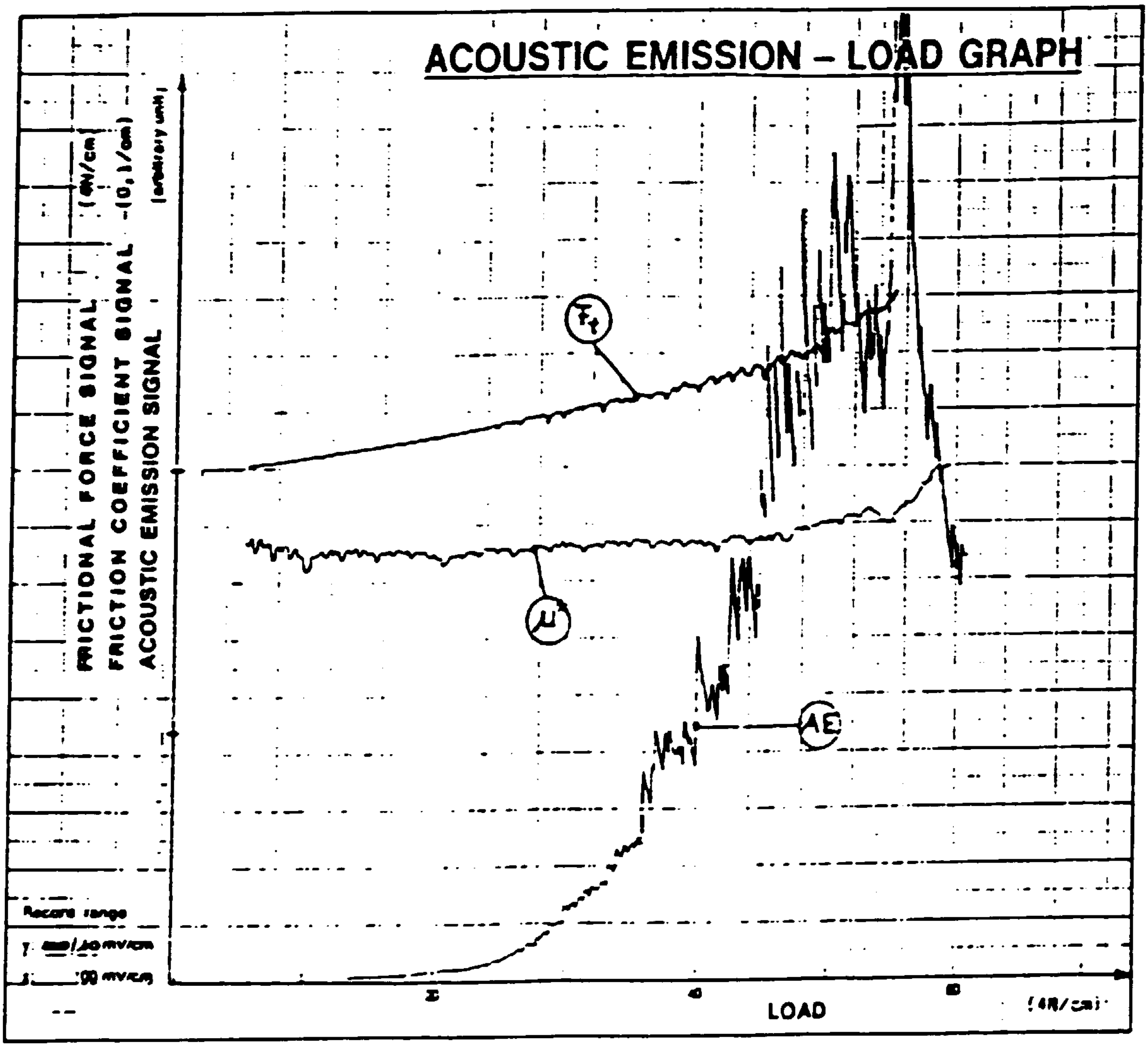


Fig. 1 : Example of measurement recordings.
Showing simultaneous recording of the acoustic emission signal (AE) and the tangential force (Ft) and scratching coefficient (μ^*) signals.

Specimen: TiN (PVD) coating on stainless steel substrate.

2 DESCRIPTION

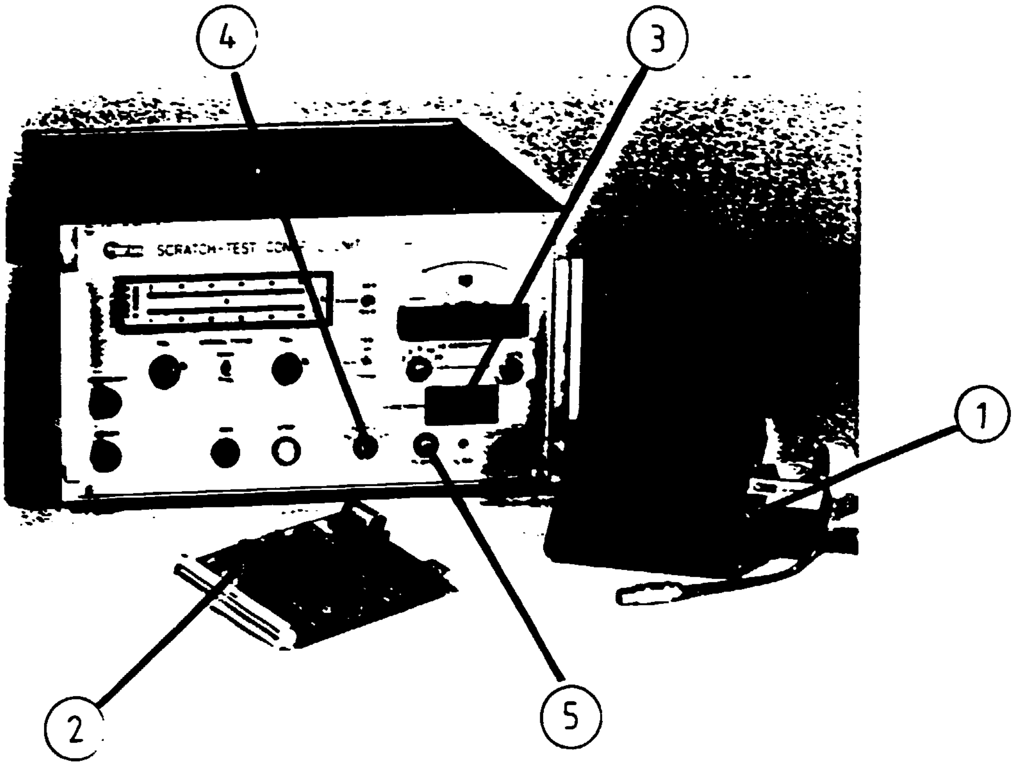


Fig. 2: Device elements

The accessory is composed of: (Fig. 2)

- A measurement table combined with a work base supporting the sample holder (1).
- A friction measurement board (2) to connect into the SCRATCH-TEST CONTROL UNIT, as explained below. This board, (see illustration on page 11) has already been calibrated at CSEM and does not need any subsequent adjustement.

Tangential force Ft or scratching coefficient μ^* can be displayed on the CONTROL UNIT (3) after its selection with the FUNCTION selector (4).

Signals can also be recorded on a convenient chart recorder.

3 INSTALLATION

3.1 Measurement Table (Fig. 3)

Remove the original work table by unscrewing the four M4 screws which fix it to the slide table.

Make sure the elastic base plate of the measurement table and its small gaps are clean (Fig. 4). If there is not enough clearance between the slide table and the elastic base plate, 4 washers can be used as spacers.

Position the measurement table on the slide table by means of 2 pins and fix it with the four M4 screws (Fig. 4).

Important: Never unscrew the work table fixed to the elastic base plate by the other four M4 screws: this could deteriorate the sensitivity of the tangential force measurement.

Connect the transducer to the connector board of the REVETEST.

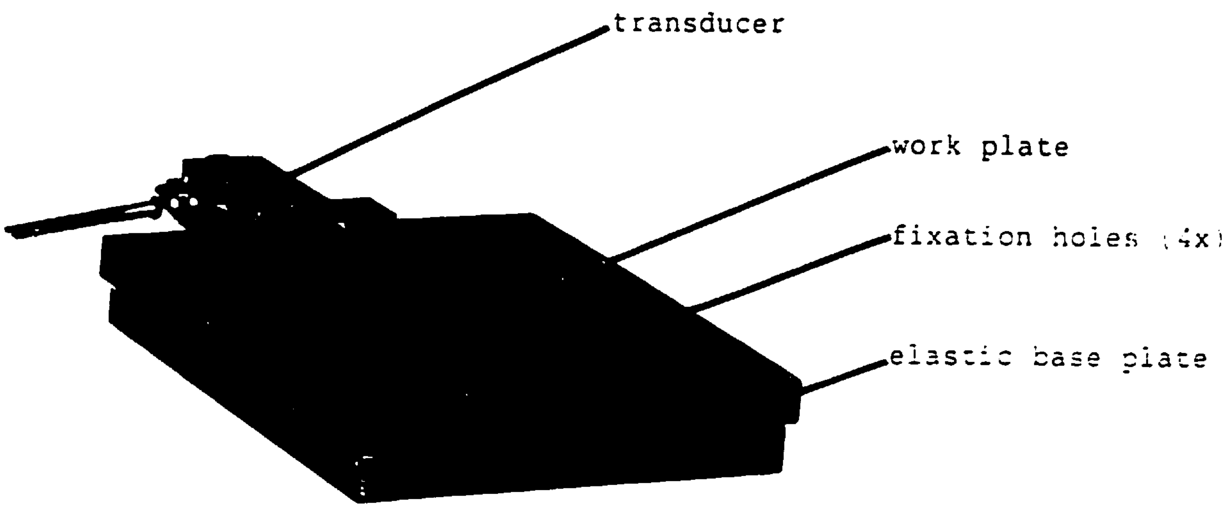


Fig. 3: Measurement table.

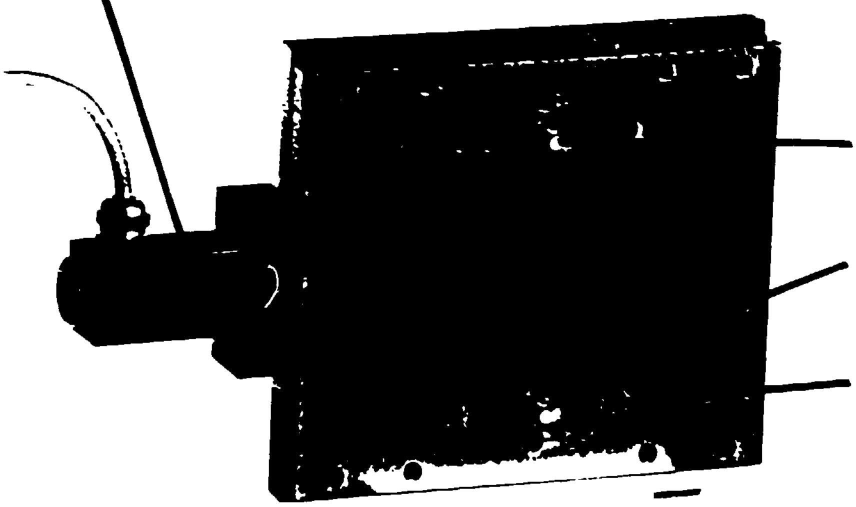


Fig. 4: Elastic base plate and transducer.

3.2 Friction Measurement Board

This electronic board (marked ③) needs to be introduced into the SCRATCH-TEST CONTROL UNIT at the position 3 reserved for it.

Proceed as follows:

- POWER off: disconnect all the cables from the rear panel, except the AE cable.
- By means of the 4 screws, remove the black upper plate from the CONTROL UNIT.
- Also remove the CONTROL UNIT rear panel as shown on Fig. 3.
- Disconnect the 9 pole power connector (1) and the green yellow ground wire (2). From the board marked ②, disconnect the 9 pole grey connector (3).
- Now lean the rear panel against the right-hand side (4) of the CONTROL UNIT.

- Slide the friction measurement board into the rail marked (3) as shown by the arrow on Fig. 5 (rail number 4 is reserved for further options).

- Connect the little wire from PCB 3 to the socket marked "SYNC" on PCB 2 (see location on PCB 2 drawing). This is to synchronize the transducer oscillators.

- Connect the 3 pole blue socket (5), and the 9 pole grey connector (6), marked (3), to the friction measurement board 3 .

- Reconnect the 9 pole grey connector (3), the ground wire (2) and the power connector (1). Rescrew the rear panel and upper plate on the unit.

- Reconnect all the cables on the rear panel. The equipment is ready after a warming period of about 2.5 hours.

- Sensors supply adjustment (with a true RMS* voltmeter only):

  - on PCB 2 , between test points TP1 and TP2, adjust the FN sensor voltage supply to 10,000 ±0,005 VRMS with potentiometer R2.

  - on PCB 3 , between test points TP0 and TP6, adjust the FT sensor voltage supply to 2,500 ±0,002 VRMS with potentiometer R4.

  - check those two last settings once more at least (and correct if needed).

* 4½ digital voltmeter, 5 kHz minimum frequency range.

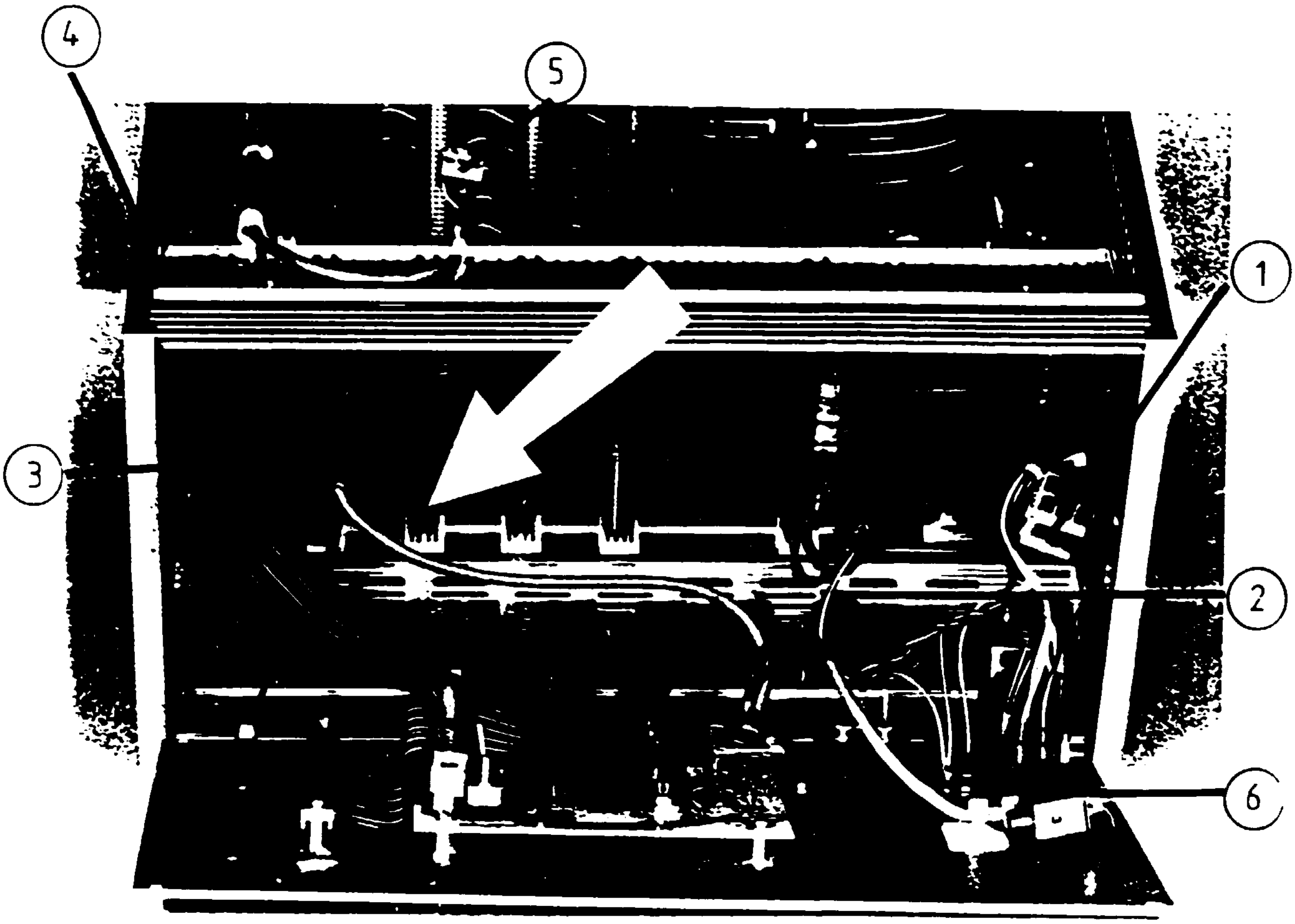


Fig. 5: Friction measurement board location.

4 MEASUREMENT

Proceed in the same way as for a normal test. If needed, connect the Ft and ω^* outputs to a convenient chart recorder.

After a warming periode of about 2.5 hours, set the Ft Offset to zero (see Fig. 2):

> With FUNCTION selector (4) Ft, set display (3) to 00.0 by means of the Ft Offset trimmer (5).

The device is now ready for scratching !

