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AN INTERIM REPORT ON THE EFFECT OF COAL TYPE, PARTICLE SIZE AND STORAGE CONDITIONS ON PROPERTIES OF COKING COALS

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B.N. Nandi*, L.A. Ciavaglia** and J.C. Botham***

INTRODUCTION

A study, which includes the effect of various methods of sample preparation and storage on the thermal rheological properties of selected samples of coking coals, is currently in progress at the Energy Research Laboratories.

Some of the information now available is given herein as a partial response to Resolution 3 of the meeting of ISO/TC27/WG12 held in Denver, Colorado, U.S.A., October 30-31, 1975.

The properties of the coals were determined by standard methods of test (i.e. Constant Torque Gieseler Plastometer by ASTM Designation: D2639-71, Ruhr Dilatometer by DIN 51739 and Test for Free Swelling Index of Coal by ASTM Designation D720-67).

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Coals Selected

The following coals were selected to determine the effect of particle size on their storage properties in air:

(a) No. 1 Western Canadian (low volatile coal)

(b) No. 2 Western Canadian (high volatile coal)

(c) No. 3 Western Canadian (coal blend)

(d) No. 4 German (coal blend)

(e) No. 5 American (low volatile coal)

(f) No. 6 American (high volatile coal)

The coals selected for studies on the effect of storage in different media were as follows:

(a) No. 1 Western Canadian (low volatile coal)

(b) No. 2 Western Canadian (high volatile coal)

(c) No. 5 American (low volatile coal)

(d) No. 6 American (high volatile coal)

(e) No. 7 Eastern Canadian (high volatile coal)

Proximate analysis, thermal rheological properties and petrographic analysis of the above coals are given in Table 1.

Sample Preparation

1. Particle size in air

Three sizes were proposed for this investigation:

(a) Coal as received (< 2-4 mm)

(b) Coal crushed to minus 12 mesh U.S. Standard (< 1.68 mm)

(c) Coal crushed to minus 48 mesh U.S. Standard (< 0.3 mm)

2. Particle size for storage in various media.

The particle size for all storage studies in argon, nitrogen, carbon dioxide, water and refrigeration in air was minus 48 mesh U.S. Standard (< 0.3 mm). All samples were crushed mechanically using a grinding mill to the desired particle sizes.

PROCEDURE

1. Air Medium

The three different particle sizes of the six coals were spread out on cardboard sheets of about 25 cm x 40 cm to about a thickness of 6 mm in open air at room temperature (21-23^{o}C). Representative samples (10-12 gms) were taken out at various intervals of 1, 3, 8, 13 and 25 weeks. Dilatation and Free Swelling Index tests were then carried out on all these samples. Fluidities were determined after the 25 week interval only.

2. Storage in Other Media

(a) Water - Powdered coal was placed in a stoppered Erlenmeyer flask of 500 c.c. capacity and distilled water was used to cover the coal up to the neck of the flask. The dilatation and F.S.I. were carried out at intervals of 4, 9, 14, 19 and 26 weeks. Fluidity determinations were restricted to 26 weeks of storage.

(b) Gases - The powdered coal was placed in different plastic bags and after evacuating the air, the argon, nitrogen and carbon dioxide were introduced into the bags and they were sealed with a twist tie. This procedure was repeated after each test at the specified time intervals.

(c) Refrigeration at $4^{\circ}C$ -

The powdered coals were put in plastic bags under atmospheric conditions and were tightly sealed with a twist tie. They were kept in a refrigerator at $4\text{-}5^{\circ}C$.

RESULTS AND DISCUSSION

The effect of coal particle size on the thermal rheology properties (fluidity and dilatation) of the samples tested after 25 weeks of exposure to air at room temperature is given in Table 2. As may be observed the reduction in the fluidity and dilatation, in general, remained about the same for the three different particle sizes. The degree of change however varied amongst the different coal types tested.

A summary of the results obtained for the various coals in different media for a prolonged period (26 weeks) is given in Table 3. In general, the results of this series of tests indicated that refrigeration of the coal samples is the best method of retaining the fluid and dilatation properties of coal samples.

