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APPLICATION IN CLINICAL USE OF A SMALL CARBON DIOXIDE ANALYZER

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With the recently renewed interest in the effect of carbon dioxide on the biochemical and physiological changes during and after anesthesia, search was made for a small simple apparatus which could be used in the operating room, so that study of the carbon dioxide content of the anesthetic atmospere might be possible. The requirements set up were: accuracy of ± 0.5 %, rapidity of analysis and simplicity of operation.

Apparatus

The piece of equipment which best met these requirements was a modification of a commercial analyzer used for testing the carbon dioxide content of the exhaust gas from furnaces. The effective range of concentration in the original model was 0-20 % but the modification measured from 0-5 % carbon dioxide and could be extended on the scale to about 7 %. The original and modified models are both shown in figure 1, and a diagram of the 0-5 % indicator in figure 2.

The water chamber shown on the left of the apparatus (figure 2) was designed by the manufacturer for humidification of the gas, but understandably, this interfered with the results by

premature partial solution of the carbon dioxide. There are springloaded valves at the top of the other two columns which can be opened to the atmosphere, and thus allow the pressure above the fluid to be the same in both the sample chamber and indicator tube before aspiration of the sample.

Method

The procedure used in this study began with aspiration of a gas sample by use of a unidirectional hand bulb pump, through a distensible bag, so that a constant rather than an intermittent stream of gas passed through and flushed the sample chamber,

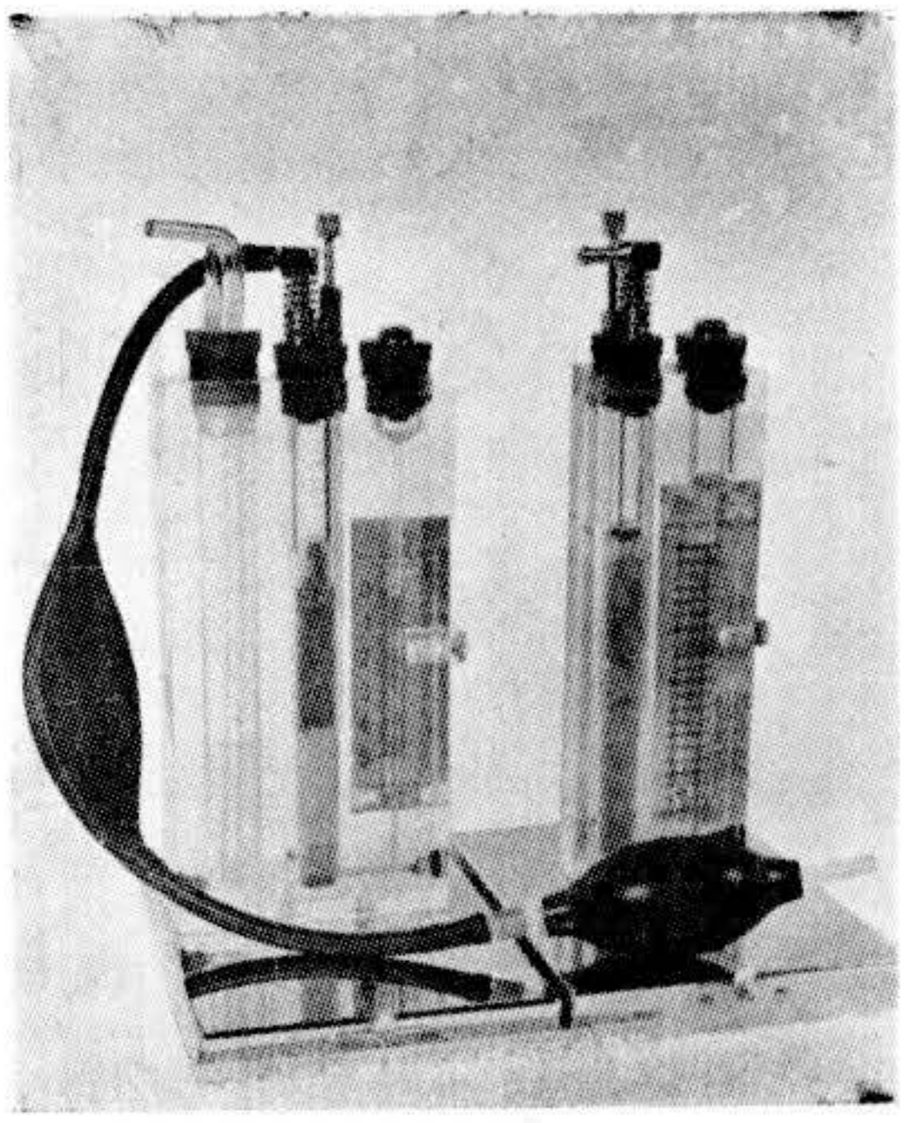
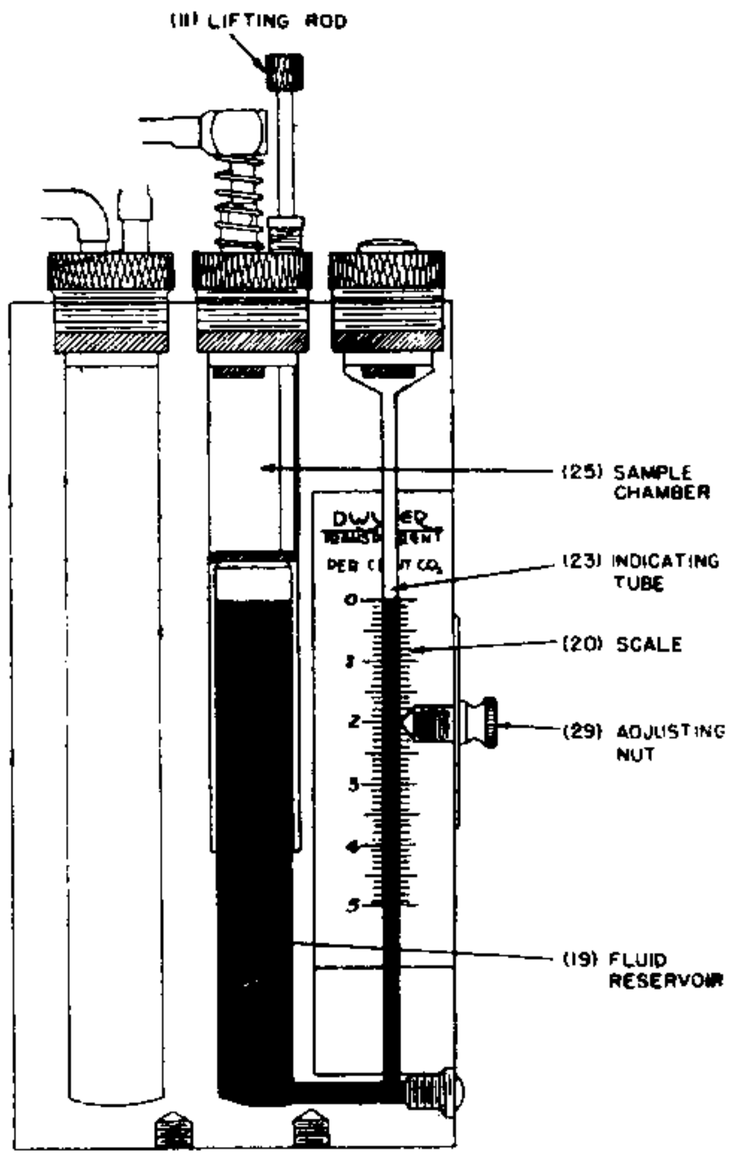