5 MAIN CHARACTERISTICS

Measurement table:

Maximum tangential force	:	200 N
Resolution	:	0.1 N
Linearity error and hysteresis	:	< 1 %
Resonance frequency	:	~ 220 Hz
Stiffness	:	0.5 μm/N

Control unit:

- Display:
  - Tangential force Ft in N : resolution 0.1 N
  - Normal force Fn in N : resolution 0.1 N
  - Scratching coefficient μ*: : resolution 0.01 N
- Output signals:
  - Tangential force Ft : 25 mV/N
  - Normal force Fn : 25 mV/N
  - Scratching coefficient μ*: : 1 V -> μ* = 1
  - Minimum μ* calculation : Fn > 7 N

CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE S.A.
– Recherche et Développement –

CSEM MALADIERE 71 CH-2007 NEUCHATEL (SWITZERLAND)
TEL. 038/24 01 61 TELEX 952 664 (CSEM) TELEFAX 038/25 40 78

CSEM REVETEST
DEVICE FOR THE FRICTION PARAMETER DETERMINATION

CALIBRATION

Control unit, type __AMI__ , No _16-297_

PCB friction, No ____170_

Measurement table, No ____174_

Destination, ___UNIDO____

Force calibration N	Display Ft N
10	10,0
25	25,0
50	50,0
75	74,9
100	99,9
150	150
195	

Linearity: _0,3%____

Hysteresis: _0,3%____

MAL/11.11.87

Date: _8.7.91____ Visa: ______
G. Besson

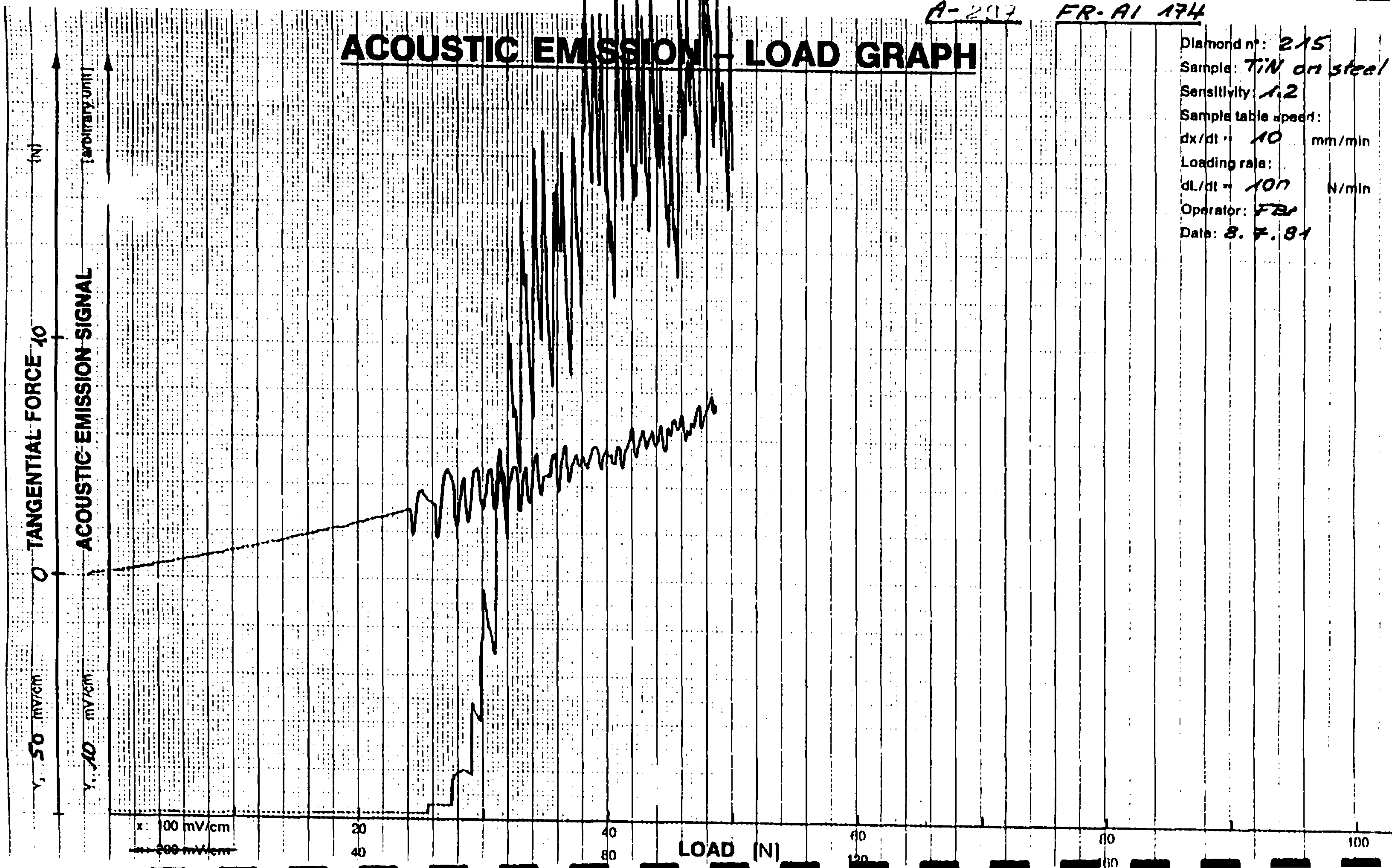
CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE S.A.
DIV. MATERIAUX ET MICROMECANIQUE CH-2007 NEUCHATEL, SUISSE

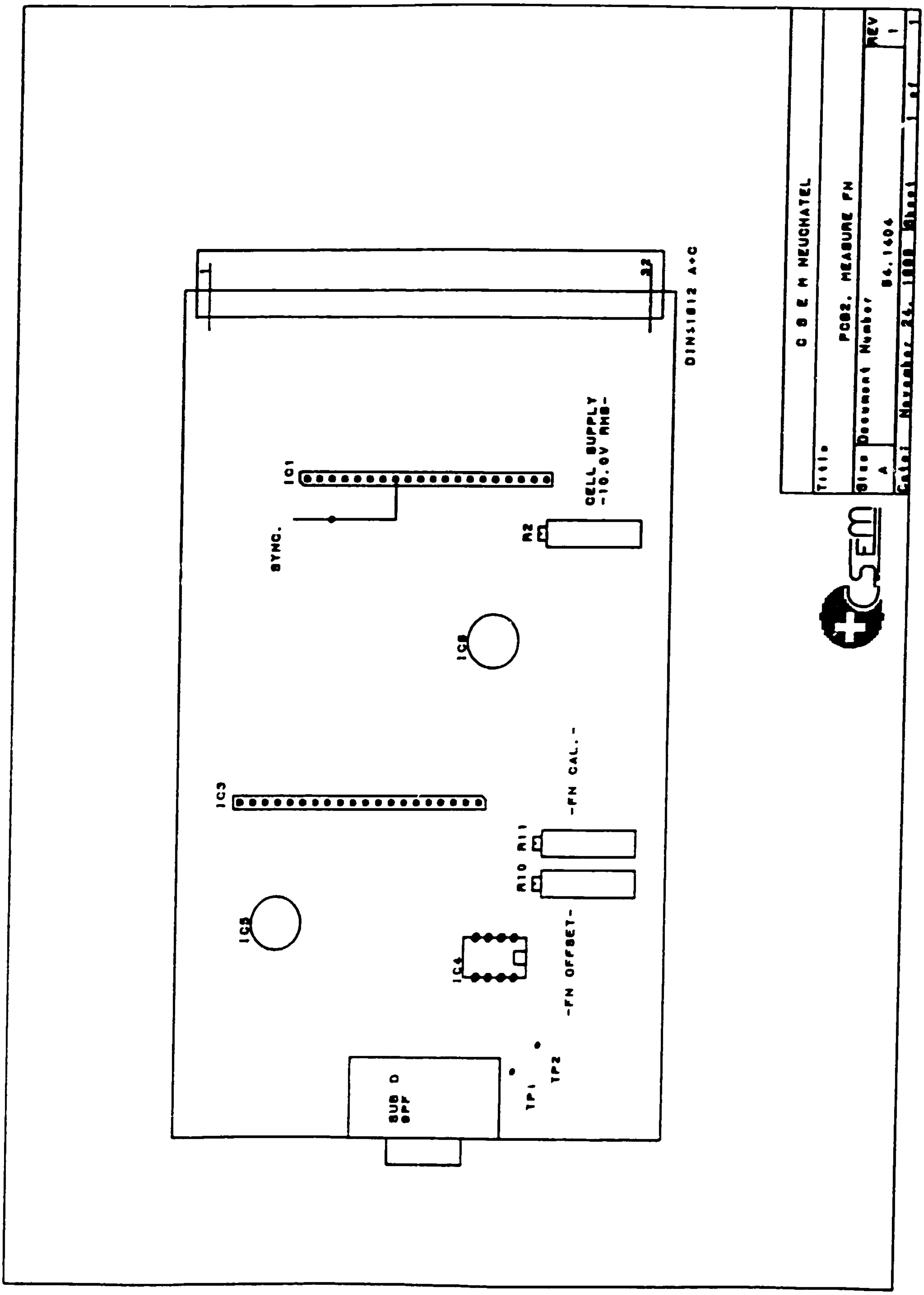
REVETEST®/AUTOMATIC SCRATCH TESTE

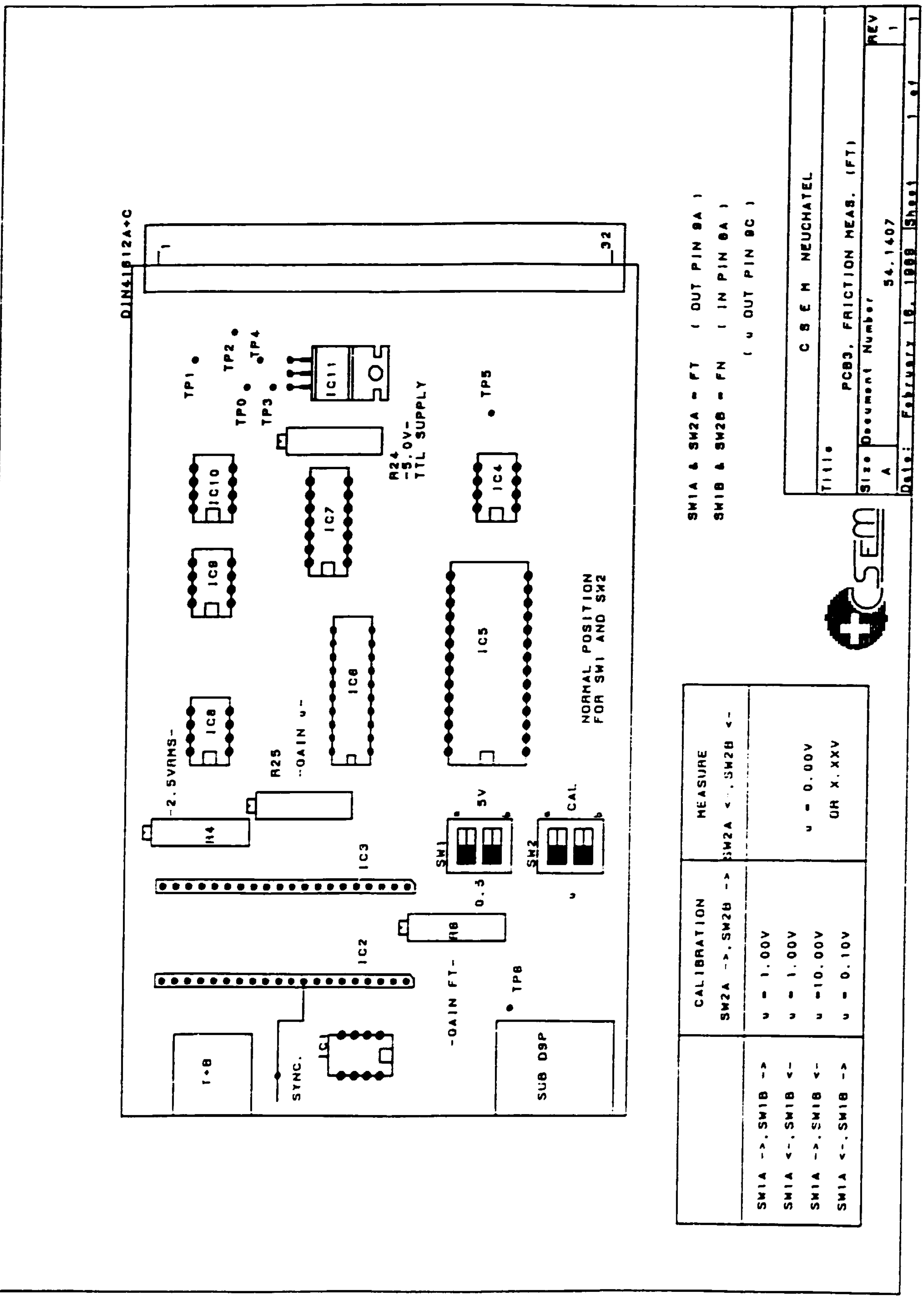
A-207 FR-AI 174

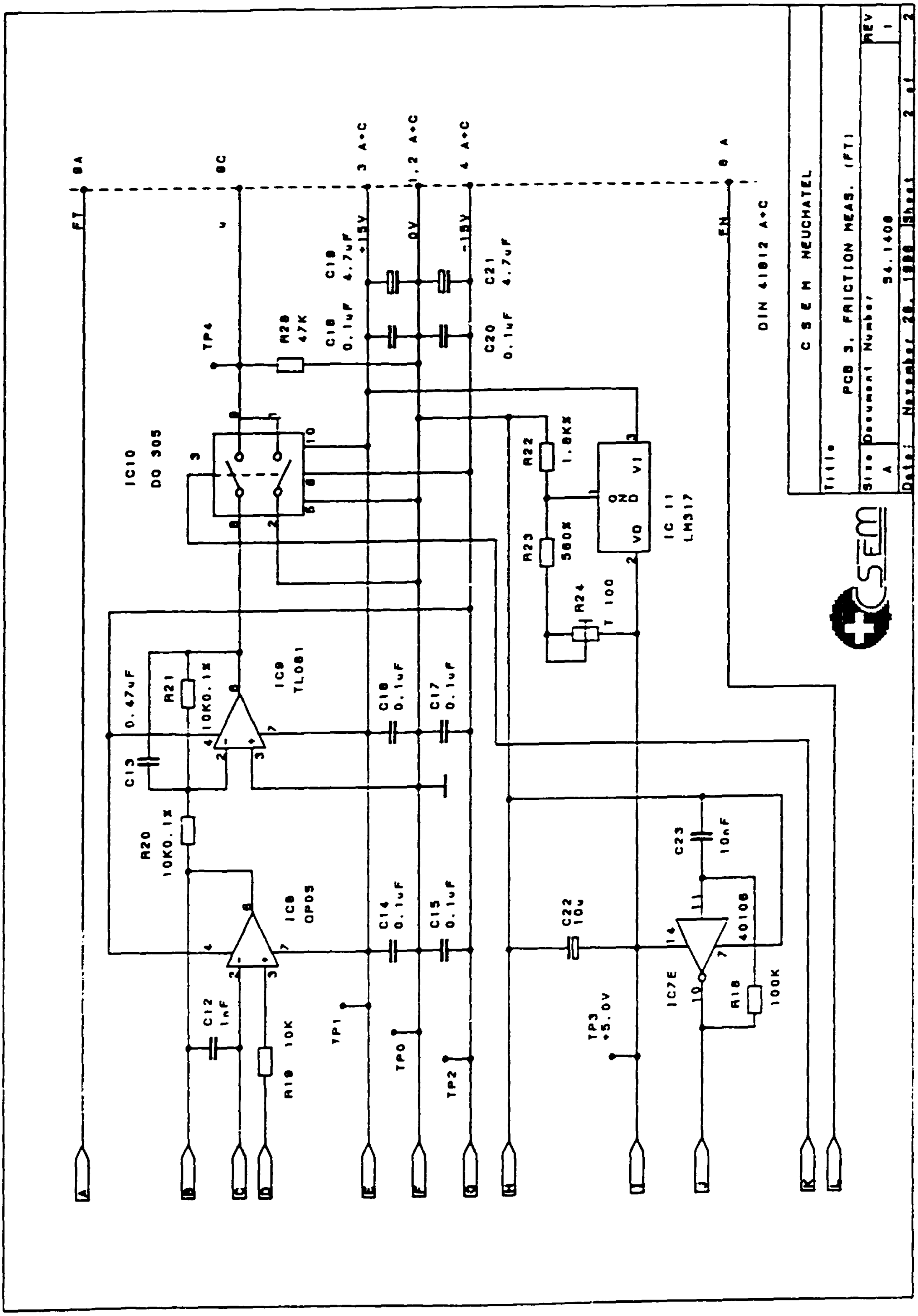
ACOUSTIC EMISSION – LOAD GRAPH

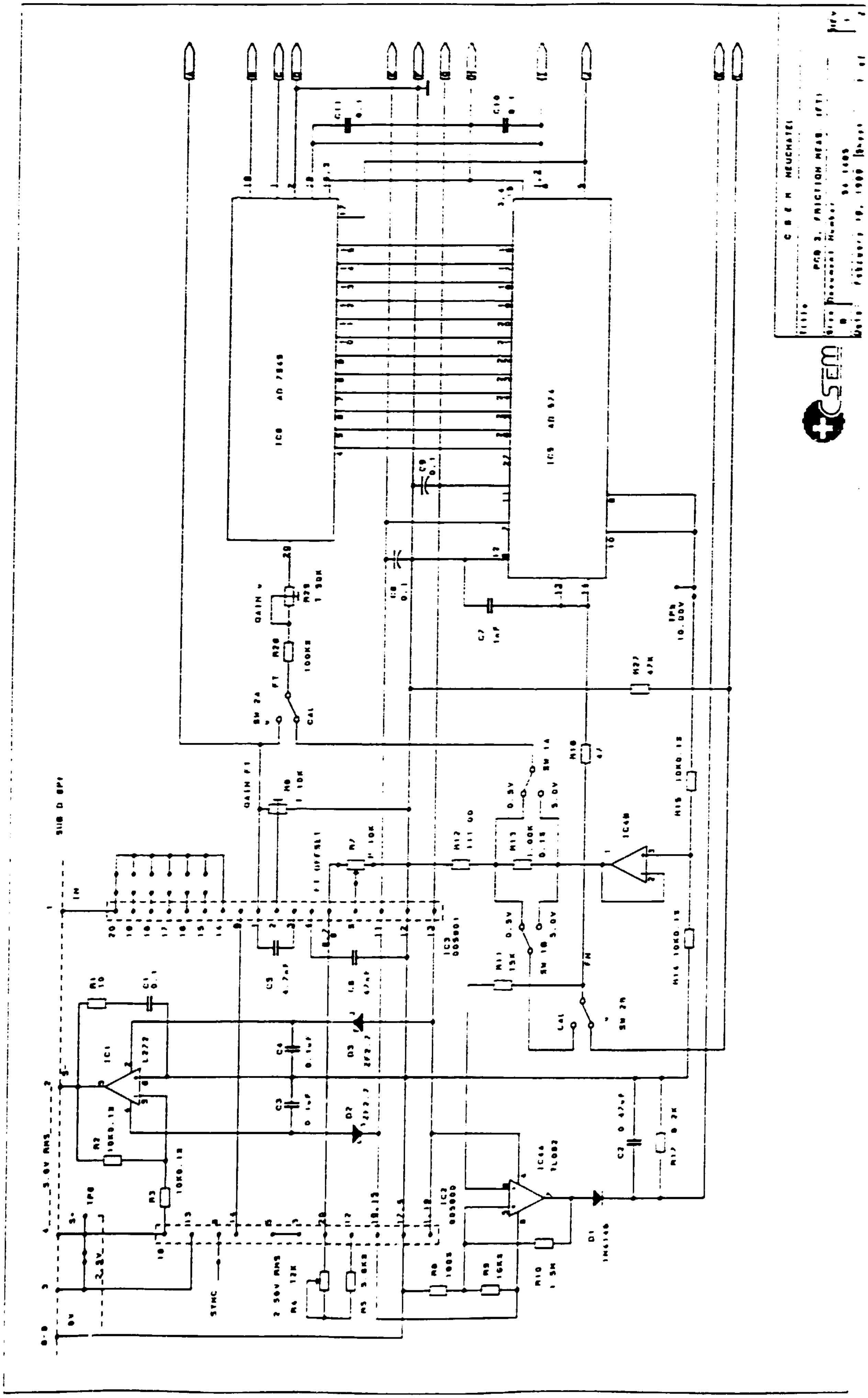
Diamond nº: 215
Sample: TiN on steel
Sensitivity: 1.2
Sample table speed:
dx/dt = 10 mm/min
Loading rate:
dL/dt = 100 N/min
Operator: FBr
Date: 8. 7. 81