The results obtained are also presented in Figures 1 to 11.

TABLE 1

Table I

Proximate Analysis

Sample No.	1	2	3	4	5	6	7
Ash	9.4	7.5	9.3	8.1	5.9	4.9	4.3
Volatile matter	20.6	31.2	20.6	24.5	18.6	32.9	36.9
Fixed carbon	70.1	61.3	70.1	67.4	75.5	62.2	58.7
F.S.I.	9.0	9.0	7.5	7.5	9.0	8.5	7.0

Dilatation Test

Softening temperature °C θ_S	384	346	405	398	404	344	348
Contraction % C	21	26	21	23	24	24	26
Max. temperature of contraction °C θ_C	449	420	456	442	449	414	411
Dilatation %	48	179	-1	45	48	139	110
Max. temperature of dilatation °C	485	466	486	473	489	452	443
Plasticity index $\frac{C}{\theta_C - \theta_S}$	0.32	0.35	0.41	0.41	0.53	0.34	0.41

Maceral Analysis

Vitrinite	56.3	75.7	48.3	74.0	80.1	73.7	72.2
Exinite	0.0	4.0	0.1	4.8	-	6.4	4.0
Micrinite	1.9	1.8	1.5	3.3	2.6	4.7	10.2
Semi fusinite	29.9	9.1	35.1	8.9	8.9	6.4	7.0
Fusinite	6.2	5.1	9.7	4.3	5.0	5.8	6.6
Pyrites							
R_r (Max.)	1.43	0.98	1.31	1.28	1.55	1.03	0.91

*Resinous materials

Gieselar Plasticity

Start	437	412	450	426	432	402	402
Fusion Temp.	452	428		439	446	415	418
Max. Fluid Temp.	475	456	470	456	477	442	448
Final Fluid Temp.	503	484	485	484	502	476	486
Solidification Temp.	506	490	494	491	508	478	489
Melting range	66	72	35	48	70	74	84
Max. Fluidity	73	2050	4	39	237	5350	1893
Torque	40	40	40	40	40	40	40

TABLE 2

Effect of Oxidation on Different Particles Exposed to Air

(a) Percent Decrease in Dilatation After 25 Weeks

Sample	2-4 mm	1.7 mm	0.3 mm
#1	35	39	33
#2	27	27	28
#3	-	-	-
#4	77	84	84
#5	13	31	35
#6	42	40	41

(b) Percent Decrease of Fluidity (dd/m) After 25 Weeks

#1	67	52	51
#2	81	69	68
#3	0	43	37.5
#4	74	74	81
#5	-	-	-
#6	46	57	64

(c) Decrease of Free Swelling Index (F.S.I.)
After 25 Weeks

	Orig.	2-4 mm	1.7 mm	0.3 mm
#1	9.0	8.5	8.0	7.5
#2	9.0	8.5	8.0	7.5
#3	7.5	5.0	5.0	5.0
#4	7.5	6.5	5.0	6.0
#5	9.0	8.5	8.5	8.5
#6	8.5	6.0	6.5	7.5

TABLE 3

Effect of Storage in Different Media

(a) Percent Decrease in Dilatation after 26 Weeks

Sample	Air	Argon	Nitrogen	Carbon Dioxide	Refrigerated	Water
#1	33	23	21	25	20	15
#2	28	20	26	31	7	21
#5	35	23	23	27	8	17
#6	41	33	37	38	10	22
#7	-	59	58	60	29	21

(b) Percent Decrease in Fluidity (dd/m)
After 26 Weeks

Sample	Air	Argon	Nitrogen	Carbon Dioxide	Refrigerated	Water
#1	51	40	45	45	9.6	27
#2	68	62	68	74	33	58
#5	-	-	-	-	-	-
#6	64	52	58	58	1	39
#7	-	88	86	88	59	56

(c) Decrease of Free Swelling Index (F.S.I.)
After 26 Weeks

	Orig.	Argon	N_2	CO_2	Refrigerated	Water
#1	9.0	8.5	8.5	9.0	8.5	9.0
#2	9.0	7.0	8.0	8.0	7.5	8.0
#5	9.0	8.5	8.5	8.5	9.0	8.5
#6	8.5	7.5	8.0	8.0	7.0	7.5
#7	7.0	6.0	6.5	6.0	6.5	6.0