Fig. 1

until the selected 20 ml. for the analysis were trapped. Initially, both valves (mentioned above) are opened to the air so that the zero level in the nidicator arm might be adjusted on the movable scale. During aspiration of the sample, the outlet of the sample chamber was opened and that above the indicating tube was closed. When the sample had been aspirated, the outlet of the sample chamber was also allowed to close. Absorption of the carbon dioxide in the sample chamber then resulted by increasing the surface area of the KOH solution by raising and lowering the "basket"

several times. With the absorption of a portion of the sample in the absorption chamber, the pressure and volume there decreased. By then opening the valve above the indicator arm the pressure returned to that of the atmosphere and the decrease in volume was read directly as % of CO_2 from the scale in back of the indicating tube.

The whole procedure took about a minute for completion. By opening the valves over each chamber simultaneously the pressure was again equalized and another aspiration and analysis could be done.



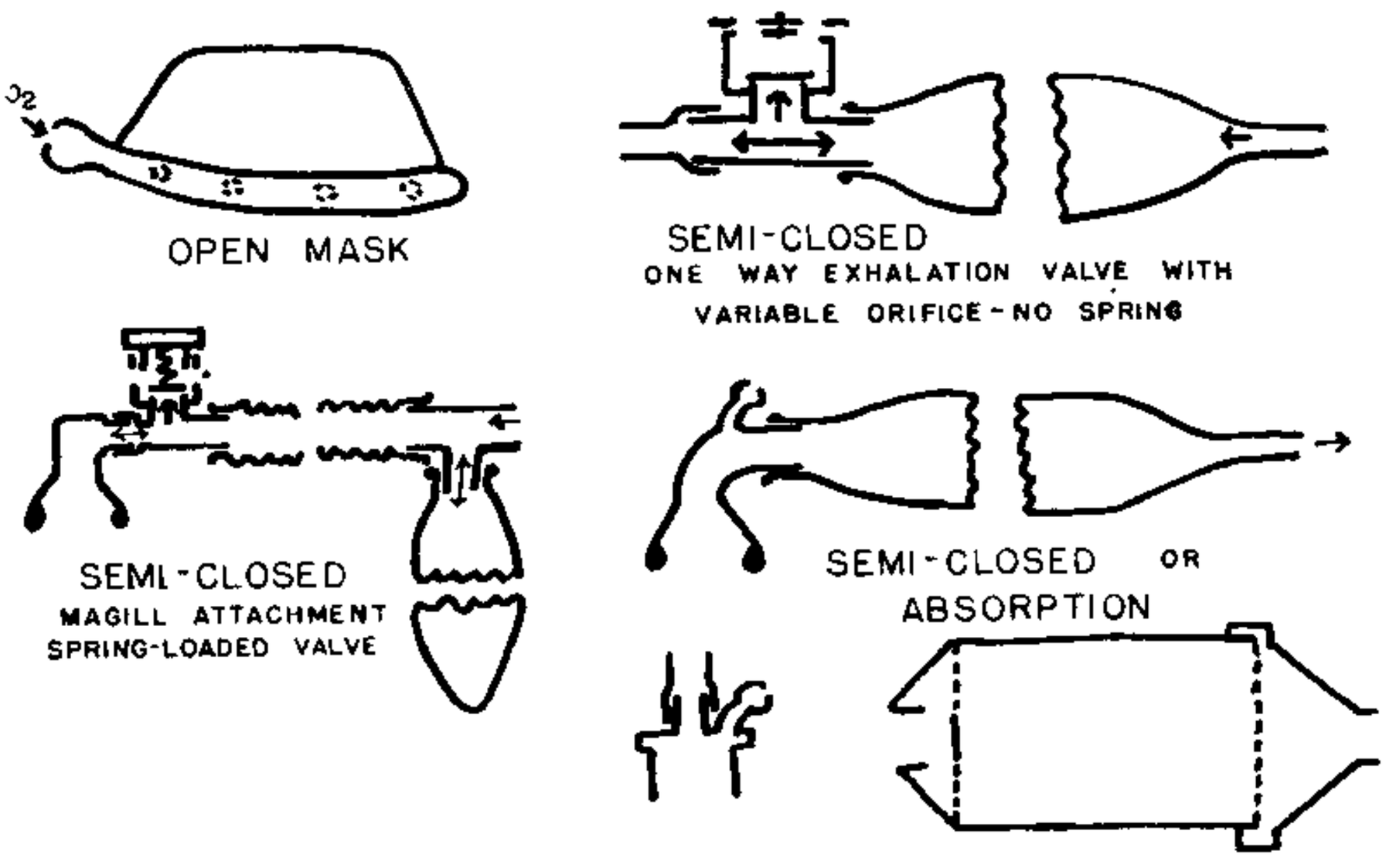
DWYER #800-5 ZERO TO 5% CARBON DIOXIDE INDICATOR

