COMMISSION OF THE EUROPEAN COMMUNITIES

environment and quality of life

A CALIBRATION DEVICE FOR LONG-PATH SENSORS OF ATMOSPHERIC POLLUTANTS

1976

EUR 5472 e

Printed in the United Kingdom.

COMMISSION OF THE EUROPEAN COMMUNITIES

Joint Nuclear Research Centre - Ispra Establishment

A CALIBRATION DEVICE FOR LONG-PATH SENSORS OF ATMOSPHERIC POLLUTANTS

S. SANDRONI (*), E. BRAMBILLA (*), M. CERESOLI (**)

(*) Chemistry Dir. Euratom Joint Research Centre, Ispra

(**) Design and Fabrication Dir. Euratom Joint Research Centre, Ispra

Edited by the Directorate General

"Scientific and Technical Information and Information Management"

1976 EUR 5472 e

ABSTRACT

The calibration of long-path optical sensors of atmospheric pollutants like the Barringer correlation spectrometer is obtained by a device in which the optical pathlength is varied. By using the device here described the calibration procedure requires about 6 min. for the full length expansion of the cell equivalent to concentration-pathlength variation of 1 : 250.
The device is simple and can be installed on an optical bench i.e. for simulation of polluted atmosphere.

C O N T E N T S

I. THE NEED OF A CALIBRATION DEVICE

Within the framework of a research activity aiming at the application of optical methods to remote sensing of air pollution, some difficulties have been experienced in calibrating instruments based on resonance absorption, and suitable for air quality measurements over a long pathlength. Instruments for this application are correlation spectrometers (i.e. Barringer (x) Cospec^{TM}) which uses a modulated Xe lamp for average concentration measurements of SO_2 at around 310 nm and of NO_2 at around 440 nm, and tunable laser analysers which use specific absorption of infrared light emitted by a diode laser or by other tunable laser device[1].

The classical ways of calibrating these absorption analysers are : 1) by inserting two optical standards and extrapolating a linear relationship to a zero level or
2) by introducing some mixtures of gases at different concentrations in a cell having a fixed length. Practically for a correct calibration following method 2), some difficulties are experienced, for example a) it is necessary to prepare and to store large volumes of gas mixtures at very low concentration, b) the analysis of gas mixtures at a concentration of ppm or lower requires large volumes of gases or some sophisticated techniques and c) the wall effect in the cell and in the container may modify the mixture composition.

For these reasons we studied a device which by varying the length could permit a calibration by using a gas mixture only.

II. THE VARIABLE PATHLENGTH CELL

The device we realised and its schematic are shown in fig.1 and 2 respectively. Essentially, it consits of two cylindrical teflon bellows cells (C_1, C_2), having the left head fixed on the frame holder of the device and the right one moving on three bars; the cells are connected by silicone tubes in order to have a constant pressure. The cells are mounted one upon the other for use on an optical bench. A motor (M) operated by a button on the front of the holder moves by means of a driving cam (B) one of the right heads towards the fixed one, and the other in the opposite direction. The PVC heads hold the optical windows (W); the left heads hold the optical windows by a teflon cylinder some cm in length placed inside the bellows to allow a zero thickness in the cell when compressed. In one connecting tube, an inlet valve (I) for gas filling and a teflon fan (F) operated by a motor are inserted. To wash the gas circuit, an exit valve (V) is inserted in one left head. The mode of operation is quite simple: the circuit is flushed with the gas mixture to be used for several minutes; once (I) and (V) have been closed by simply pushing the buttons for (M) and (F) the cell length can be varied from about zero to the maximum value of b possible. The pathlength b of one cell is given by a indicator on a meter scale on the front of the frame holder; in a more sophisticated way, the b values can be transferred to a recorder (R) via a potentiometer connected to (B). A two-pen recorder can display simultaneously the gas signal and b values. In our device the maximum pathlength is 50 cm with a minimum of 0.2 corresponding to a concentration path length (c.b) range of 1 : 250. By introducing i.e. the commercial gas mixture SO_2/N_2 at 100 ppm (in vol.) we can get c . b values from 50 ppm-m down to 0.2 ppm-m. These data are equivalent over a 1000 m. optical path to concentrations from 50 to 0.2 ppb. The concentration range 1 : 250 fully covers the concentration range of most of the pollutants

in the atmosphere.
The device operates at atmospheric pressure but a somewhat lower pressure can be used. It is quite simple, easy to realize and can be installed on an optical bench, i.e. for simulation of polluted atmosphere.