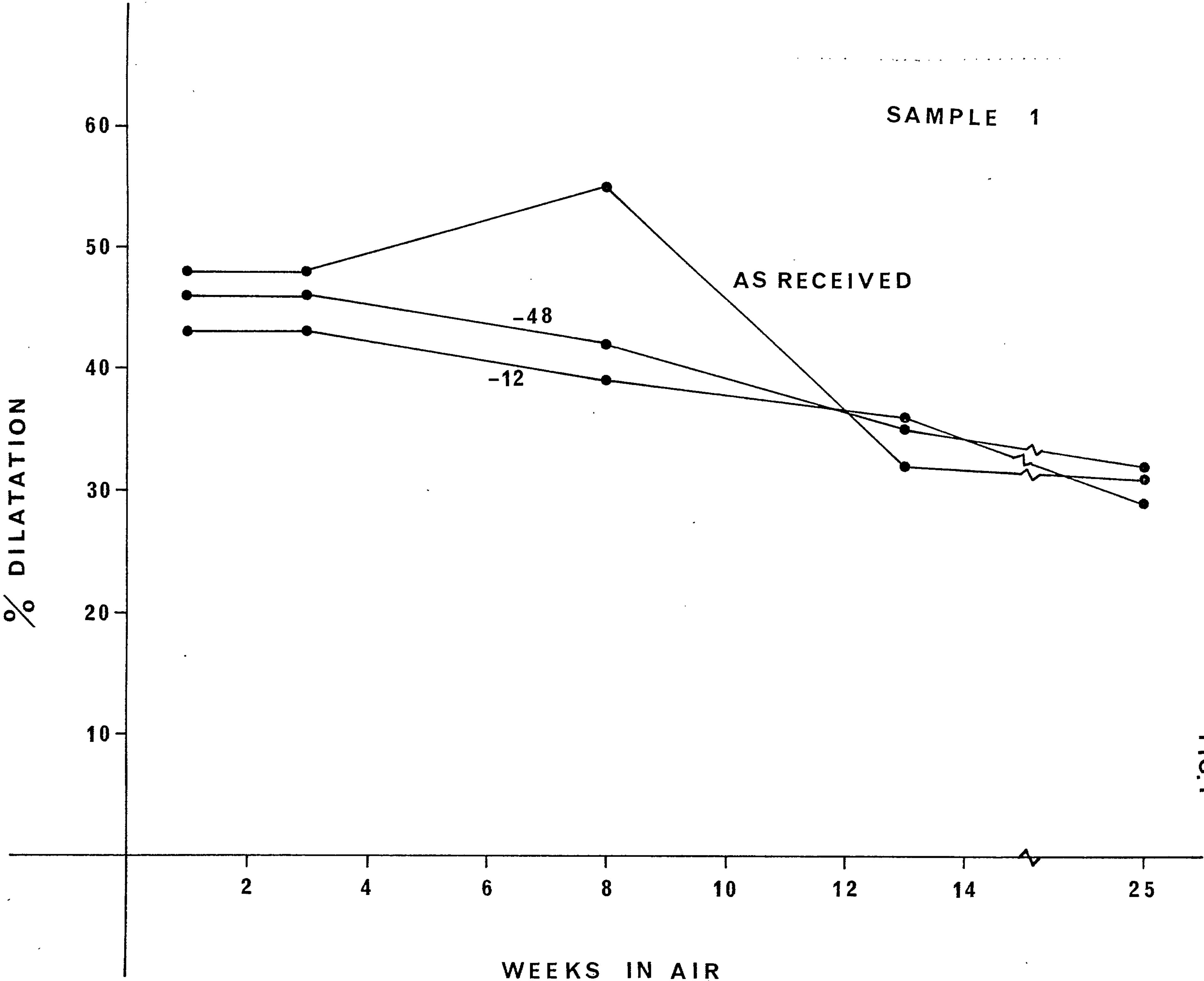

SAMPLE 1
AS RECEIVED
-48
-12
% DILATATION
60
50
40
30
20
10
2
4
6
8
10
12
14
25
WEEKS IN AIR