C S E M NEUCHATEL
Title
PCB2, MEASURE FN
Size
A
Document Number
84.1404
REV
1
Date: November 24, 1988 Sheet 1 of 1
DINS1612 A+C
1
32
CELL SUPPLY
-10.0V RMS-
IC1
SYNC.
R2
IC8
IC3
-FN CAL.-
R11
R10
IC5
IC4
-FN OFFSET-
SUB D
9FF
TP1
TP2


C S E M NEUCHATEL
Title
PCB3, FRICTION MEAS. (FT)
Size A
Document Number
54.1407
REV 1
Date: February 16, 1989 Sheet 1 of 1
SW1A & SW2A = FT (OUT PIN 8A)
SW1B & SW2B = FN (IN PIN 6A)
(u OUT PIN 8C)
DIN41612A+C
NORMAL POSITION FOR SW1 AND SW2
R24 -5.0V- TTL SUPPLY
-2.5VRMS-
R25 -GAIN u-
-GAIN FT-
SYNC.
SUB D9P
CALIBRATION
SW2A ->, SW2B ->
MEASURE
SW2A <-, SW2B <-
SW1A ->, SW1B -> u = 1.00V
SW1A <-, SW1B <- u = 1.00V
SW1A ->, SW1B <- u =10.00V
SW1A <-, SW1B -> u = 0.10V
u = 0.00V
OR X.XXV


C S E M NEUCHATEL
PCB 3. FRICTION MEAS. (FT)
DIN 41612 A+C
IC9 TL081
IC8 OP05
IC11 LM317
IC7E 40106



MST - CSEMEX®
Micro-Scratch-Tester

REVETEST® and MST-CSEMEX®

The Micro-Scratch-Tester uses the same basic scratching principle as the REVETEST®.

The main differences are:

- lower range of loads

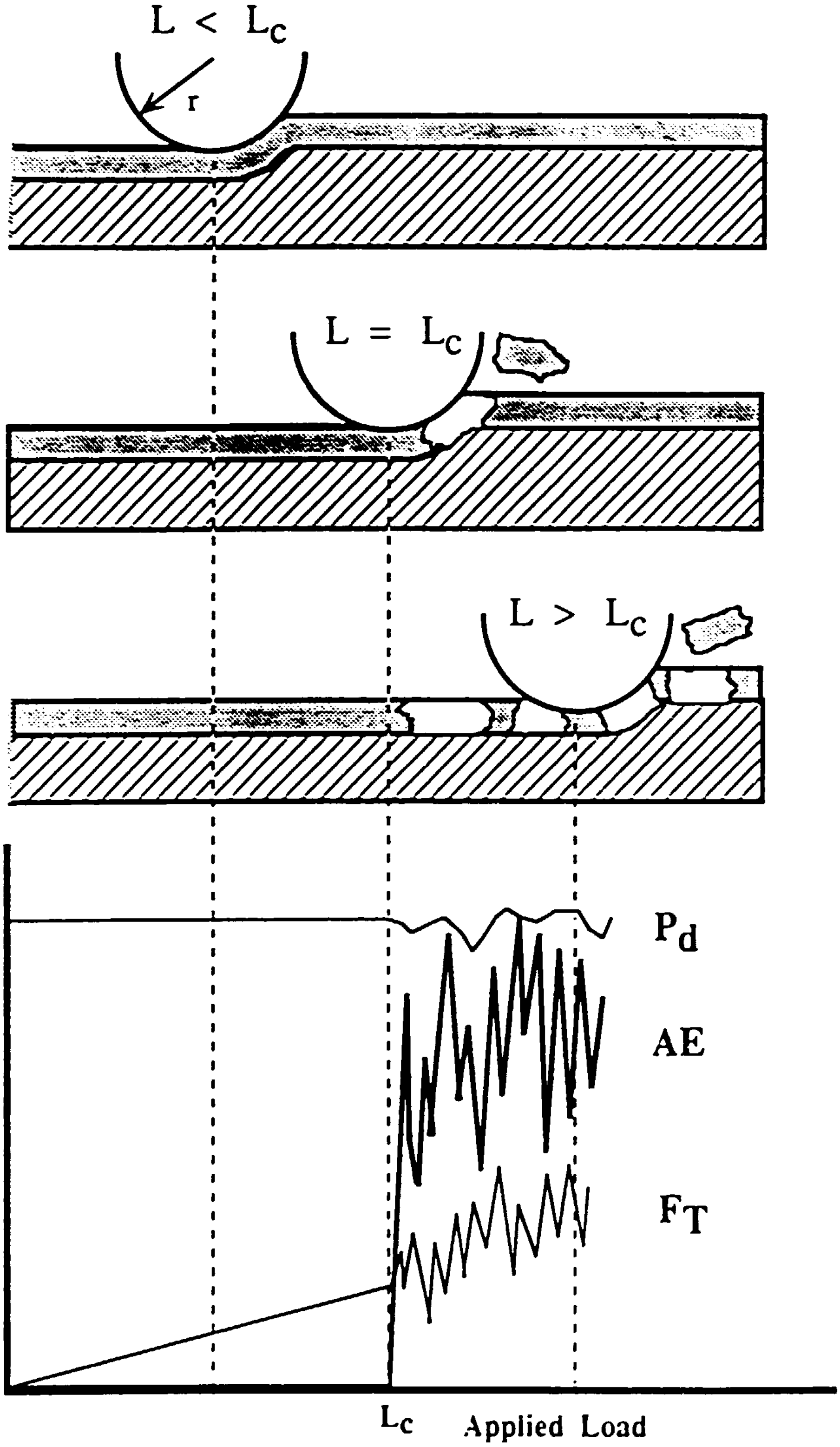
REVETEST	1	to	200	N
MST	0.01	to	30	N

- significantly increased accuracy

REVETEST	1 N
MST	< 1 % of the full scale (10 or 30 N) depending on the surface finish

- MST and its Control Unit are entirely PC-controlled:
  - easy to use since it is entirely menu-driven
  - immediate display of all test parameters and graphical results
  - recording of all scratch measurements results in a mass memory

PRINCIPLE

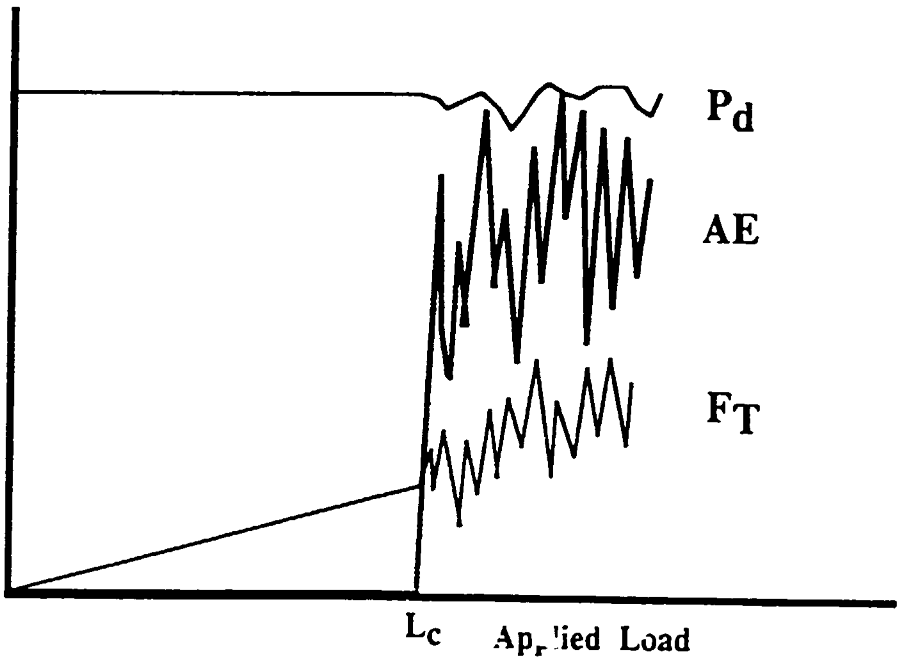


MST-CSEMEX®
Micro-Scratch-Tester

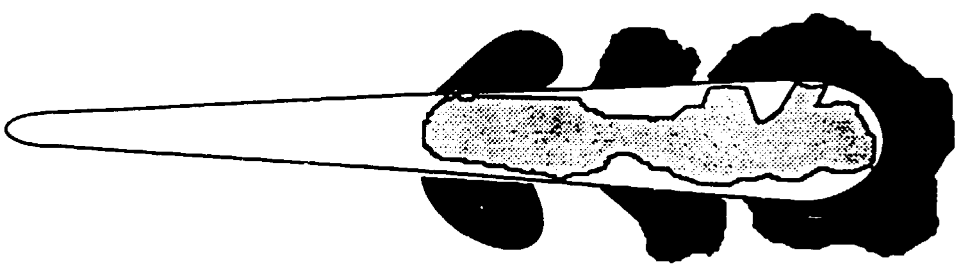
INVESTIGATION METHODS

The Micro-Scratch-Tester provides four different means of analyzing the scratch:

- 3 methods ON-LINE: P_d, F_T AND AE

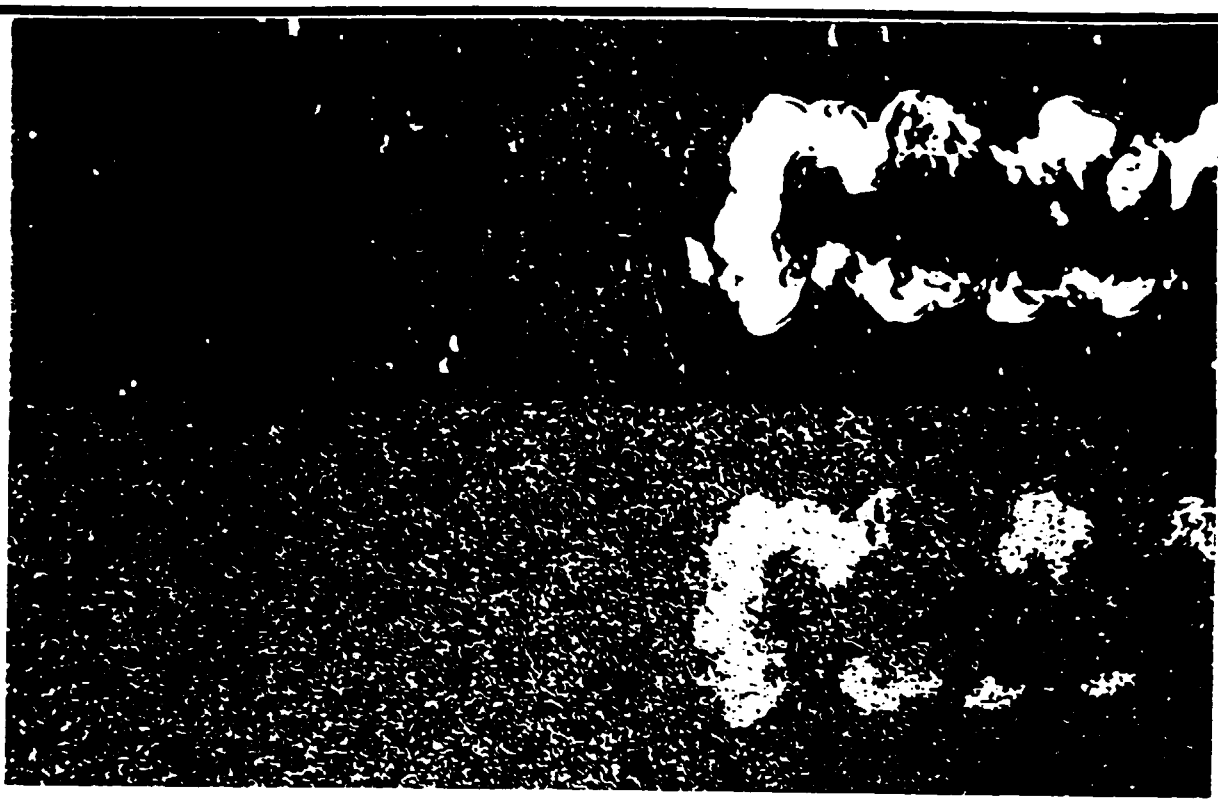


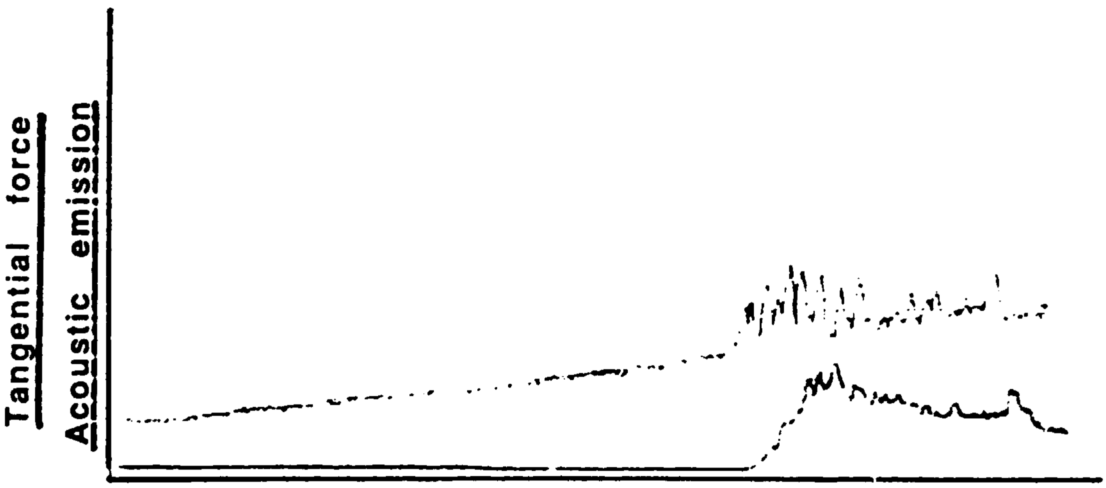
- and thereafter optical observation through a microscope.