III. DETAILED DESCRIPTION (fig.2)

Cells (C_1,C_2) They consists of teflon bellows (fig.4), 600 mm. length, external diameter 120 mm., internal diameter 80 mm. with 45 coils. The bellows are made by direct melting. The minimum length one can obtain is 120 mm. At one side of the cell a teflon cylinder 113 mm length, 78 mm diameter is inserted. At the internal end of the teflon cylinder the optical windows (W) are welded by Araldite type Ay 101. For operation in the ultraviolet/visible spectral region, which is the case of Barringer Cospec analyser, Tetrasil A discs 78 mm diameter, 6 mm thickness have been used. In the infrared region KRS-5 windows could be used.

Fan (F) It is a mixing teflon fan moved by an electric motor Crouset type 82160, 3000 rpm. The gas tightness is assured by Viton type O-rings resistent to most of corrosive gases.

Connecting tubes (T) These are silicone tubes HW/55 type, 14 mm external diameter.

Motor (M) It is a Isotermic Swiss speed reducer with a reduction ratio 405 : 1 with 5,9 rpm. The motor moves the screw cams (B) by gears.

Bars (B) Both the screw cams and the fixed bars are in stainless steel. The screw cams move on ball bearings and their position is regulated by two microswitches.

Potentiometer (P) It is a Helipot type potentiometer with an accuracy of 0.25% and a resistence of 0.5 K Ω

Recorder (R) It is a two pen recorder 10 mV full scale we use a Philips type 8221 PM recorder.

Valves(V and three ways valve Y) are teflon or glass valves. The device holder is in aluminium AG-3: the front panel has two buttons for (M) and (F) and a meter for the direct reading of the lower cell length. The bellows are moved by the motor (M)throu two gears; when one cell reaches the maximum optical length of 500 mm, the other reaches the minimum optical length of 2 mm (obviously these distances refer to the internal walls of the windows). The speed of pathlength variation is 82 mm/min., the full expansion being obtained in about 6 minutes. The length of the lower cell can be read (a) directly on the meter scale or (b) on the recorder simultaneously with the gas signal. So one can directly verify the relationship between pathlength and absorption.

IV. MODE OF OPERATION

The mode of operation of this device is quite simple. First the flushing of the system is obtained in the following manner; the valve (I) is connected to a gas supply and (V) is opened. The gas circulates alternatively via (F) and by (C_1) and (C_2), and then on closing (I) and (V) the fan (F) is started for some minutes, after which the gas is removed by (V). This operation is repeated several times until a stable instrumental response is obtained. Once filled the cells and closed (I) and (V), the variation of the pathlength is obtained by pushing the button for (M) on the front panel. In about 6 minutes the pathlength varies from 2 to 500 mm continously and the length b is recorded together with the gas signal (fig. 4)

ACKNOWLEDGMENTS

We are indebted to Mr. G. Giovanelli and G. Cesari, Istituto di Fisica dell'Atmosfera del C.N.R. Bologna for the helpful discussions in the realisation of the device.