FIG.1

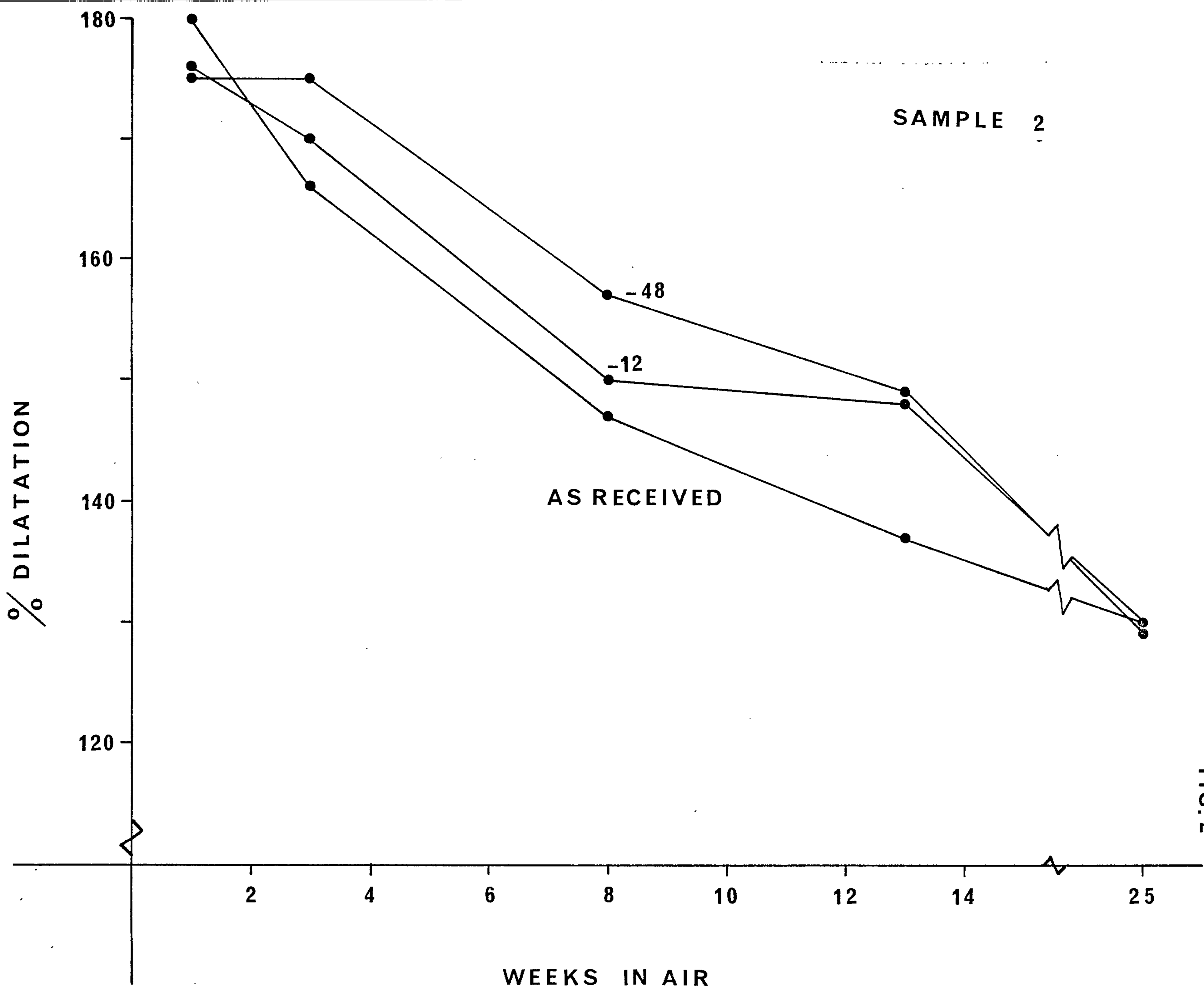

SAMPLE 2
-48
-12
AS RECEIVED
% DILATATION
180
160
140
120
2
4
6
8
10
12
14
25
WEEKS IN AIR