Fig. 2

Accuracy

Comparisons were made with the Orsatt-Henderson apparatus and the standard manometric Van Slyke technique. The results were nearly identical with the Orsatt-Henderson, but were at least 0.2 % lower than any specific Van Slyke measurement. For this latter accuracy it was necessary to aspirate 500-700 ml. specimens (20-30 ml. each aspiration) but for levels accurate to about minus 0.5 %, 300 ml. samples were sufficient.

This large sample volume constitutes a great disadvantage in studying the atmosphere in closed systems.



TYPES OF APPARATUS USED IN STUDY

Fig. 3

VARIATION IN CARBON DIOXIDE WITH RATE OF FLOW

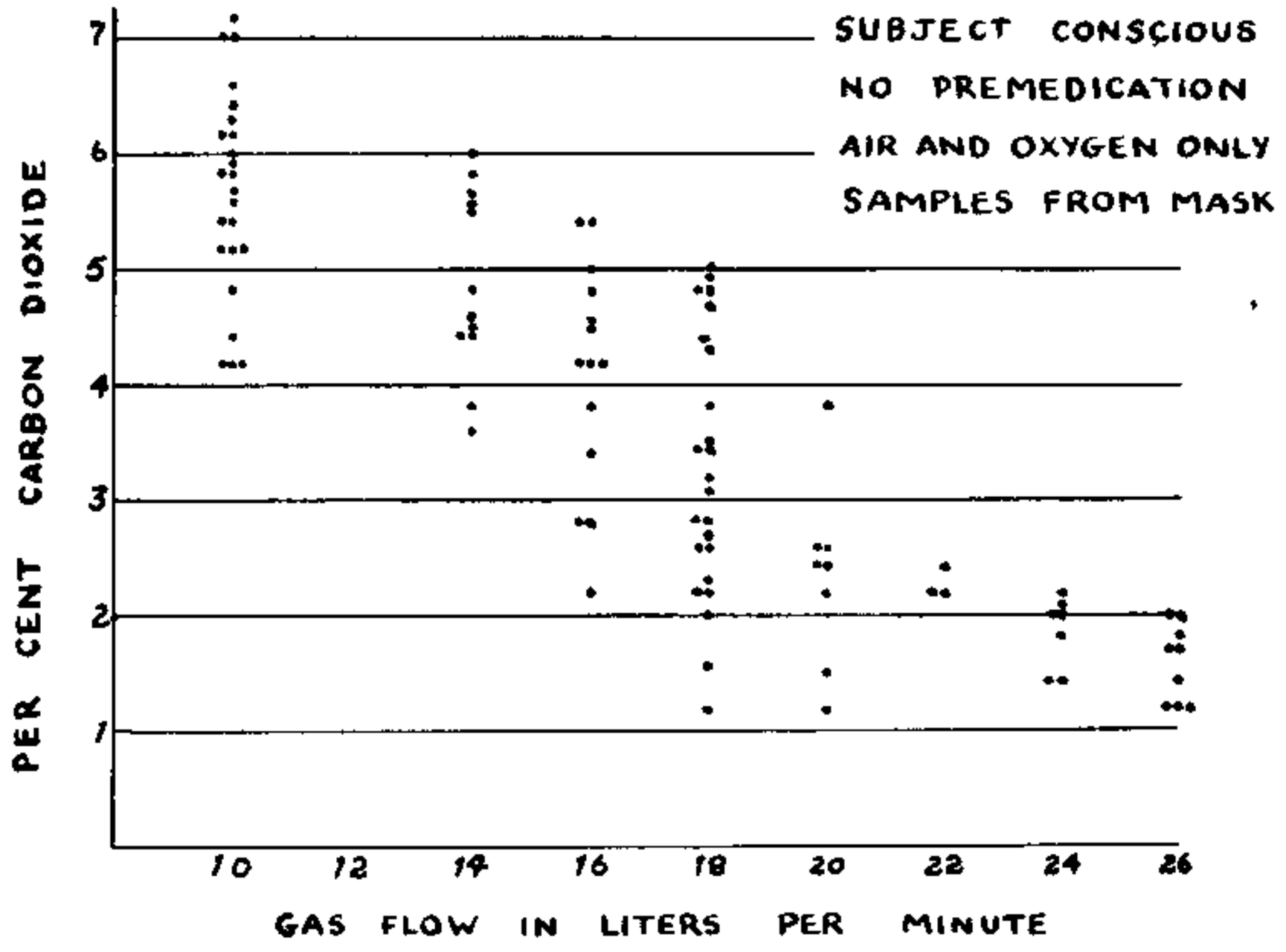


Fig. 4

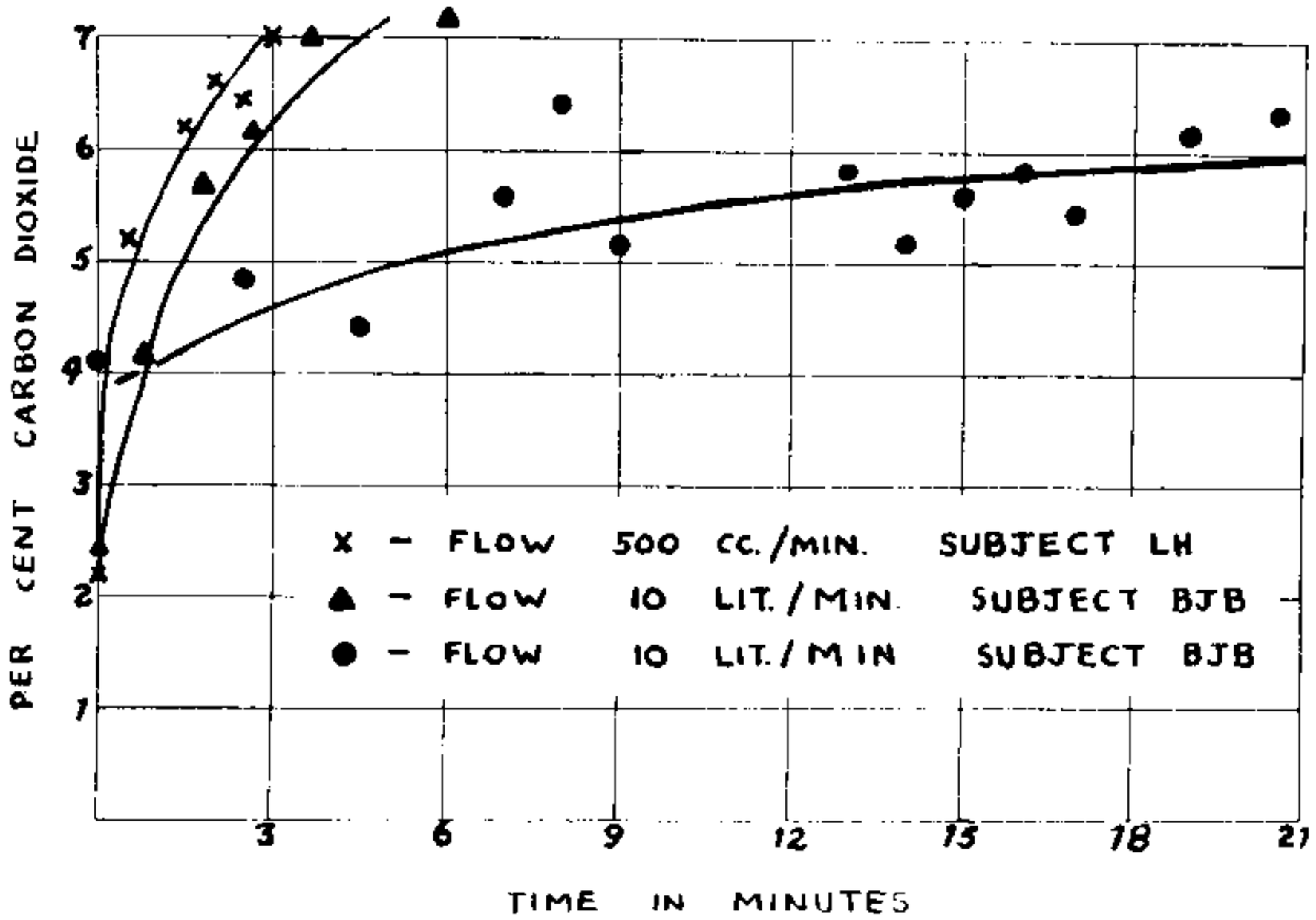

VARIATION IN CO_2 WITH FLOW RATE AND TIME
PER CENT CARBON DIOXIDE
7
6
5
4
3
2
1
X - FLOW 500 CC./MIN. SUBJECT LH
▲ - FLOW 10 LIT./MIN. SUBJECT BJB
● - FLOW 10 LIT./MIN SUBJECT BJB
3
6
9
12
15
18
21
TIME IN MINUTES