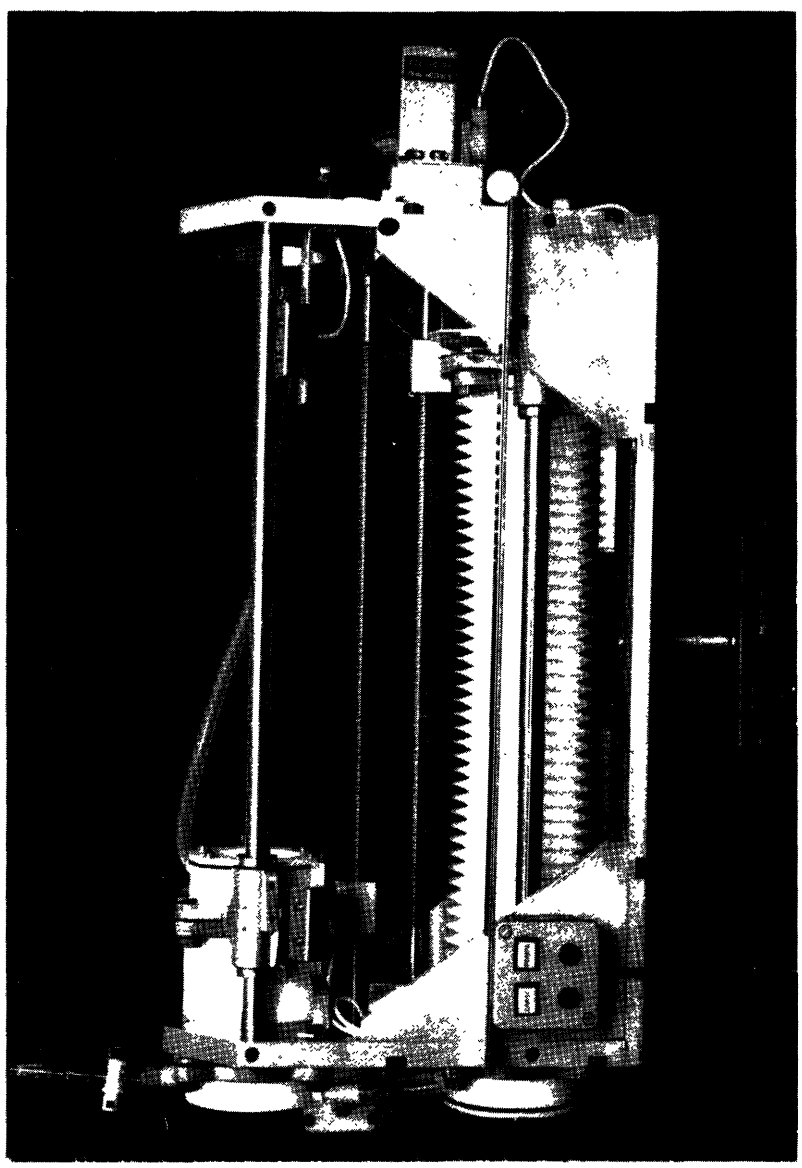


Fig. 1 - The calibration device

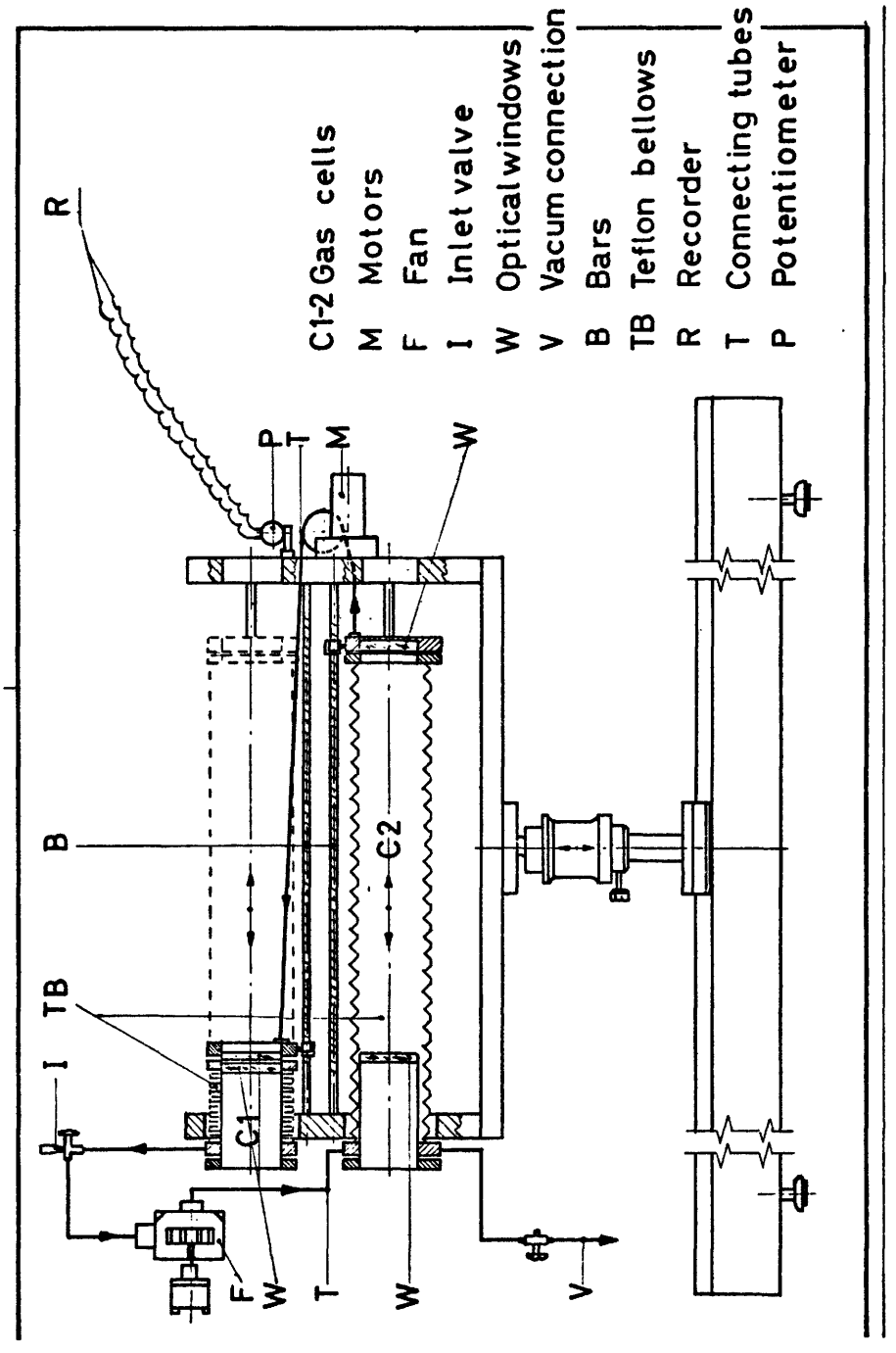


Fig. 2 - Schematic