CSEM

MST-CSEMEX®
Micro-Scratch-Tester

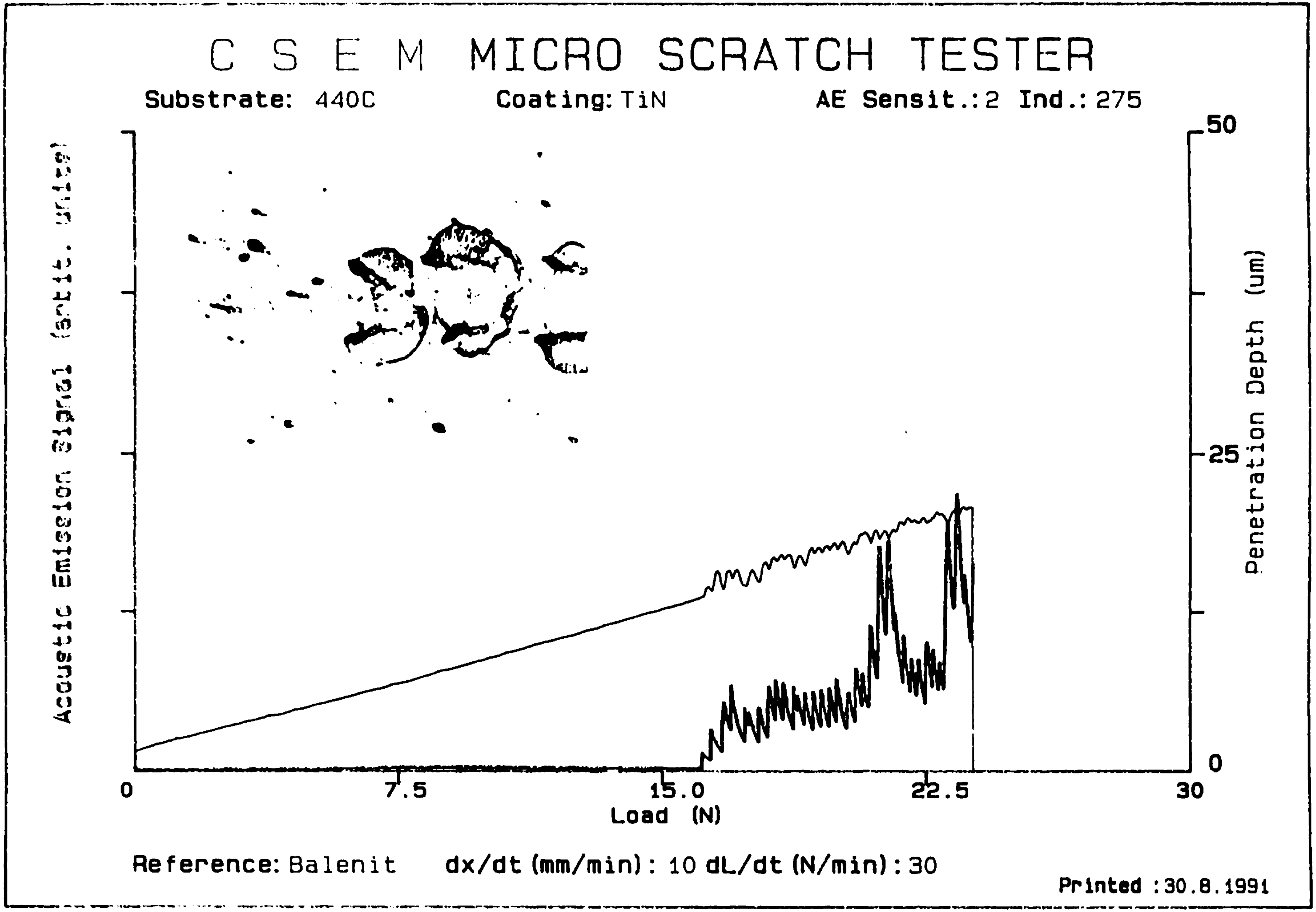


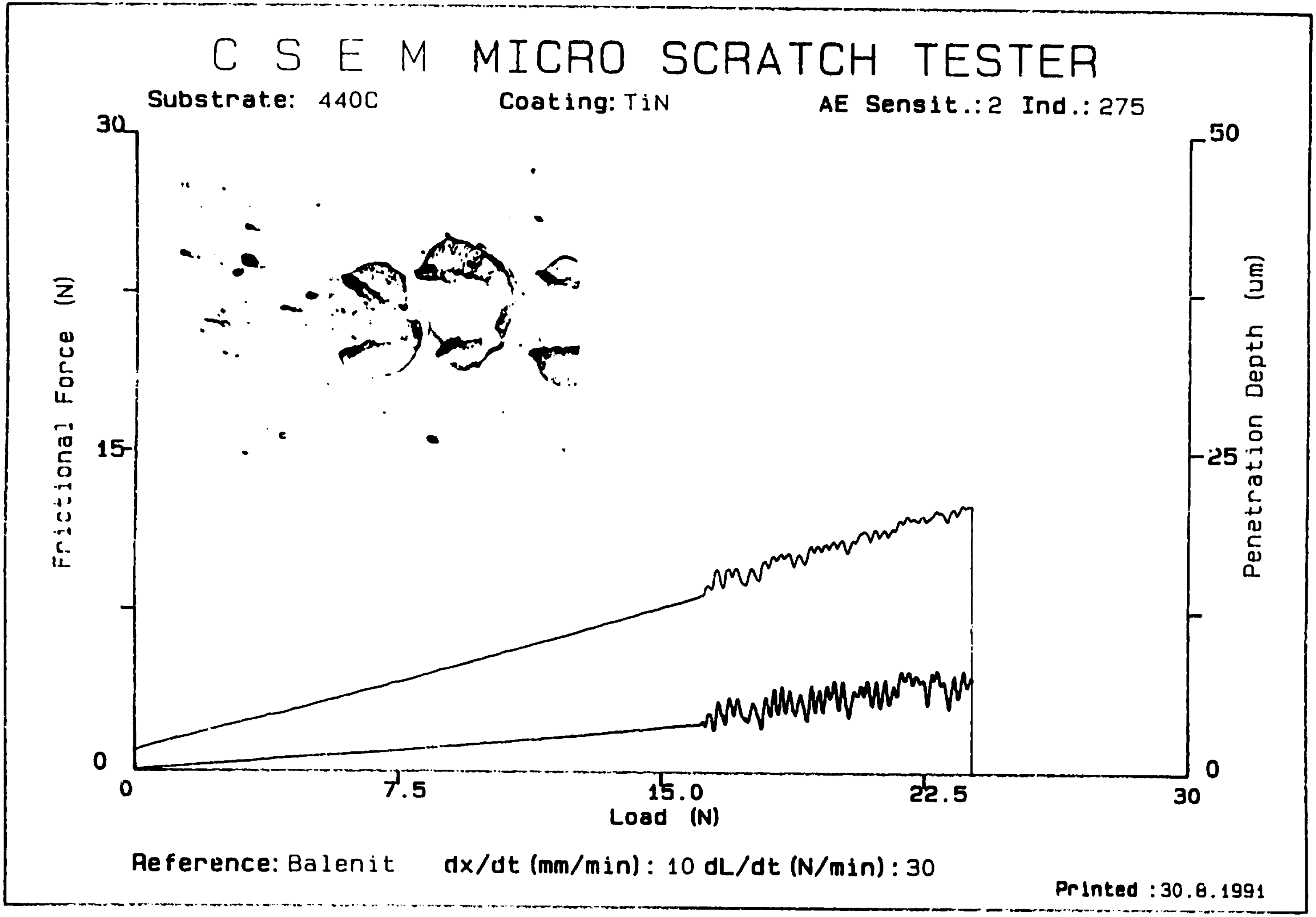


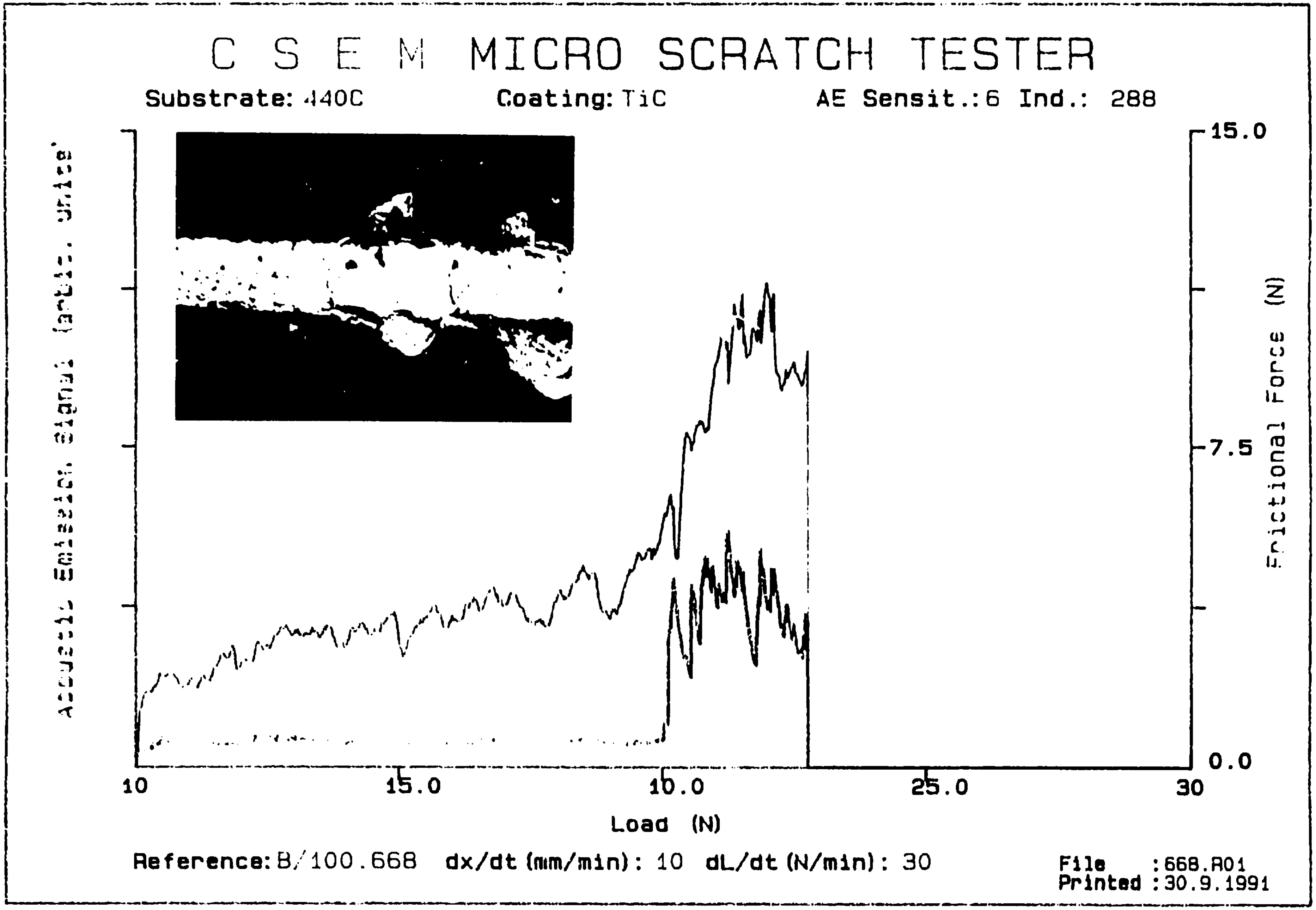
CSEM

4279

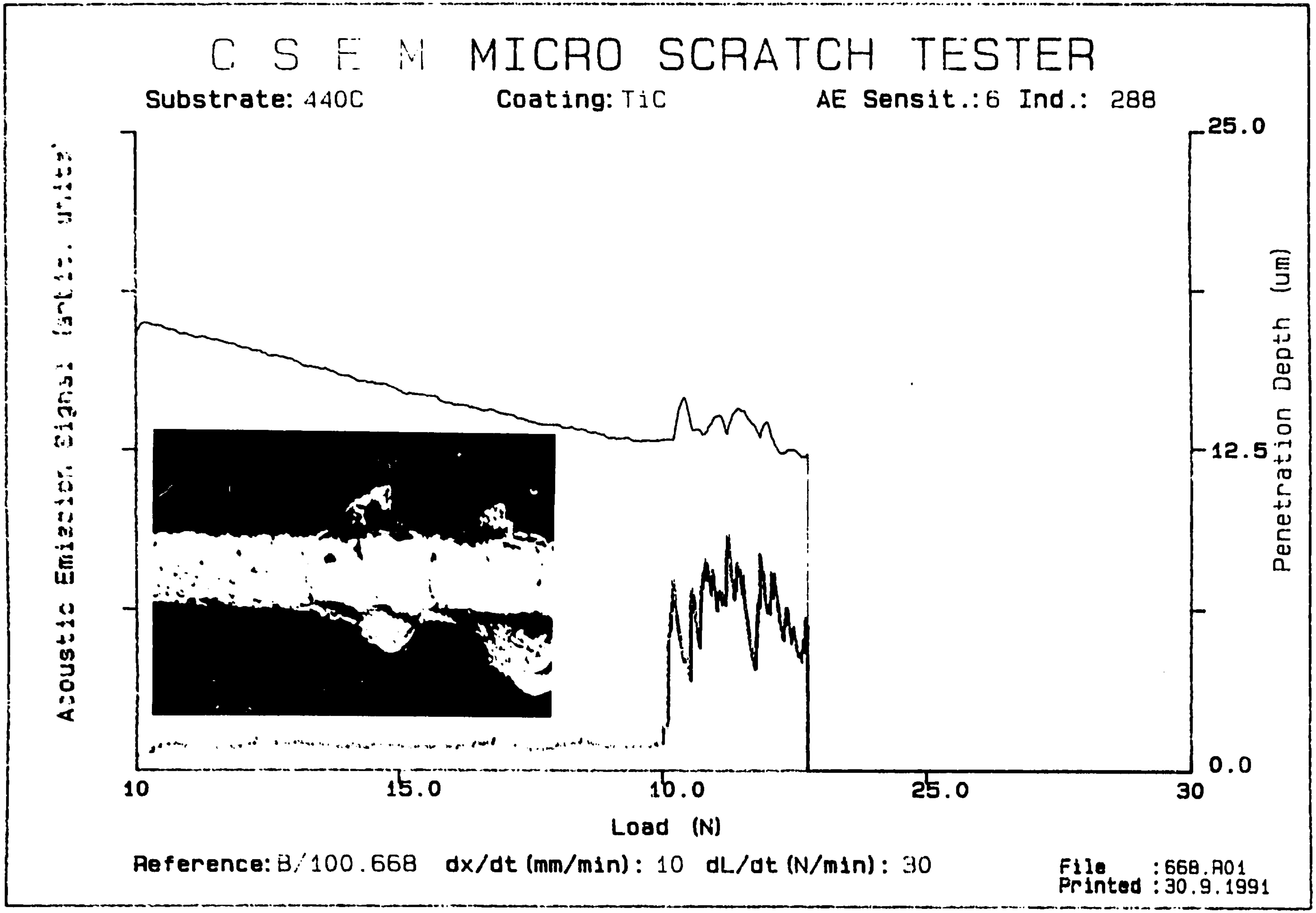
Critical load determination


C S E M MICRO SCRATCH TESTER
Substrate: 440C
Coating: TiN
AE Sensit.: 2 Ind.: 275
Acoustic Emission Signal (arbit. units)
Penetration Depth (um)
50
25
0
7.5
15.0
22.5
30
Load (N)
Reference: Balenit
dx/dt (mm/min): 10 dL/dt (N/min): 30
Printed: 30.8.1991


C S E M MICRO SCRATCH TESTER
Substrate: 440C
Coating: TiN
AE Sensit.: 2 Ind.: 275
Frictional Force (N)
Penetration Depth (um)
30
15
0
50
25
0
0
7.5
15.0
22.5
30
Load (N)
Reference: Balenit
dx/dt (mm/min): 10 dL/dt (N/min): 30
Printed : 30.8.1991



C S E M MICRO SCRATCH TESTER
Substrate: 440C
Coating: TiC
AE Sensit.: 6 Ind.: 288
15.0
7.5
0.0
10
15.0
20.0
25.0
30
Load (N)
Acoustic Emission Signal (arbitr. units)
Frictional Force (N)
Reference: B/100.668 dx/dt (mm/min): 10 dL/dt (N/min): 30
File : 668.R01
Printed : 30.9.1991



C S E M MICRO SCRATCH TESTER
Substrate: 440C
Coating: TiC
AE Sensit.: 6 Ind.: 288
25.0
12.5
0.0
Penetration Depth (um)
10
15.0
10.0
25.0
30
Load (N)
Reference: B/100.668 dx/dt (mm/min): 10 dL/dt (N/min): 30
File : 668.R01
Printed : 30.9.1991

SOME TECHNICAL SPECIFICATIONS

MECHANICAL DATA

Dimensions of work table	105 x 135 mm
Max. scratch length (X-axis)	20 mm
Max. perpendicular displacement (Y-axis)	25 mm
Max. Z-displacement (Z-axis)	125 mm
Max. course of the indentor	2.5 mm

ELECTROMECHANICAL DATA

	Display Full scale	Display res. (1 digit)	Electronic res. (1 bit)	Dynamic resolution during scratching
Normal load	10 N 30 N	± 0.001N ± 0.01 N	± 0.005 N ± 0.015 N	< 0.1 N < 0.3 N < 1% of full scale (*)
Frictional force	10 N 30 N	± 0.001N ± 0.01 N	± 0.005 N ± 0.015 N	< 0.1 N < 0.3 N < 1% of full scale (*)
Penetration depth	50 um	± 0.01 um	± 0.025 um	

(*) depending on the surface finish

ELECTRONIC CONTROL UNIT includes:

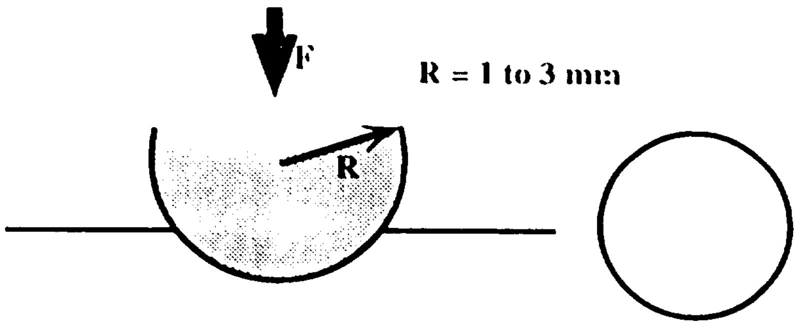
- Sensor interfaces and actuator controller
- Preamplifier for AE signal
- High-performance motor controller
- LED-dot meter for AE signal
- Digital voltmeter switchable to sensor signals
- External output of all sensor signals

UMD - CSEM
Nano indentation System

COMMON HARDNESS INDENTORS

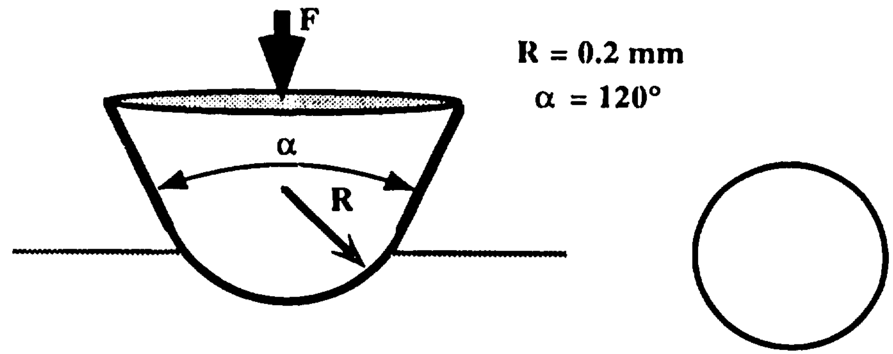
BRINELL

R = 1 to 3 mm



ROCKWELL

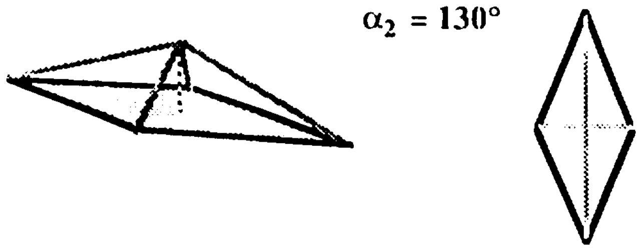
R = 0.2 mm
α = 120°



KNOOP

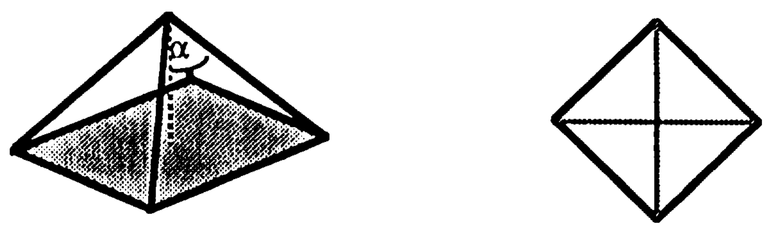
α_1 = 172° 30'