Fig. 5

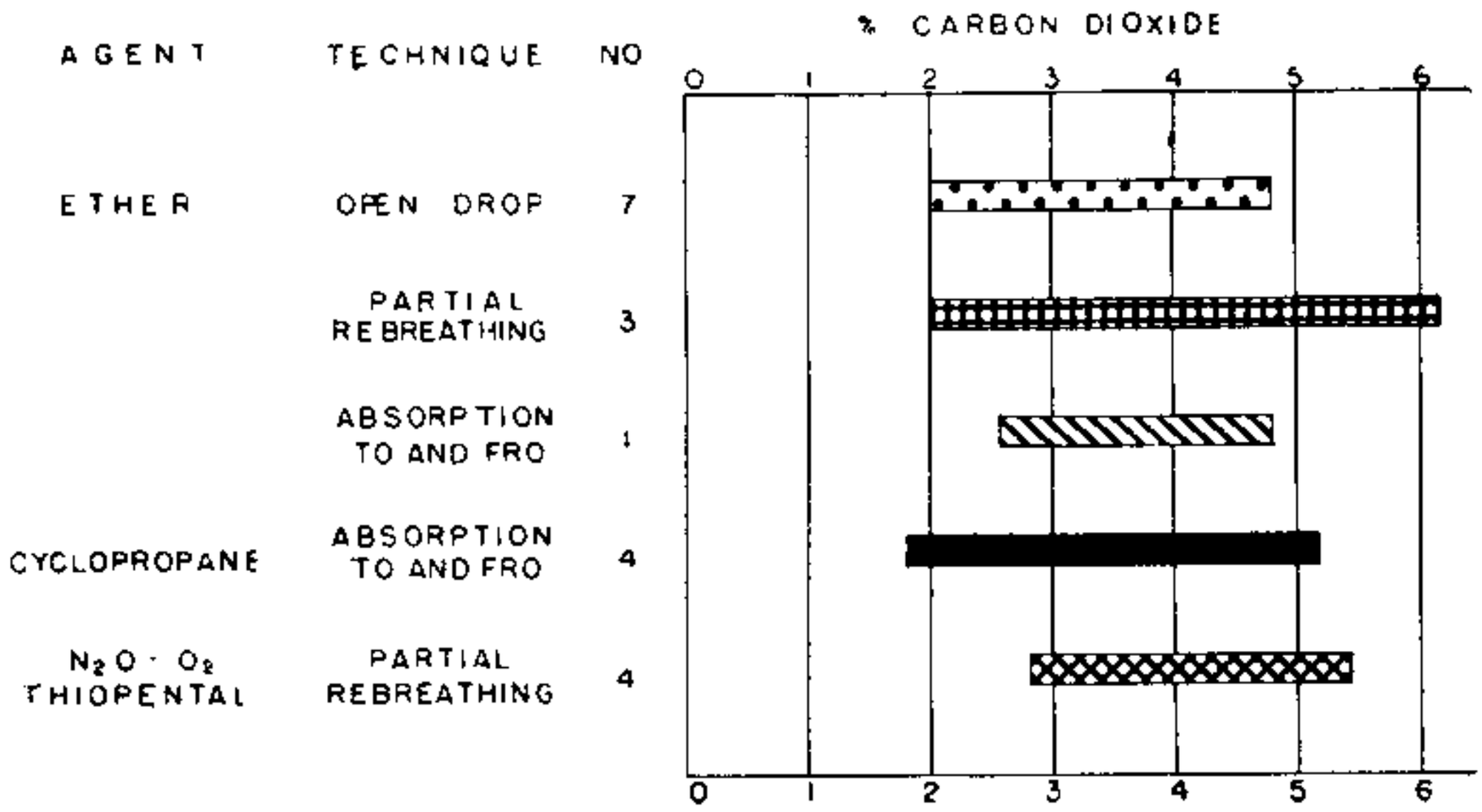

RANGE OF CARBON DIOXIDE VALUES
AGENT
TECHNIQUE
NO
% CARBON DIOXIDE
0 1 2 3 4 5 6
ETHER
OPEN DROP
7
PARTIAL REBREATHING
3
ABSORPTION TO AND FRO
1
CYCLOPROPANE
ABSORPTION TO AND FRO
4
$N_2O - O_2$ THIOPENTAL
PARTIAL REBREATHING
4
SAMPLES FROM MASK

Fig. 6

Another factor which interferes with accuracy is the absorption of ether by the KOH so that abnormally high levels were often found in the presence of that anesthetic agent.

Results

Studies were made in both conscious and anesthetized subjects. Of the studies done in unanesthetized subjects, using a mixture of air and oxygen, one of the interesting findings was the very high gas flow of 26 liters/min. necessary in the "bag and mask" (figure 3) type of rebreath system for reduction of carbon dioxide in the mask to levels of 1-2 % (figure 4). Flows of this rate would rarely be used in clinical anesthesia. Another is the rapid rise of carbon dioxide to 7 % in the mask when a flow of 500 ml./min. is used with out carbon dioxide absorption, and the slower but consistent rise to 6 %, even with flows of 10 liters/min. (figure 5). When the carbon dioxide levels reached 7 % the disconfort in these unpremedicated subjects was too great to continue, and one of the subjects developed tremors of the jaw muscles.

In the preliminary survey of anesthetized subjects samples were obtained from mask and reservoir bag. The results of these samples are shown in figures 6 and 7. The number refers to the number of cases, rather than samples, for each type of administration. The large volume necessary for measurement limits the utility in closed systems in general and the error introduced by ether also adds a complicating factor.

Since no type of spirometer was used, the effect of depth of respiration could not be estimated when unusually high or low carbon dioxide levels were obtained. Ether was found to increase the expected level by being partially absorved by the KOH.

Some variability will be noted when samples are not analyzed continuously. Dependent on the phase of respiration, the possible ranges obtainable are shown in figure 8 where two similar cases are compared.