FIG. 2

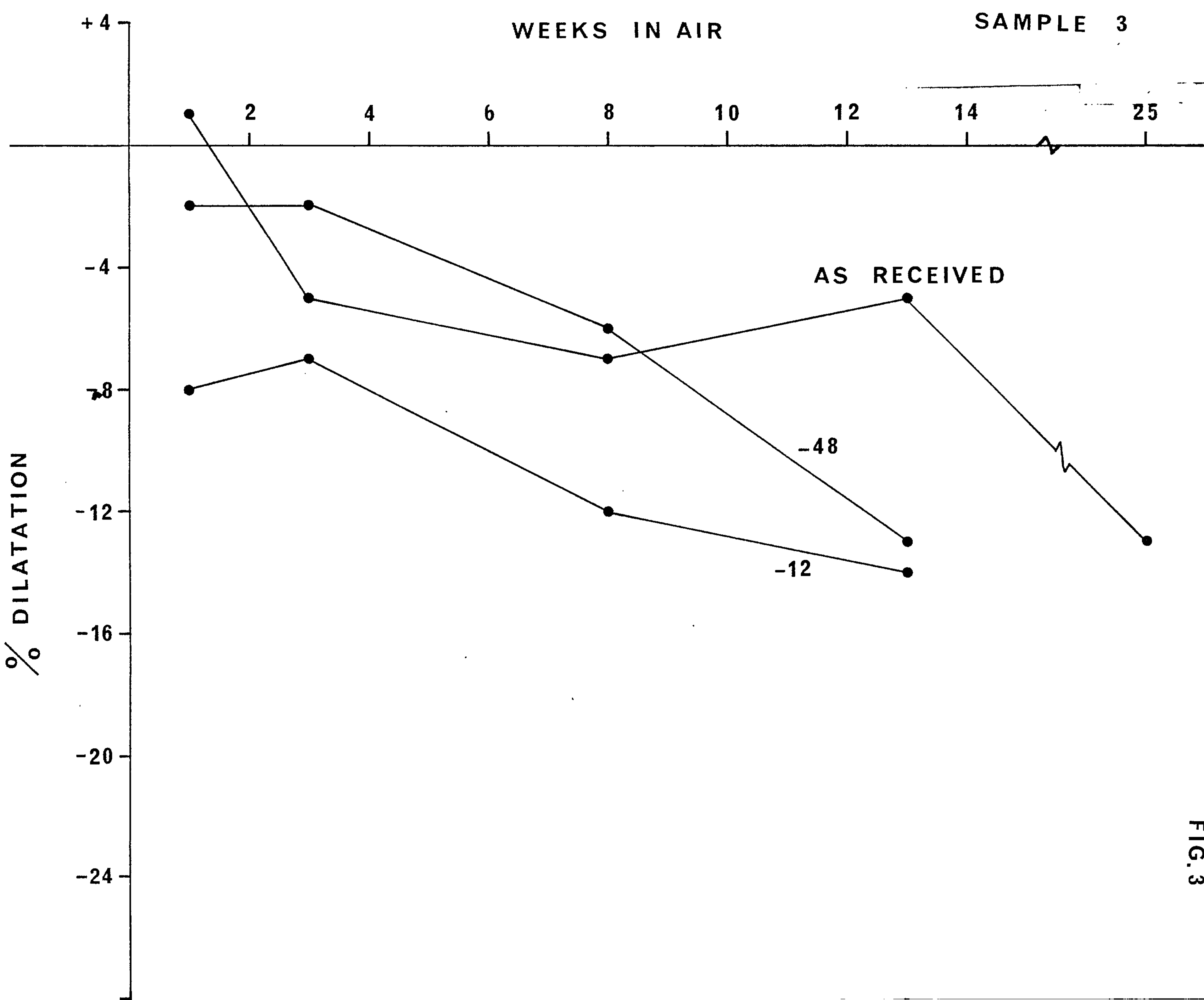

SAMPLE 3
WEEKS IN AIR
+4
2
4
6
8
10
12
14
25
-4
-8
-12
-16
-20
-24
% DILATATION
AS RECEIVED