α_2 = 130°



VICKERS

α = 68°



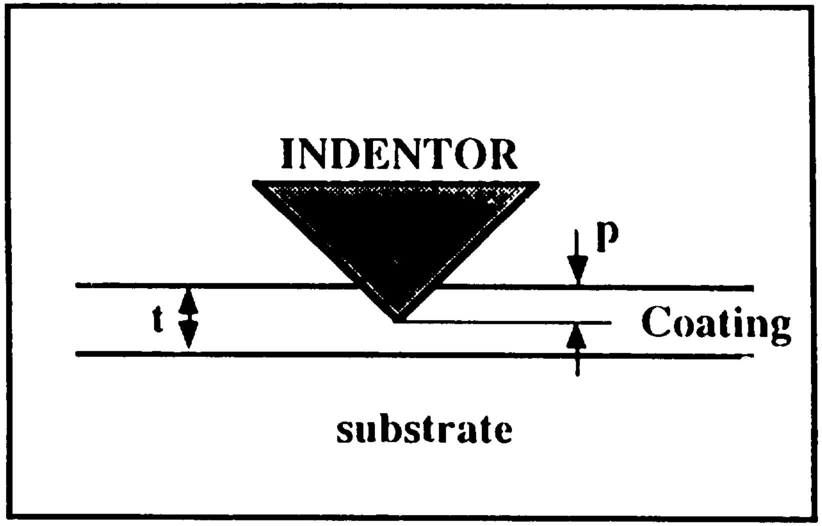
INSTRUMENTATION
optical microscope
load range, i.e. 0.05 to 5 N
sensitivity of the ocular micrometers
etc

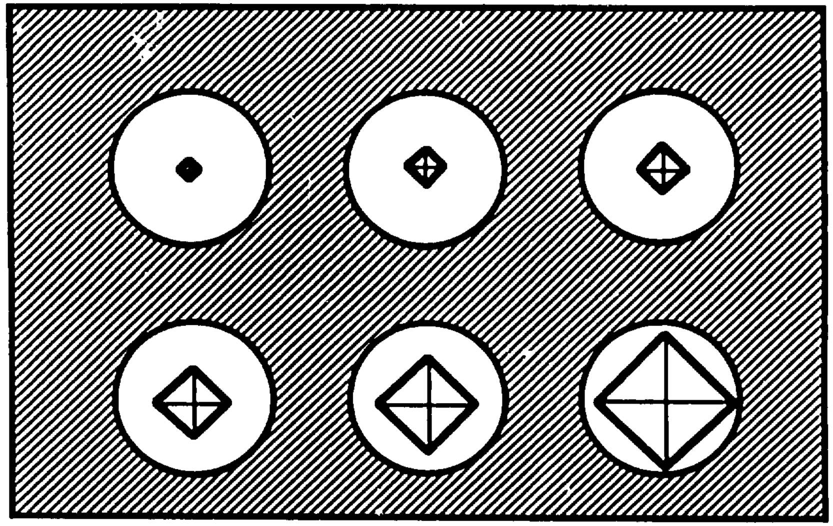
OPERATOR
physiological factors related to the eyes
physical status
experience
etc

LIMITS OF CONVENTIONAL MICROHARDNESS TESTING

COATING THICKNESSES
without influence of the substrate

COMPOSITE MATERIALS
hardness reading on individual phases
without influence of the other phase.





To measure the hardness of a thin coating, without being influenced by the substrate, it is important to respect the ratio (t/p) , penetration depth against coating thickness :

- for a hard coating on softer substrate, $(t/p) \leq 10$
- for a soft coating on harder substrate, $(t/p) \leq 4$

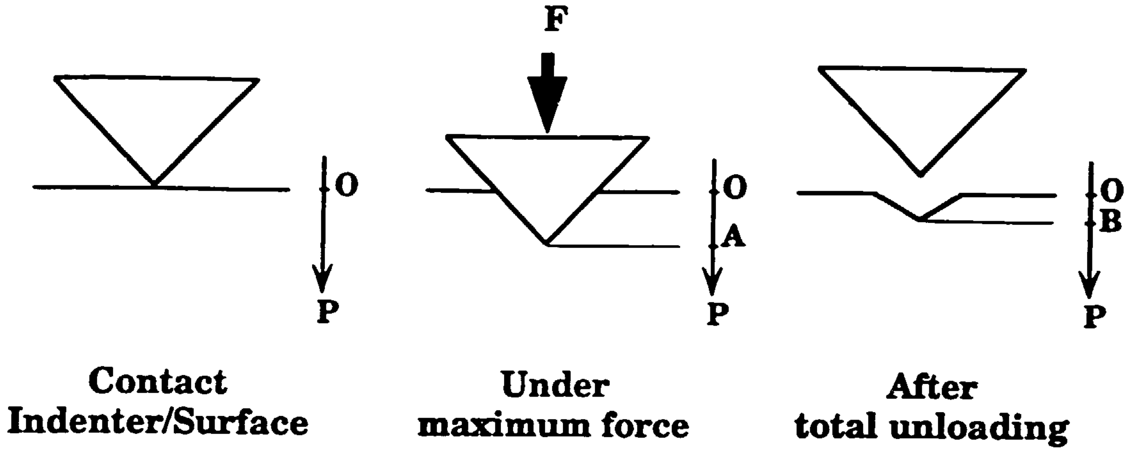
Examination of a composite A/B:

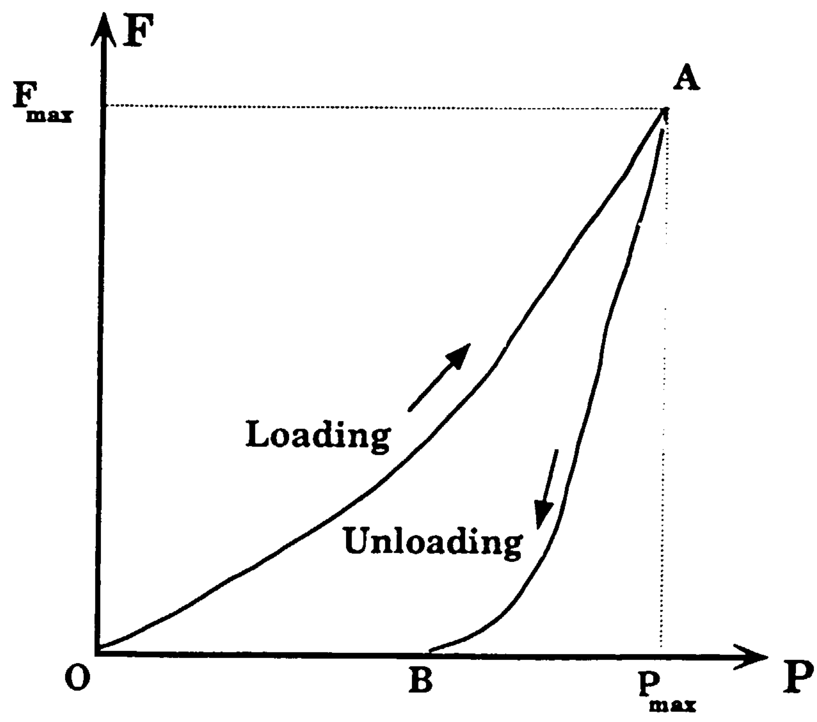
only the 3 first indentations give a correct result for the hardness. To avoid the influence of the environment, it is well known that the distance without influence is approximately 3 times the indentation diagonal.