Discussion

The apparatus used obviously has many deficiences, but if these limitations are accepted, it can be used for studying the gross va-

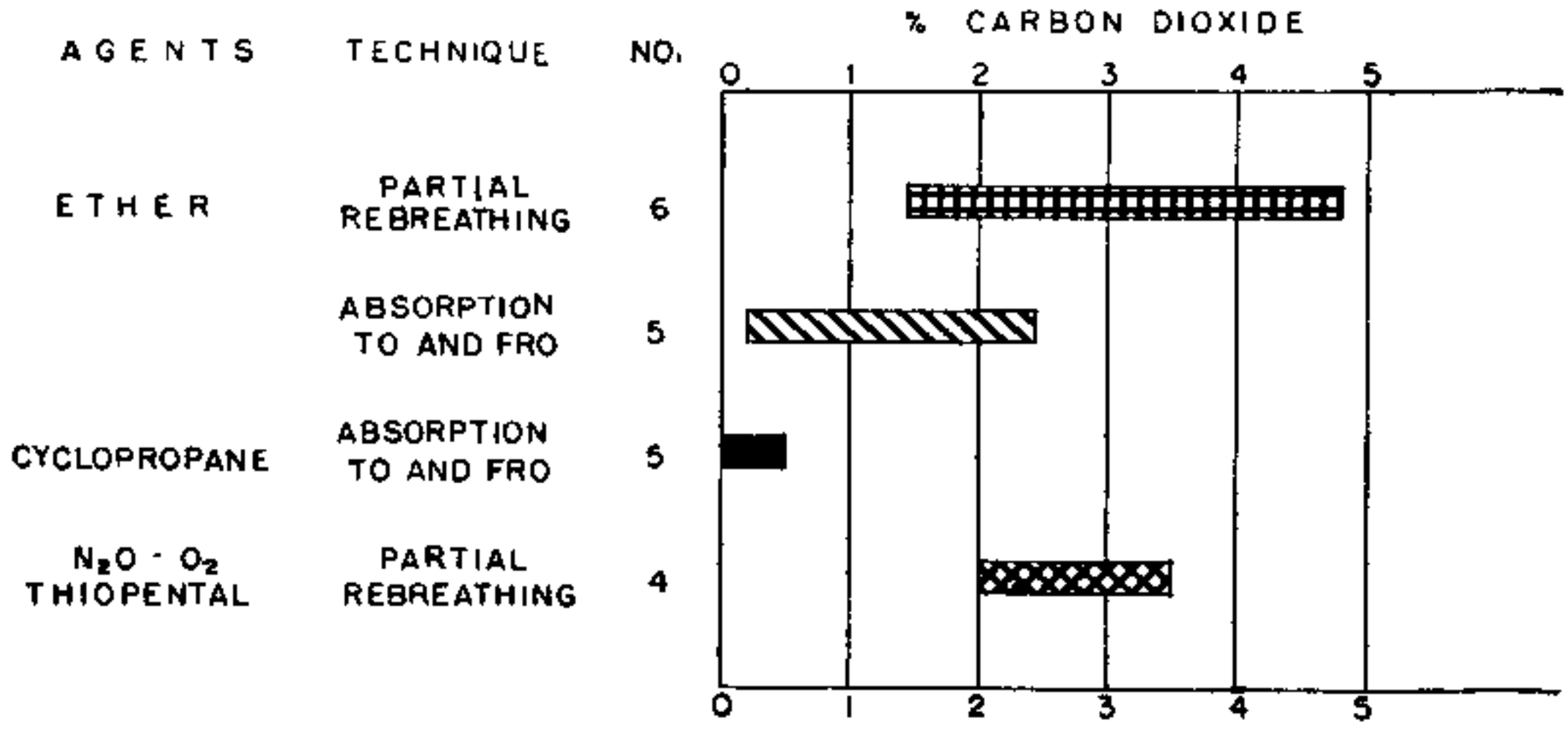


Fig. 7

VARIATION IN VALUES OBTAINED WITH RESPIRATORY PHASE

Anesthesia: Avertin liquid by rectum

Nitrous oxide - oxygen (10 liter flow)

Partial rebreathing endotracheal technique

Samples: From endotracheal tube connector and reservoir bag

Case No.	Type of System	Time of Sample	% Carbon Dioxide Endotracheal Conn. Exp.	Insp.	Reservoir Bag
10	Magill Attachment	11:24	4.0	0.5	
		11:29	4.2	0.5	
		11:45	4.0	0.2	
38	Magill Attachment	8:50	5.3	1.5	0.2
		8:55	4.4	0.5	
	Reservoir Near Face	9:15	5.5	0.5	0.2
			4.7	1.2	0.5

Fig. 8

riation in carbon dioxide tension in anesthesia. A similar study with the newer devices such as a mass spectrograph or the infrared type of carbon dioxide analyzer would add much to our present knowledge, but if it is found true, as suspected, and carbon dioxide accumulation is hazardous, this apparatus is within the price range and limits of accuracy which might be applicable to a small hospital where complicated apparatus is not available.

The study is incomplete — in the number of cases in each category, and in the absence of study of certain systems such as circle absorption, but indicates several directions in which more exact measurement would be of great clinical value.

Summary

The per cent carbon di oxide in the respired atmosphere in unanesthetized and anesthetized subjects with various types of anesthetic apparatus has been presented in graphic form.

FOOTNOTE: I wish to express my thanks for much good counsel in the research project and in preparation of this paper to Dr. O. S. Orth, (present) Director of the Department of Anesthesiology, University Hospitals, Madison, Wisconsin.