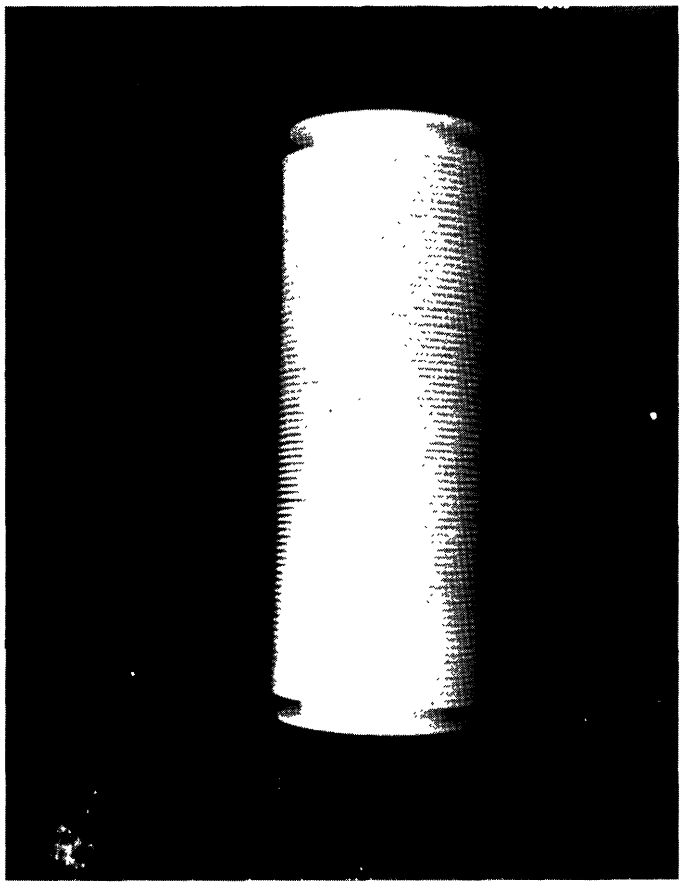
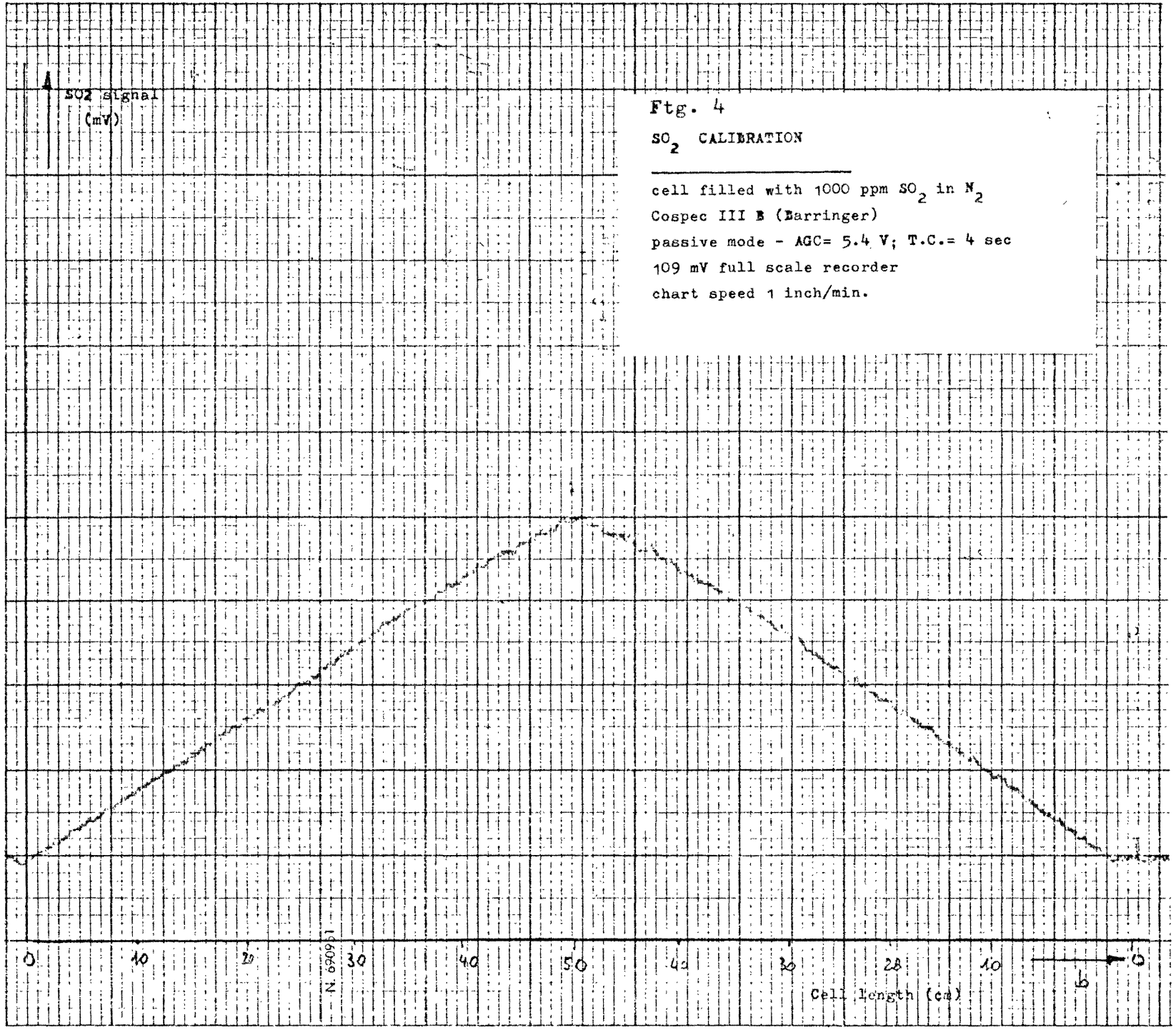


Fig. 3 - A teflon bellow



Ftg. 4

SO_2 CALIBRATION

cell filled with 1000 ppm SO_2 in N_2
Cospec III B (Barringer)
passive mode - AGC= 5.4 V; T.C.= 4 sec
109 mV full scale recorder
chart speed 1 inch/min.