CSEM

CSEM-UMD
Nano indentation system

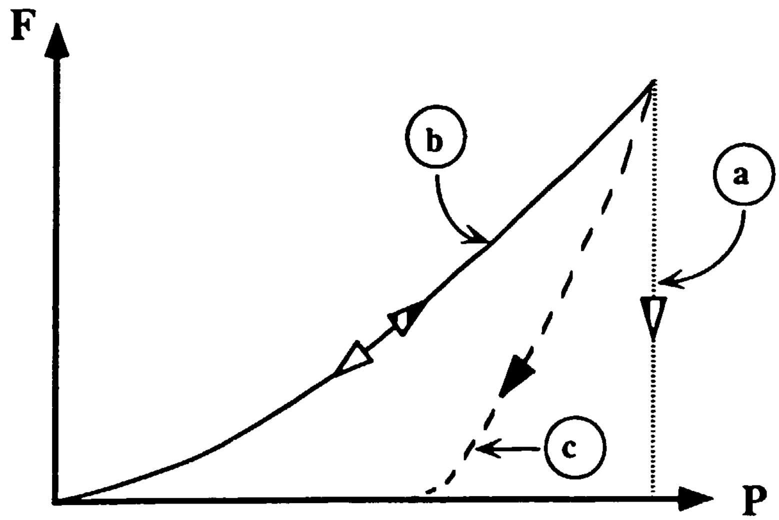
PRINCIPLE





CSEM-UMD
Nano indentation system

QUALITATIVE ANALYSIS



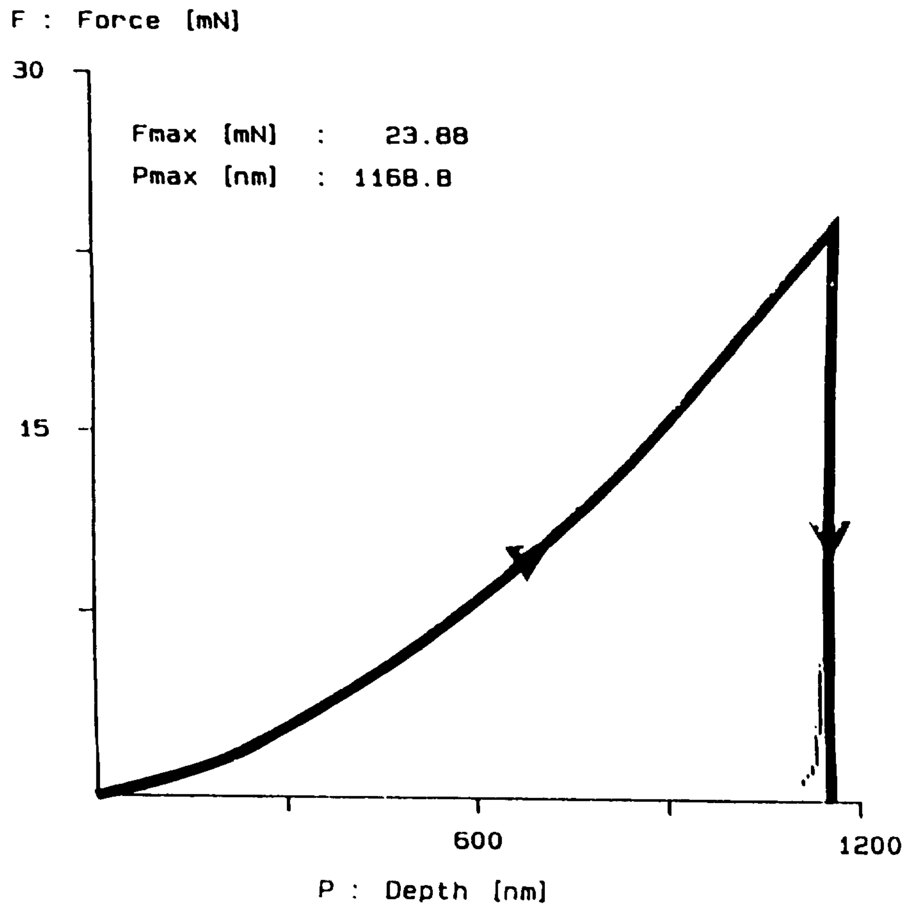
Curve (a) Plastic material

Curve (b) Elastic material

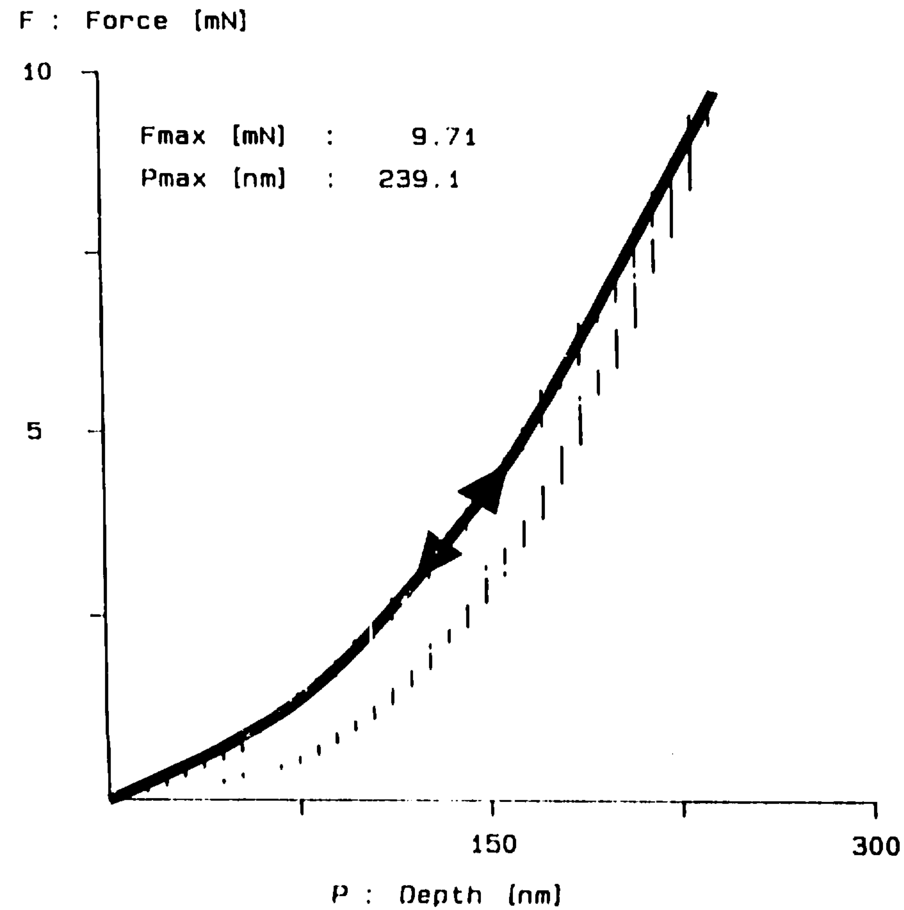
Curve (c) Elasto-plastic material

EXAMPLES OF TYPICAL BEHAVIORS

Annealed copper

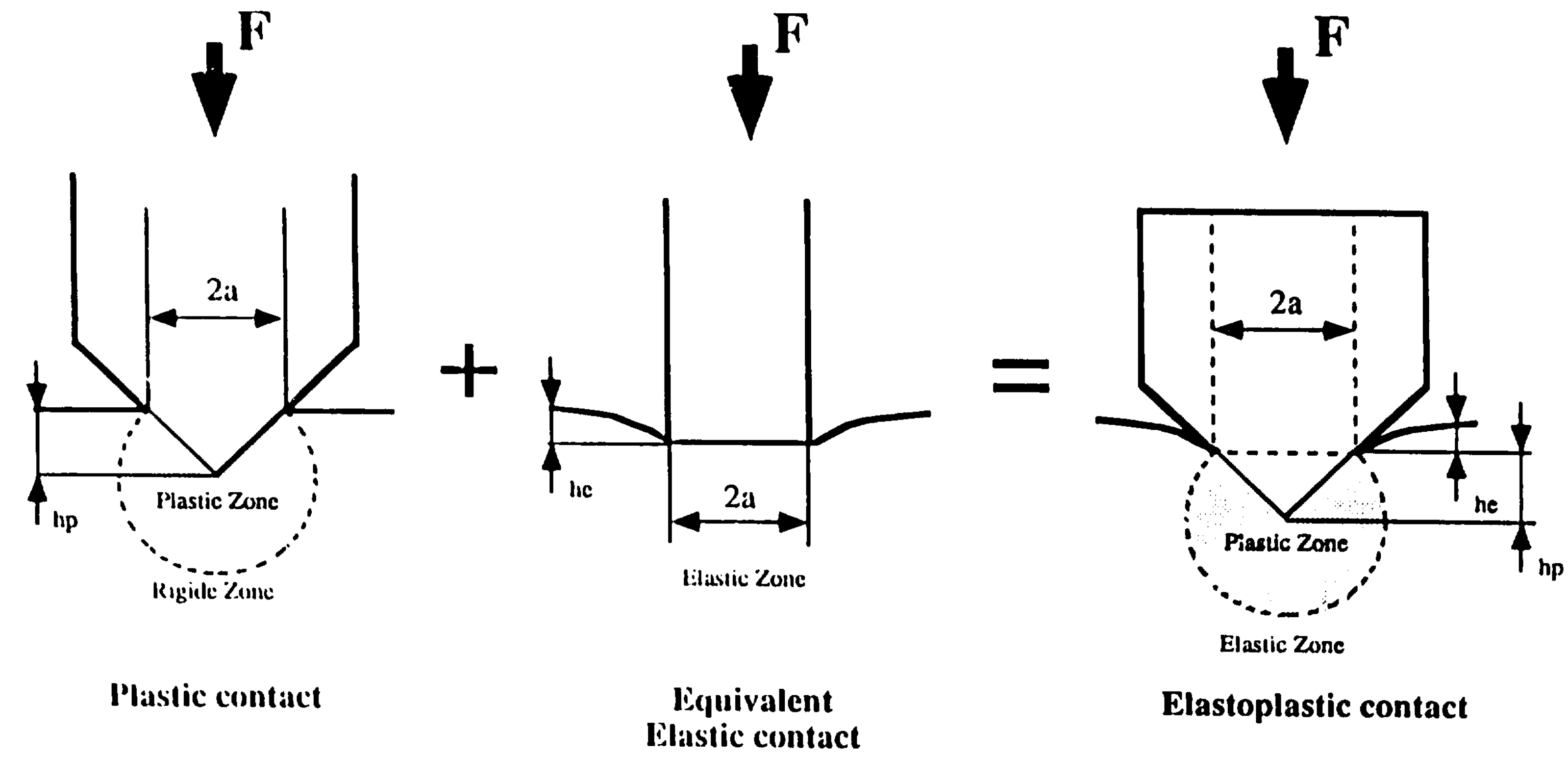


Polymer 10 μm on stainless steel

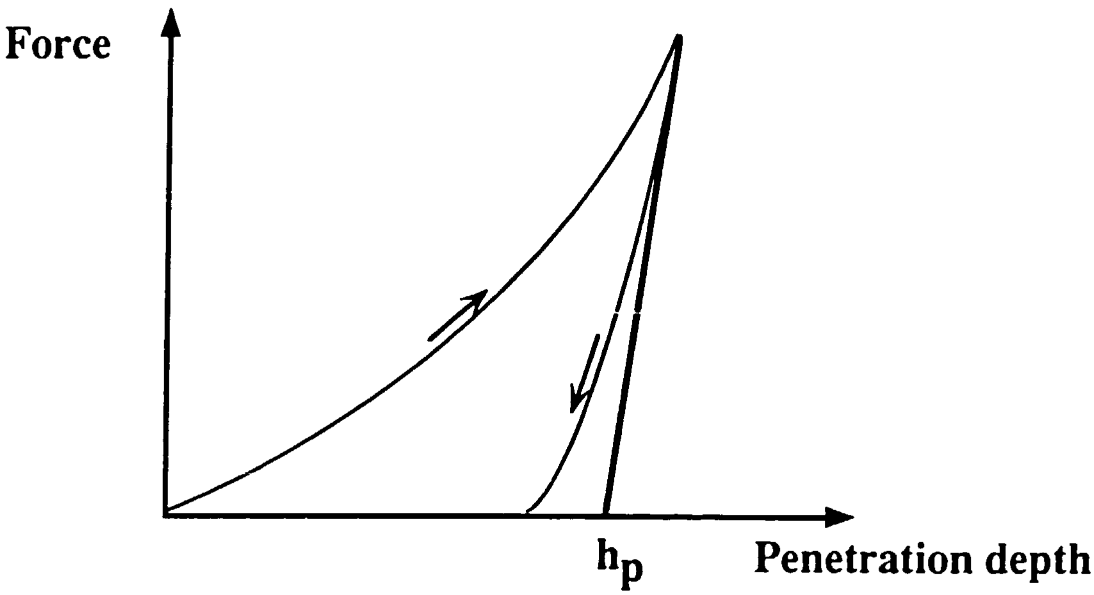


CSEM-UMD
Nano indentation system

MODELLIZATION OF THE BEHAVIOR OF AN ELASTOPLASTIC CONTACT



DETERMINATION OF THE PLASTIC DEPTH

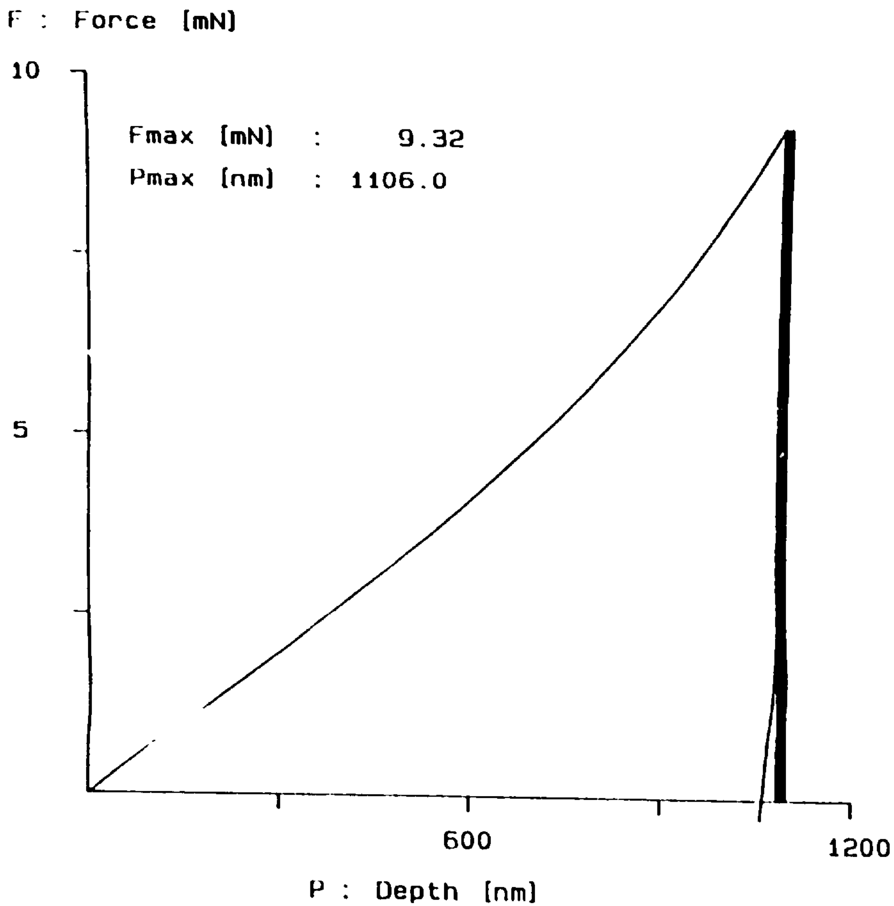


The plastic depth, $\mathbf{h_p}$, is obtained by extrapolating the tangent to the unloading curve at F_{max} to $F = 0$.

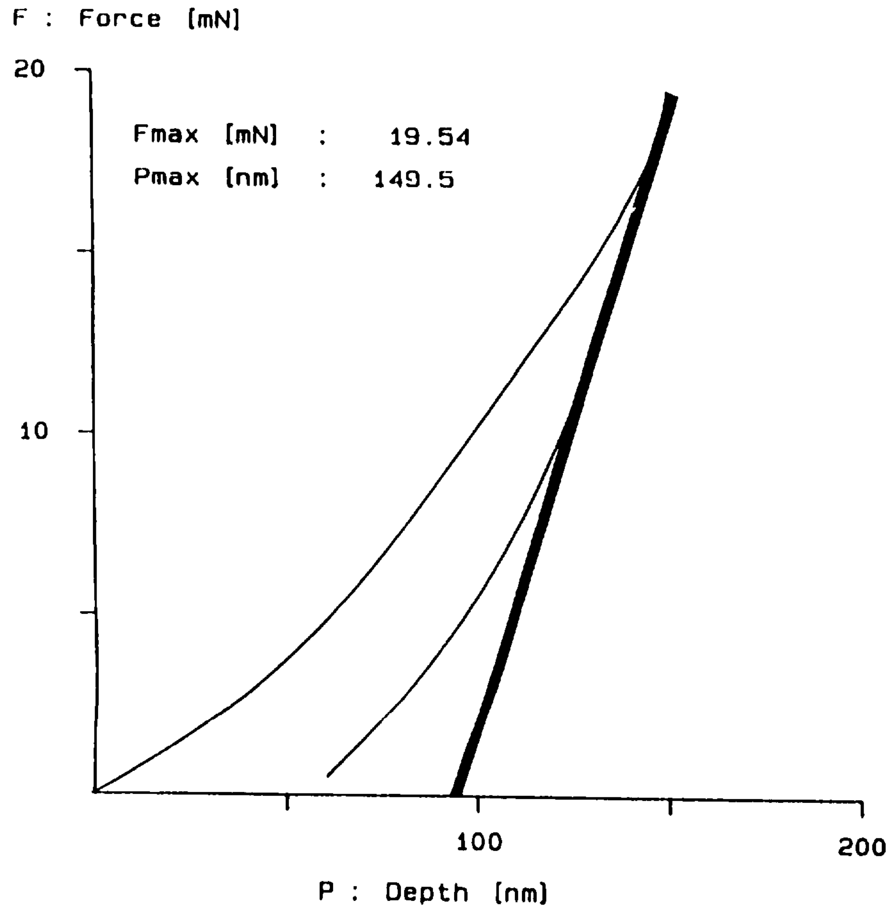
The tangent extrapolation corresponds to the unloading curve of a flat cylinder.

EXAMPLES OF PLASTIC DEPTH (h_d) DETERMINATION

Pure lead



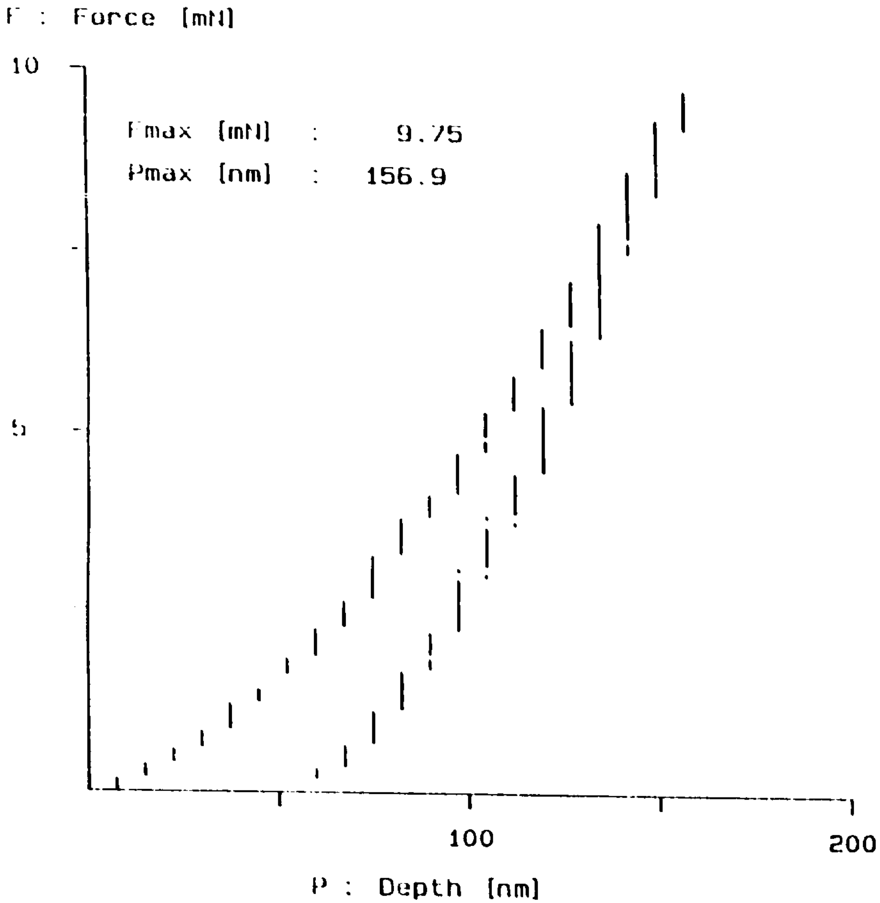
PVD-TiN 4 µm



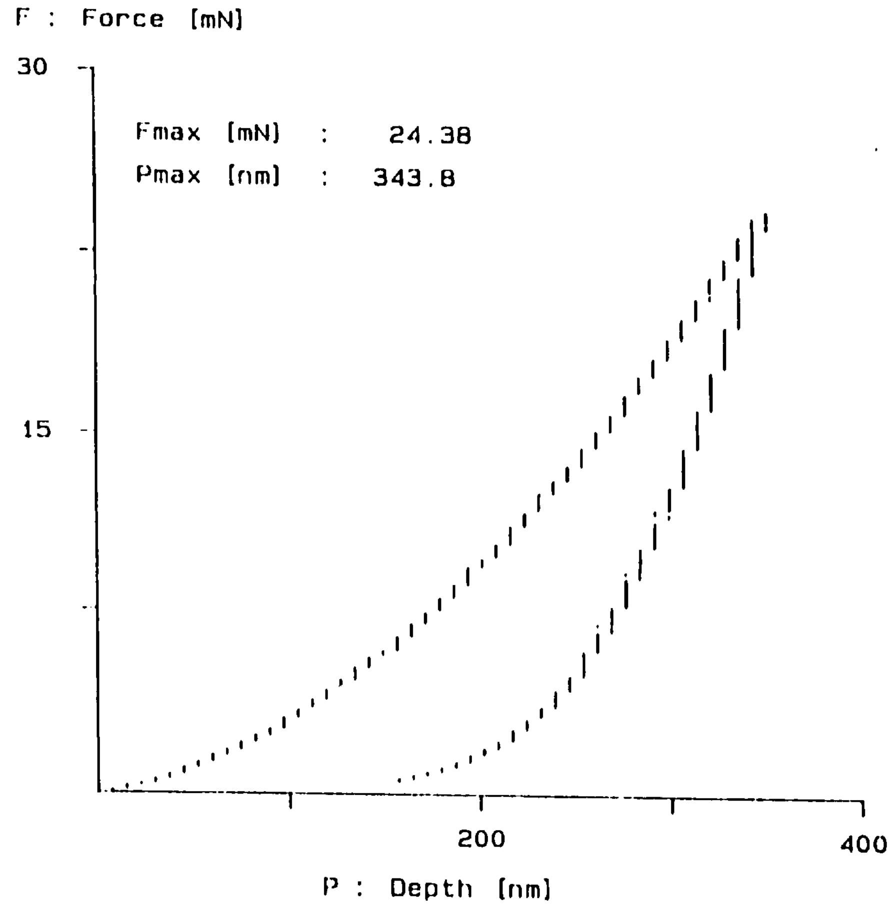
CSEM-UMD
Nano indentation system

EXAMPLES OF FORCE/PENTRATION DEPTH CURVES

a-C:H 2 μm on AISI 440C stell



MoS_2 2 μm on AISI 440C steel

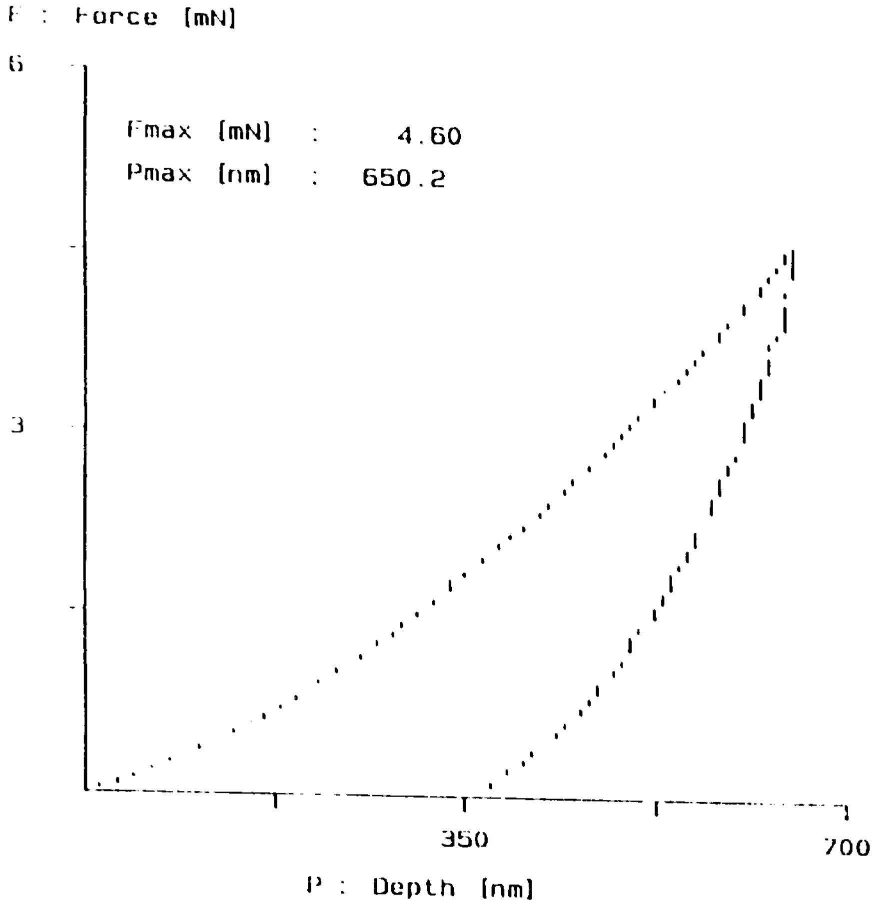


CSEM

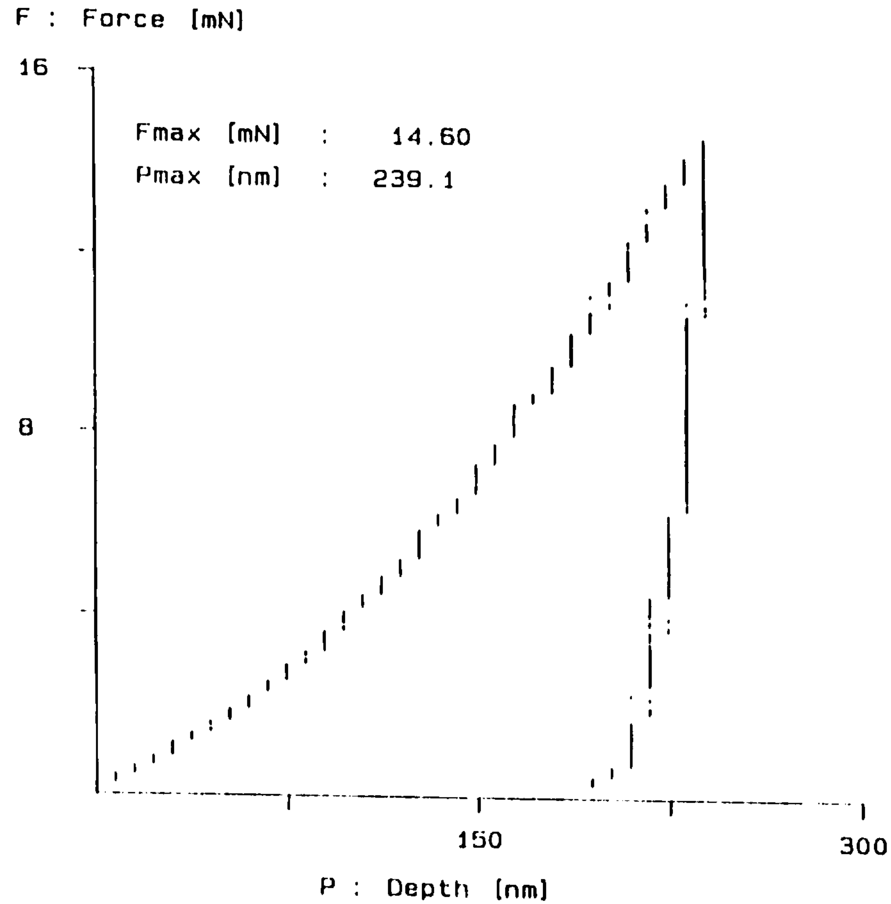
CSEM-UMD
Nano indentation system

EXAMPLES OF FORCE/PENTRATION DEPTH CURVES

Epoxy 10 µm on stainless steel



Mo phase in a ZrO_2 / Mo (50/50 wt%) cermet



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CSEM-UMD
Nano indentation system