GLICOSE A 50%

AMPOLAS COM 10 CM³

Torres

A

"GLICOSE TORRES"

É SUBMETIDA
A RIGOROSAS PROVAS
DE ESTERILIDADE,
INOCUIDADE E DE
ISENÇÃO DE PIROGÊNIO

GLICONECROTON

PREENCHE TODOS OS REQUISITOS
PARA UM SEGURO EMPRÊGO DA GLICOSE

CURARIZANTE

DE

SÍNTESE

FLAXEDIL

2559 F — 3697 RP

★

ATIVIDADE DO CURARE NATURAL

LARGA MARGEM DE SEGURANÇA

SEM EFEITOS HISTAMÍNICOS

★

CIRURGIA

ABDOMINOPELVIANA, TORÁCICA, PULMONAR

ANESTESIA ENDOTRAQUEAL

CONVULSOTERAPIA

★

INJEÇÕES INTRAVENOSAS

CAIXA DE 10 AMPOLAS DE 2 cm^3 DOSADAS A 0,04 g

AMOSTRAS E LITERATURAS À DISPOSIÇÃO DA CLASSE MÉDICA

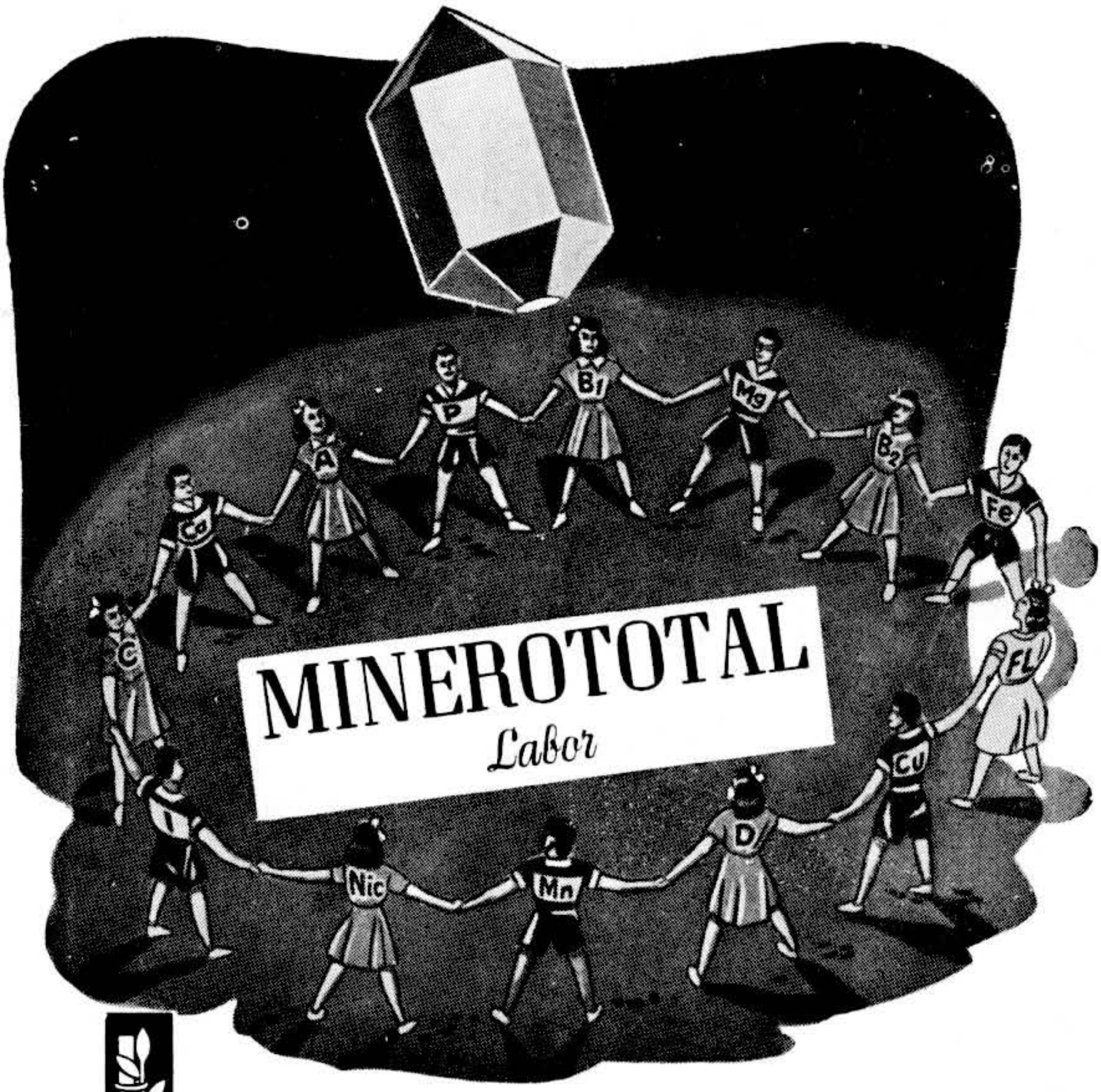
★

RHODIA

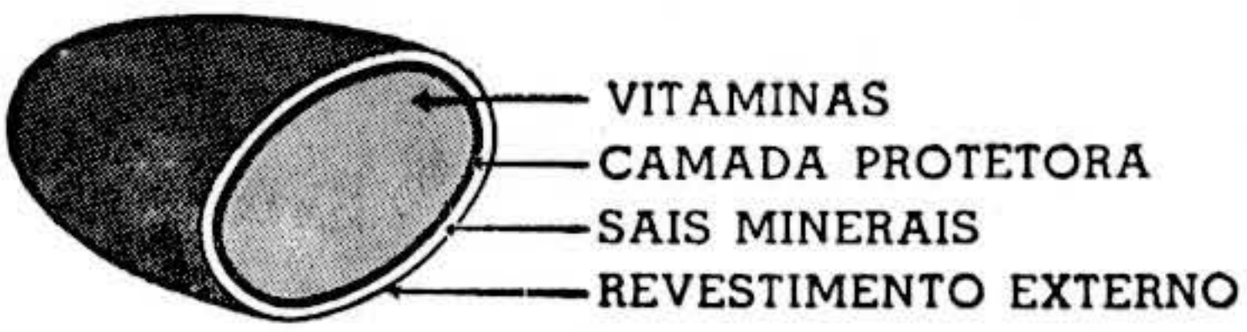
CAIXA POSTAL 8095 — SÃO PAULO, SP

Rhodia