SALES OFFICES

The Office for Official Publications sells all documents published by the Commission of the European Communities at the addresses below and at the price listed on the back cover. When ordering, specify clearly the exact reference and the title of the document.

Belgique - België

Moniteur belge — Belgisch Staatsblad

Rue de Louvain 40-42 —
Leuvenseweg 40-42
1000 Bruxelles — 1000 Brussel

Tél. 512 00 26
CCP 000-2005502-27
Postrekening 000-2005502-27

Sous-dépôt — Agentschap :

Librairie européenne —
Europese Boekhandel
Rue de la Loi 244 — Wetstraat 244
1049 Bruxelles — 1049 Brussel

Danmark

J.H. Schultz — Boghandel

Møntergade 19
1116 København K
Tel. 14 11 95

Deutschland (BR)

Verlag Bundesanzeiger

5 Köln 1 - Breite Straße —
Postfach 108 006
Tel. (0221) 21 03 48
(Fernschreiber : Anzeiger Bonn
08 882 595)
Postscheckkonto 834 00 Köln

France

Service de vente en France des publications des Communautés européennes

Journal officiel

26, rue Desaix
75 732 Paris - Cedex 15
Tél (1) 578 61 39 —
CCP Paris 23-96

Ireland

Stationery Office — The Controller

Beggar's Bush
Dublin 4
Tel. 76 54 01

Italia

Libreria dello Stato

Piazza G. Verdi 10
00198 Roma — Tel. (6) 85 08
CCP 1/2640

Agenzie :

00187 Roma - Via del Tritone 61/A e 61/B
00187 Roma - Via XX Settembre (Palazzo Ministero delle finanze)
20121 Milano - Galleria Vittorio Emanuele 3
80121 Napoli - Via Chiaia 5
50129 Firenze - Via Cavour 46/R
16121 Genova - Via XII Ottobre 172
40125 Bologna - Strada Maggiore 23/A

Grand-Duché de Luxembourg

Office des publications officielles des Communautés européennes

Boîte postale 1003 — Luxembourg

Tél. 49 00 81 — CCP 191-90

Compte courant bancaire :
BIL 8-109/6003/300

Nederland

Staatsdrukkerij- en uitgeverijbedrijf

Christoffel Plantijnstraat, s'-Gravenhage

Tel. (070) 81 45 11
Postgiro 42 53 00

United Kingdom

H.M. Stationery Office

P.O. Box 569
London S.E. 1
Tel. 01-928 6977, ext. 365

United States of America

European Community Information Service

2100 M Street, N.W.
Suite 707
Washington, D.C. 20 037

Tel. 296 51 31

Schweiz - Suisse - Svizzera

Librairie Payot

6, rue Grenus
1211 Genève
CCP 12-236 Genève

Tél. 31 89 50

Sverige

Librairie C.E. Fritze

2, Fredsgatan
Stockholm 16

Post Giro 193, Bank Giro 73/4015

España

Librería Mundi-Prensa

Castelló 37
Madrid 1

Tel. 275 46 55

Other countries

Office des publications officielles des Communautés européennes

Boîte postale 1003 — Luxembourg

Tél. 49 00 81 — CCP 191-90
Compte courant bancaire :
BIL 8-109/6003/300

NOTICE TO THE READER

All scientific and technical reports published by the Commission of the European Communities are announced in the monthly periodical **"euro-abstracts".** For subscription (1 year: B.Fr. 1 025,—) or free specimen copies please write to the address below.

FB 165,— DK 26,— DM 11,20 FF 20,— Lit 3050 Fl. 11,40 £2.05 $4.75

OFFICE FOR OFFICIAL PUBLICATIONS OF THE EUROPEAN COMMUNITIES
Boîte postale 1003 — Luxembourg 7153