EXAMPLES OF HV CALCULATION WITH THE CSEM-UMD

MATERIAL	LOAD [mN]	HV_{diag} [kg/mm²]	HV_{plast} [kg/mm²]
AISI 440C	50 100	850 (*) 807 (*)	1071 1067
Annealed Copper	50 100	66 (*) 59 (*)	67 61
Al_2O_3 - Saphire	50 100	3431 (*) 3013 (*)	3553 3278
4 µm MoS_2 - PVD on cemented carbide	10 20	-.-	1125 970
2 µm MoS_2 - PVD on AISI 440C steel	10 15	-.-	894 583
4 µm TiN - PVD on AISI 440C steel	10 20	2000-2500 (**) for $TiN_{1.0}$	3407 3041
Amorphous C:H on HSS	10 20	-.-	1162 995
2 µm TiC - CVD on AISI 440C steel	20	2900 (**) for $TiC_{1.0}$	3682
DLC on AISI 440C steel	10 20	-.-	2358 2168

(*) measured by SEM image

(**) from Literature

CSEM

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EXAMPLES OF E CALCULATION WITH THE CSEM-UMD

MATERIAL	LOAD [mN]	E [GPa]	E_{plast} [GPa]
AISI 440C steel	10 50 100	210 (*)	220 198 215
Annealed copper	10 50 100	115 (*)	123 121 121
Al_2O_3 - Saphire	50 100	406 (*) monocristallin	420 434
4 µm MoS_2 - PVD on cemented carbide	10 20	$E_{//}$ = 238 (*)	285 to 378 301 to 395
2 µm MoS_2 - PVD on AISI 440C steel	10 15	$E_{\perp}$ = 52 (*)	210 to 328 136 to 209
4 µm TiN - PVD on AISI 440C steel	10 20	600 (*) for $TiN_{1.0}$	478 to 676 427 to 653
Amorphous C:H on HSS	10 20	-.-	101 112
2 µm TiC - CVD on AISI 440C steel	20	447 (*) for $TiC_{1.0}$	553
DLC on AISI 440C steel	10 20	-.-	304 283

(*) from Literature

CSEM

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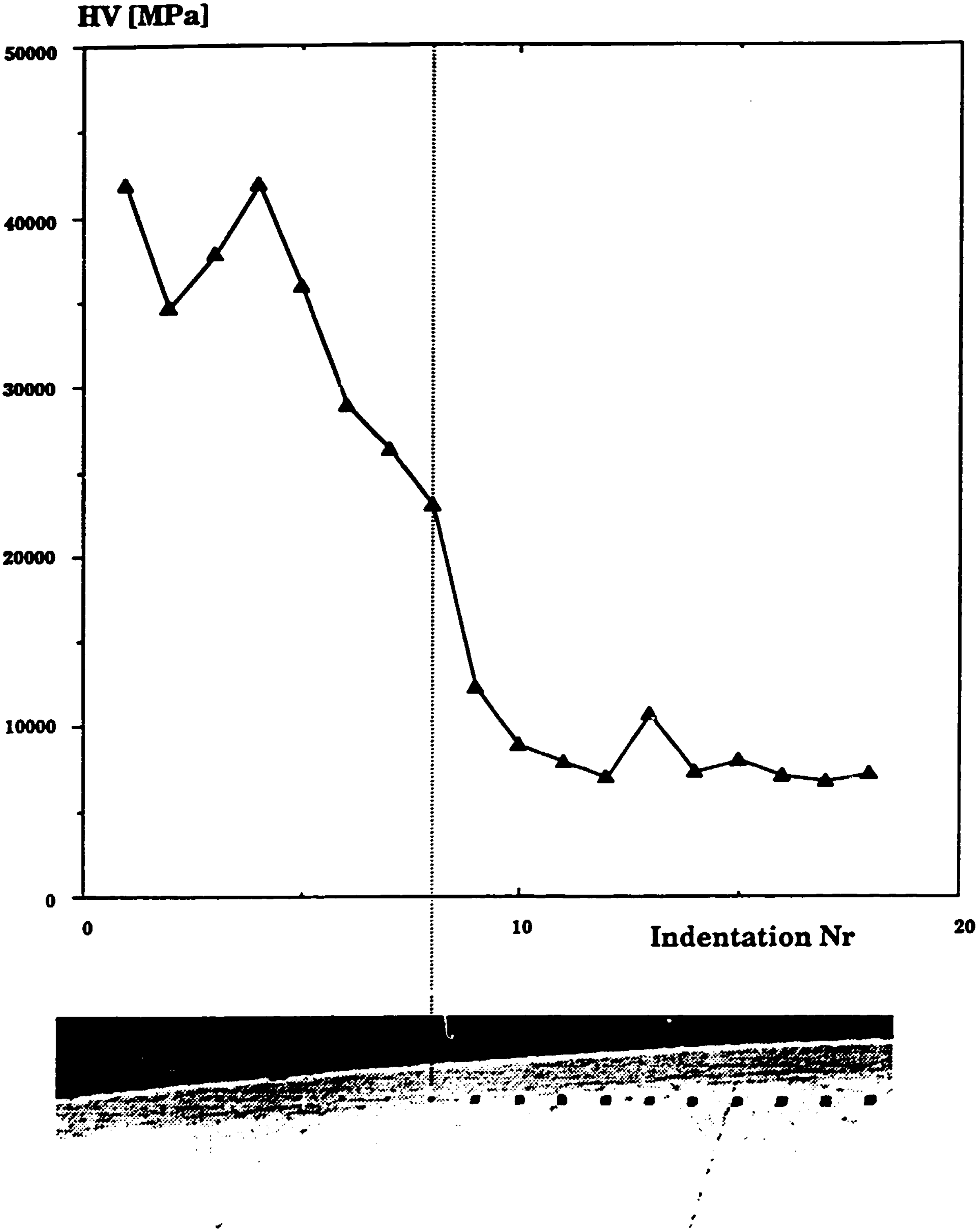
VICKERS INDENTATIONS (at 2 g) THROUGH A TiC/AISI 440C STEEL BALL INTERFACE



CSEM

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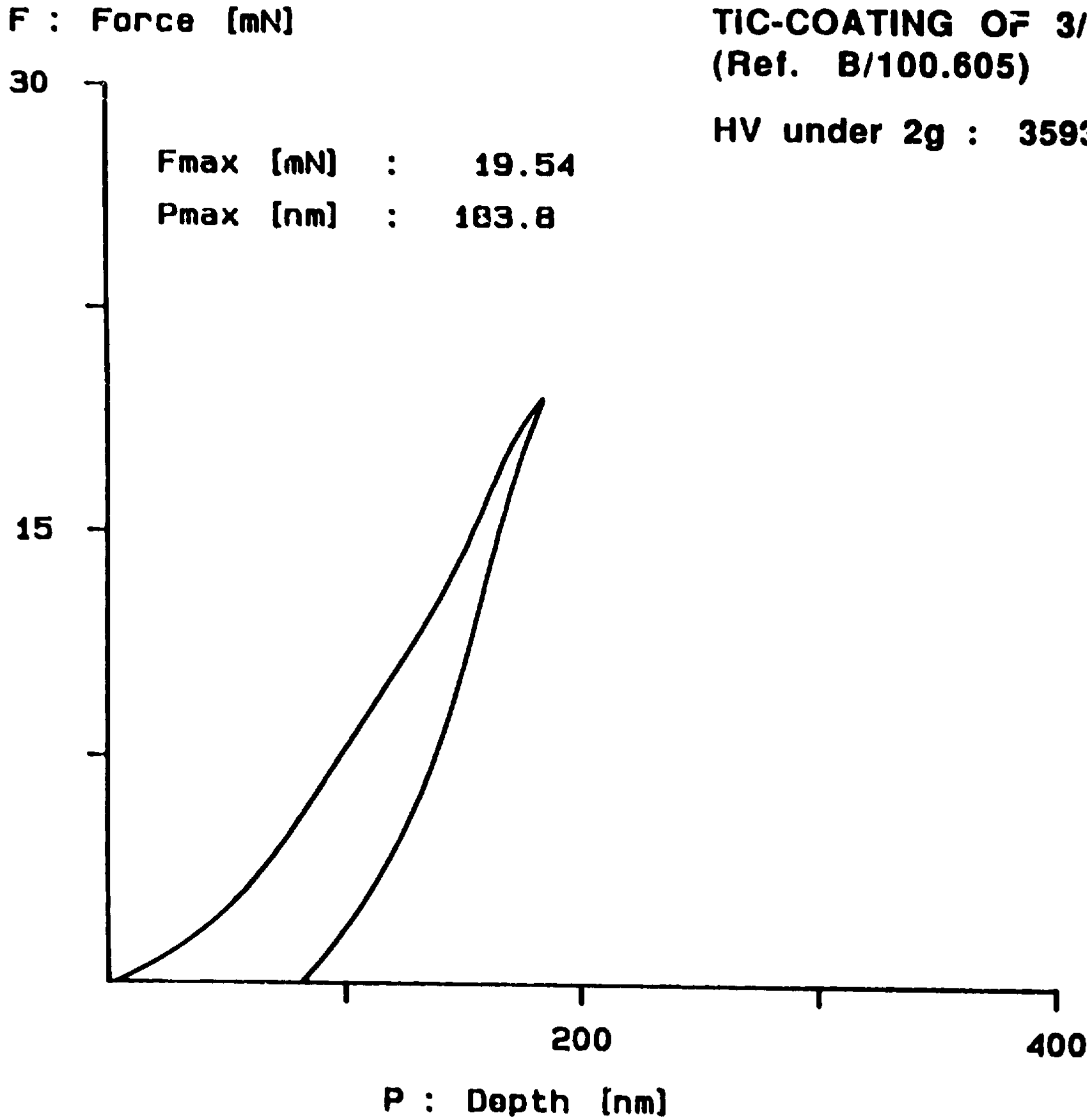
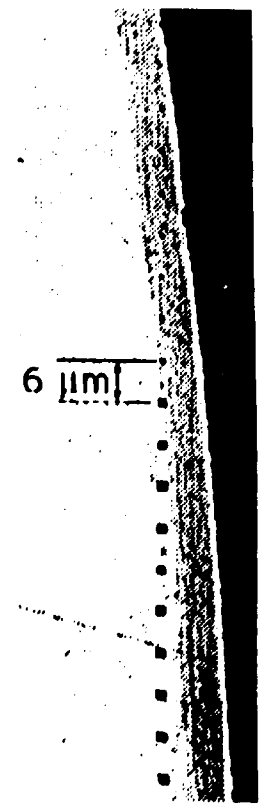
Nano indentation system

F/P DIAGRAM FROM ULTRAMICROHARDNESS TEST ON TiC-COATING OF 3/32" AISI 440C/TiC-BALL.
(Ref. B/100.605)

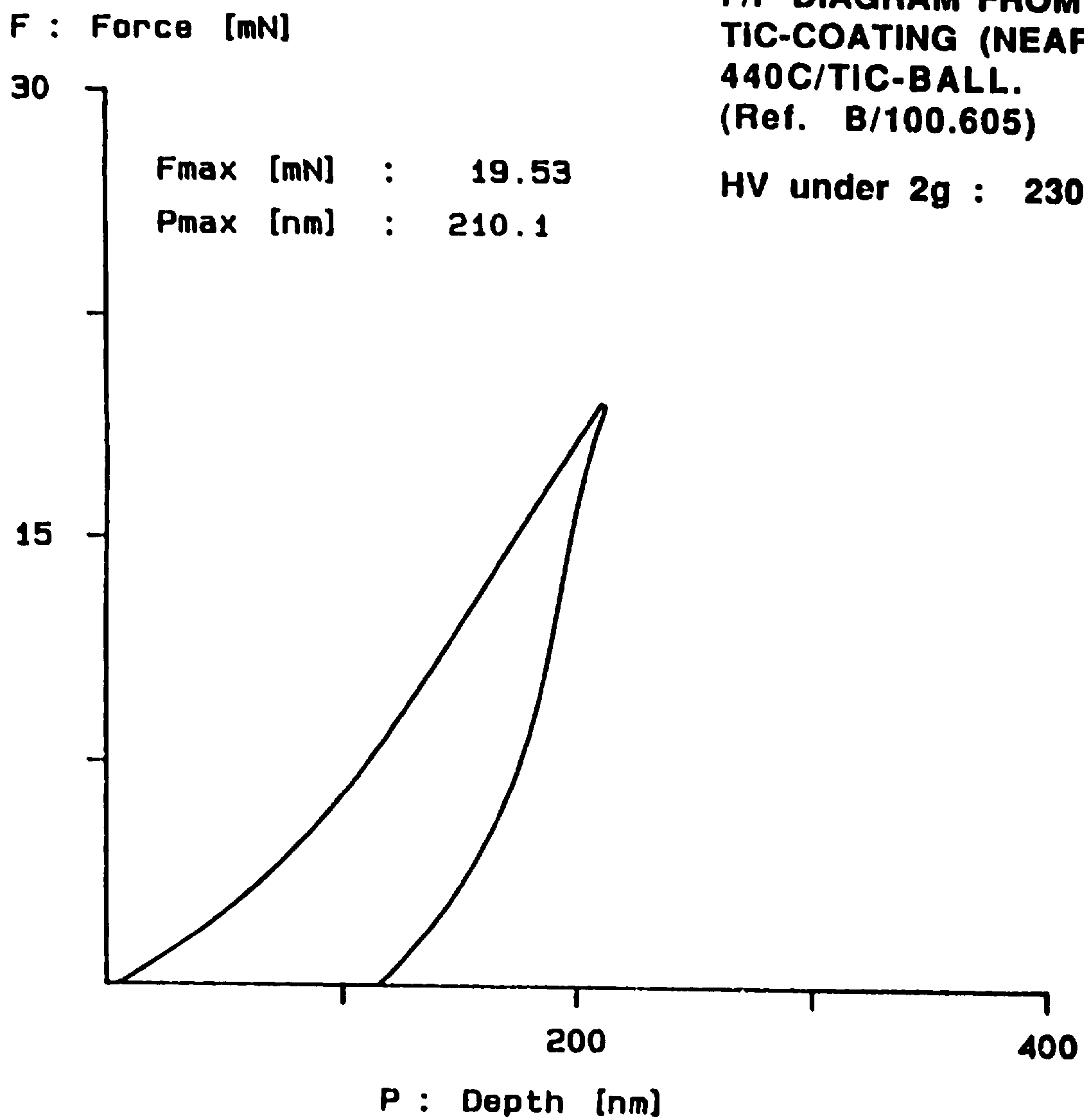
HV under 2g : 35932 MPa (3663 kg/mm²)

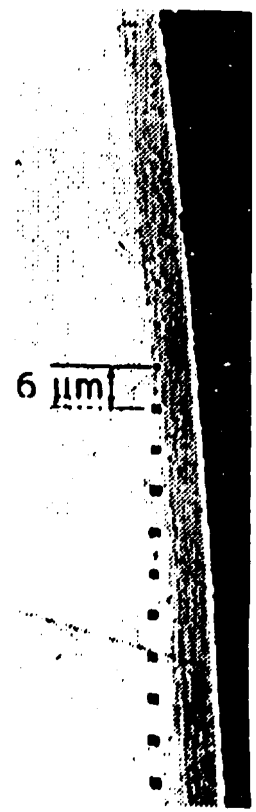




F/P DIAGRAM FROM ULTRAMICROHARDNESS TEST ON TiC-COATING (NEAR INTERFACE) OF 3/32" AISI 440C/TIC-BALL.
(Ref. B/100.605)