A marca de confiança



Reunião de sais minerais e vitaminas numa só drágea, sem que os primeiros afetem a atividade das últimas.



LABORTERAPICA S. A.

Uma instituição apoiada na confiança do médico

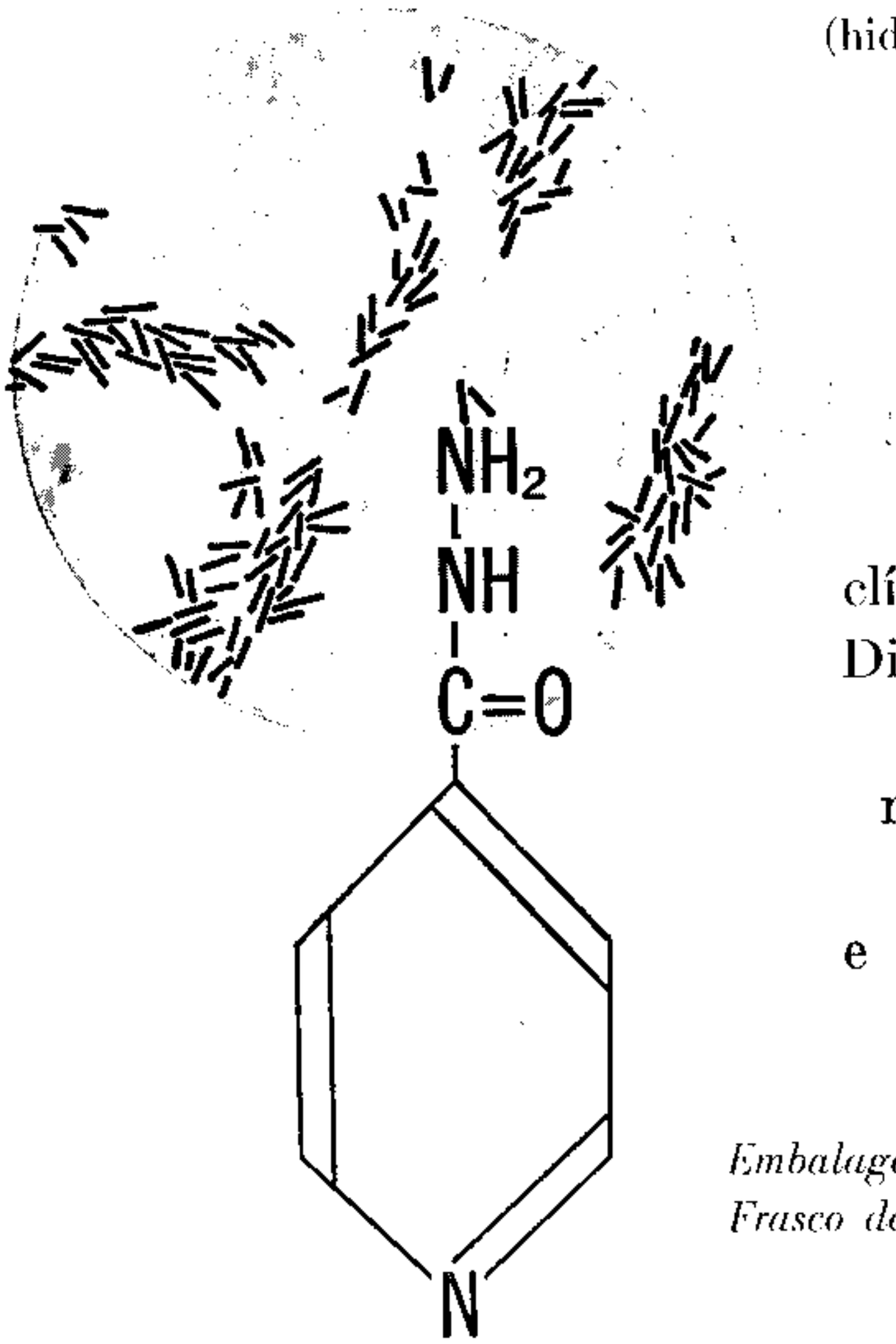
SANTO AMARO (SÃO PAULO)

Para o tratamento da tuberculose

DITUBIN

(hidrazida do ácido isonicotínico)

Schering



Numerosas pesquisas clínicas demonstraram que o Ditubin é um quimioterápico de grande valor no tratamento auxiliar da **tuberculose pulmonar** e da meningite tuberculosa.

Embalagem original
Frasco de 100 comprimidos de 0,50 g

INDÚSTRIA QUÍMICA E FARMACÊUTICA

SCHERING S/A

RIO DE JANEIRO

SÃO PAULO ★ PÔRTO ALEGRE ★ BELO HORIZONTE ★ JUIZ DE FORA ★ FORTALEZA