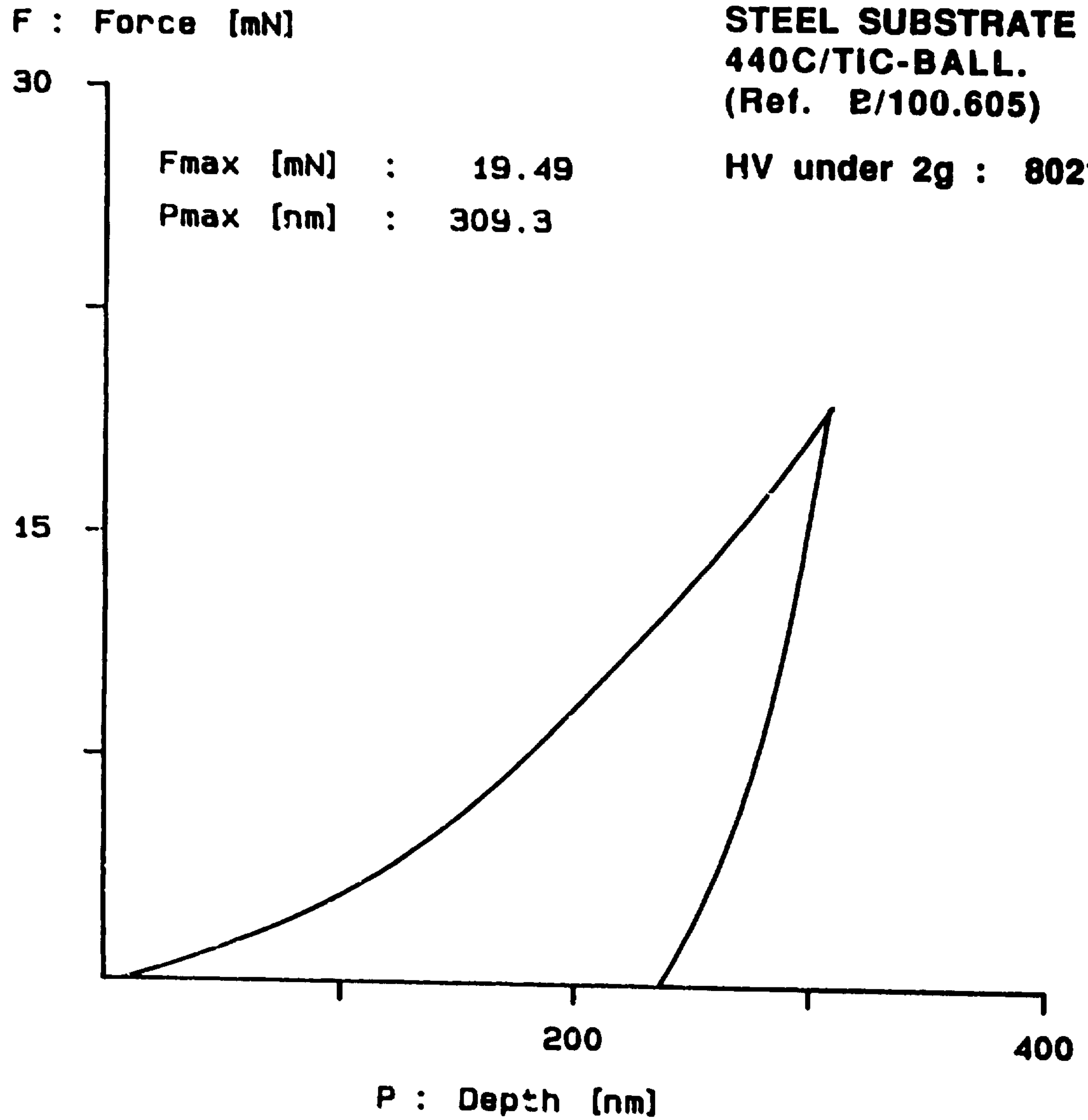
HV under 2g : 23059 MPa (2351 kg/mm²)

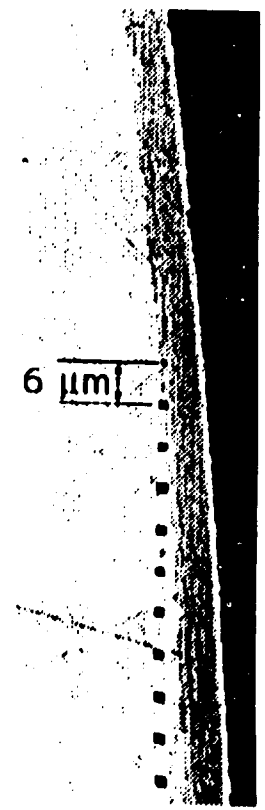




F/P DIAGRAM FROM ULTRAMICROHARDNESS TEST ON STEEL SUBSTRATE (NEAR INTERFACE) OF 3/32" AISI 440C/TIC-BALL.
(Ref. B/100.605)

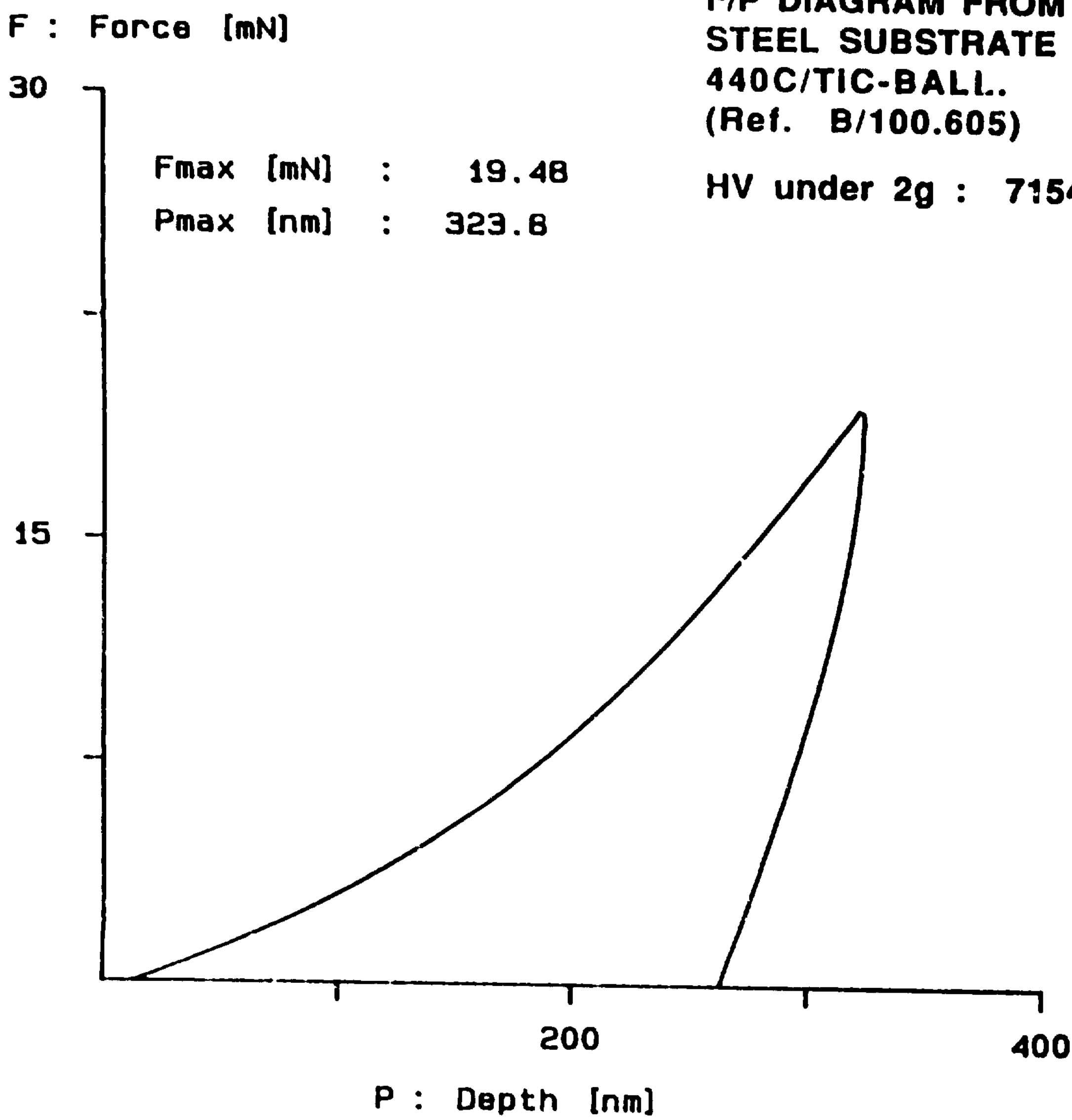
HV under 2g : 8021 MPa (818 kg/mm²)

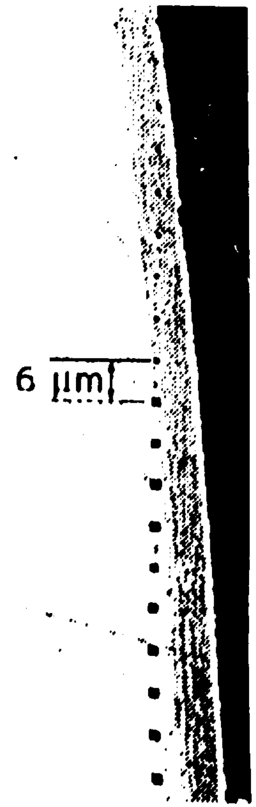




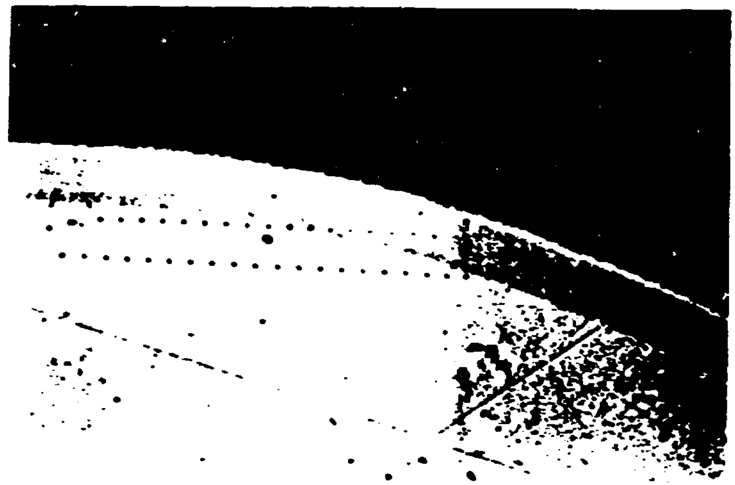
F/P DIAGRAM FROM ULTRAMICROHARDNESS TEST ON STEEL SUBSTRATE (NEAR INTERFACE) OF 3/32" AISI 440C/TIC-BALL.
(Ref. B/100.605)

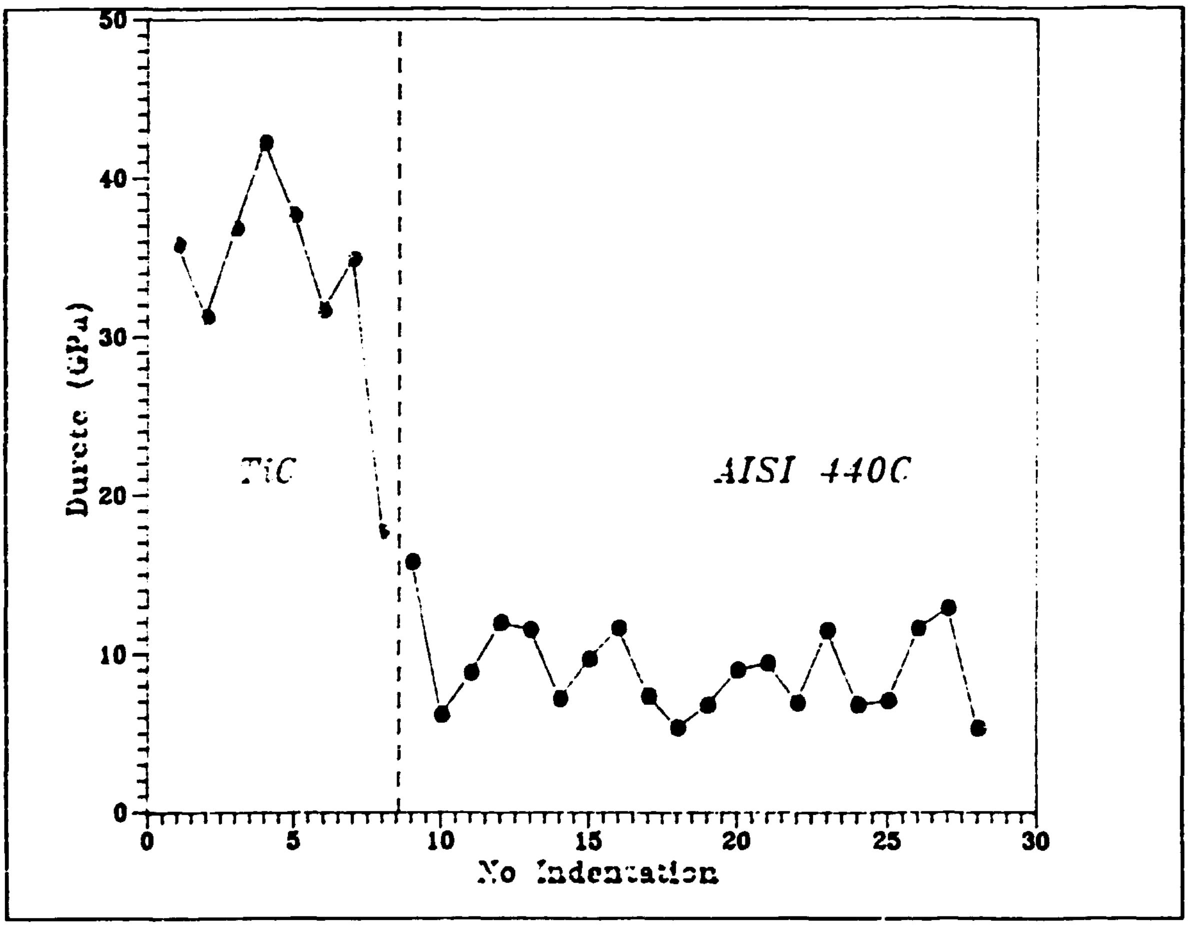
HV under 2g : 7154 MPa (729 kg/mm²)





VICKERS INDENTATIONS (at 2 g) THROUGH A TiC/AISI 440C STEEL BALL INTERFACE





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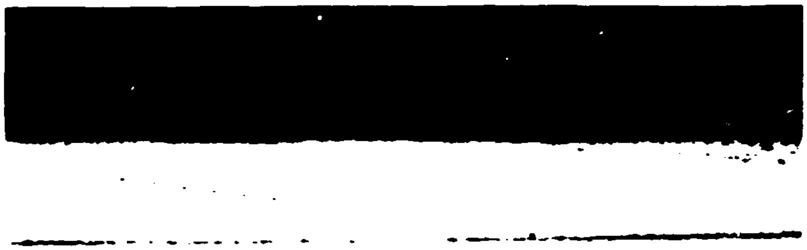
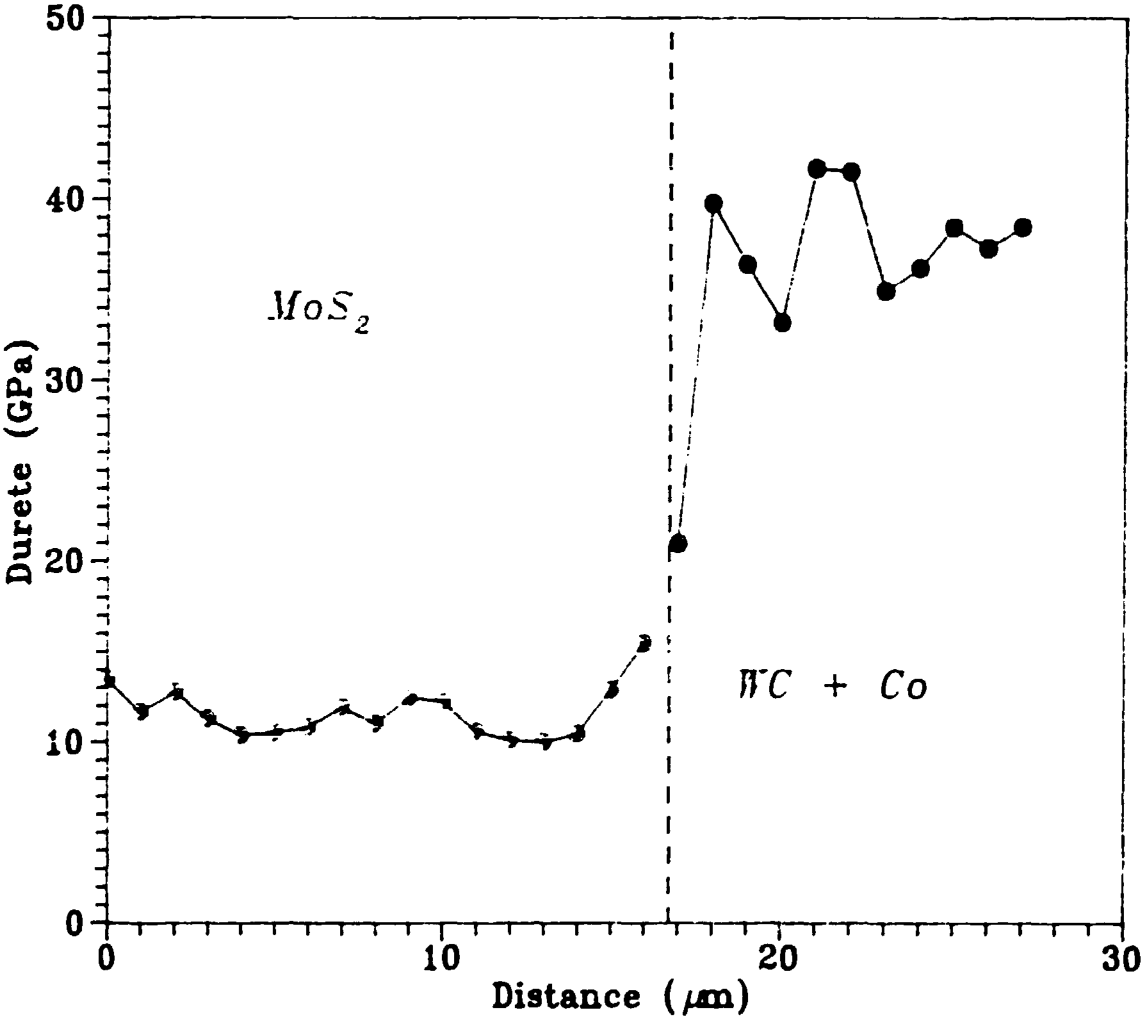
VICKERS INDENTATIONS (at 1 g) THROUGH A MoS_2 / CEMENTED CARBIDE INTERFACE





CSEM-UMD
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