-48
-12

FIG. 3

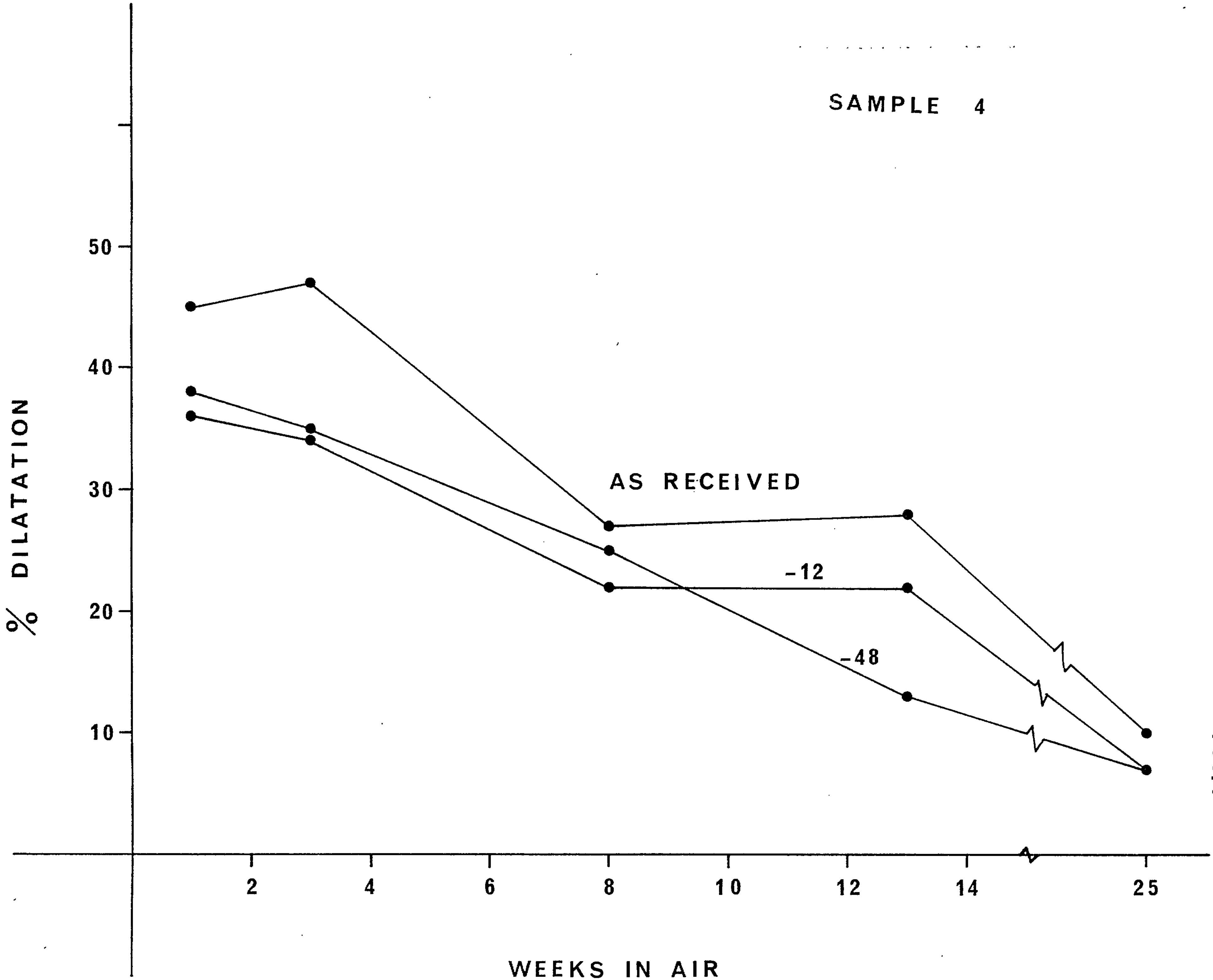
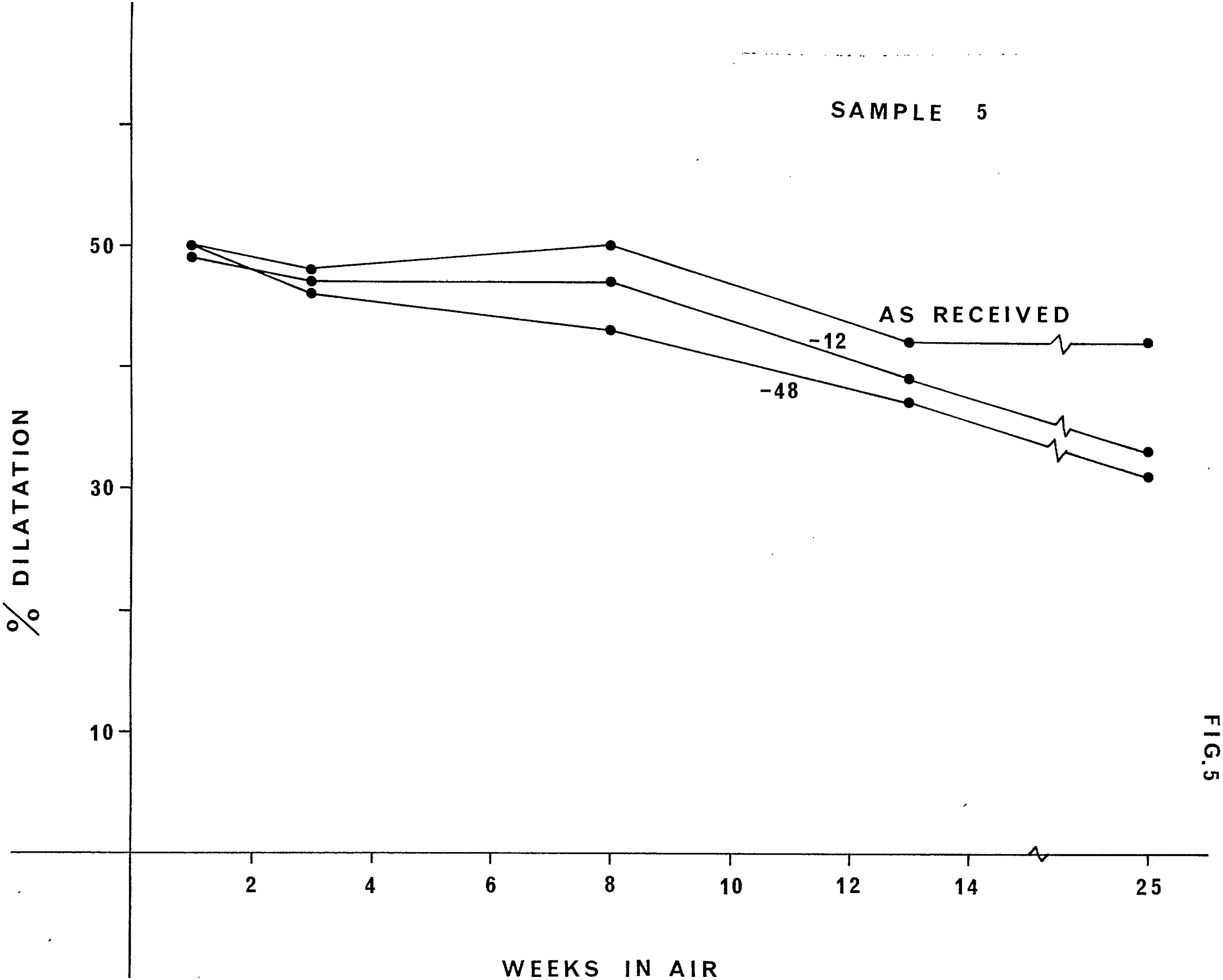
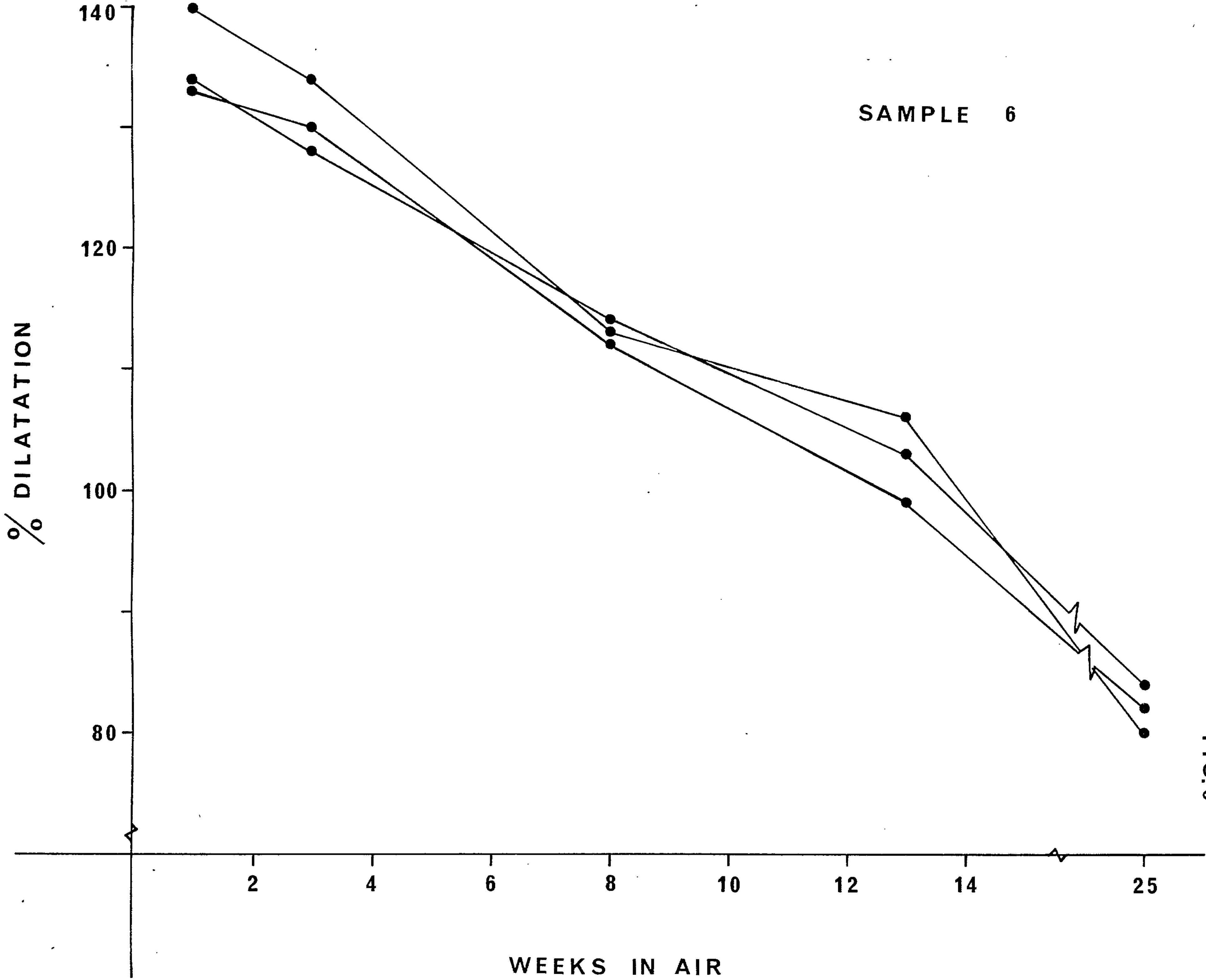

SAMPLE 4
% DILATATION
50
40
30
20
10
AS RECEIVED
-12
-48
2
4
6
8
10
12
14
25
WEEKS IN AIR

FIG.4



SAMPLE 5
AS RECEIVED
-12
-48
% DILATATION
50
30
10
2
4
6
8
10
12
14
25
WEEKS IN AIR

FIG.5



SAMPLE 6
% DILATATION
140
120
100
80
2
4
6
8
10
12
14
25
WEEKS IN AIR

FIG. 6

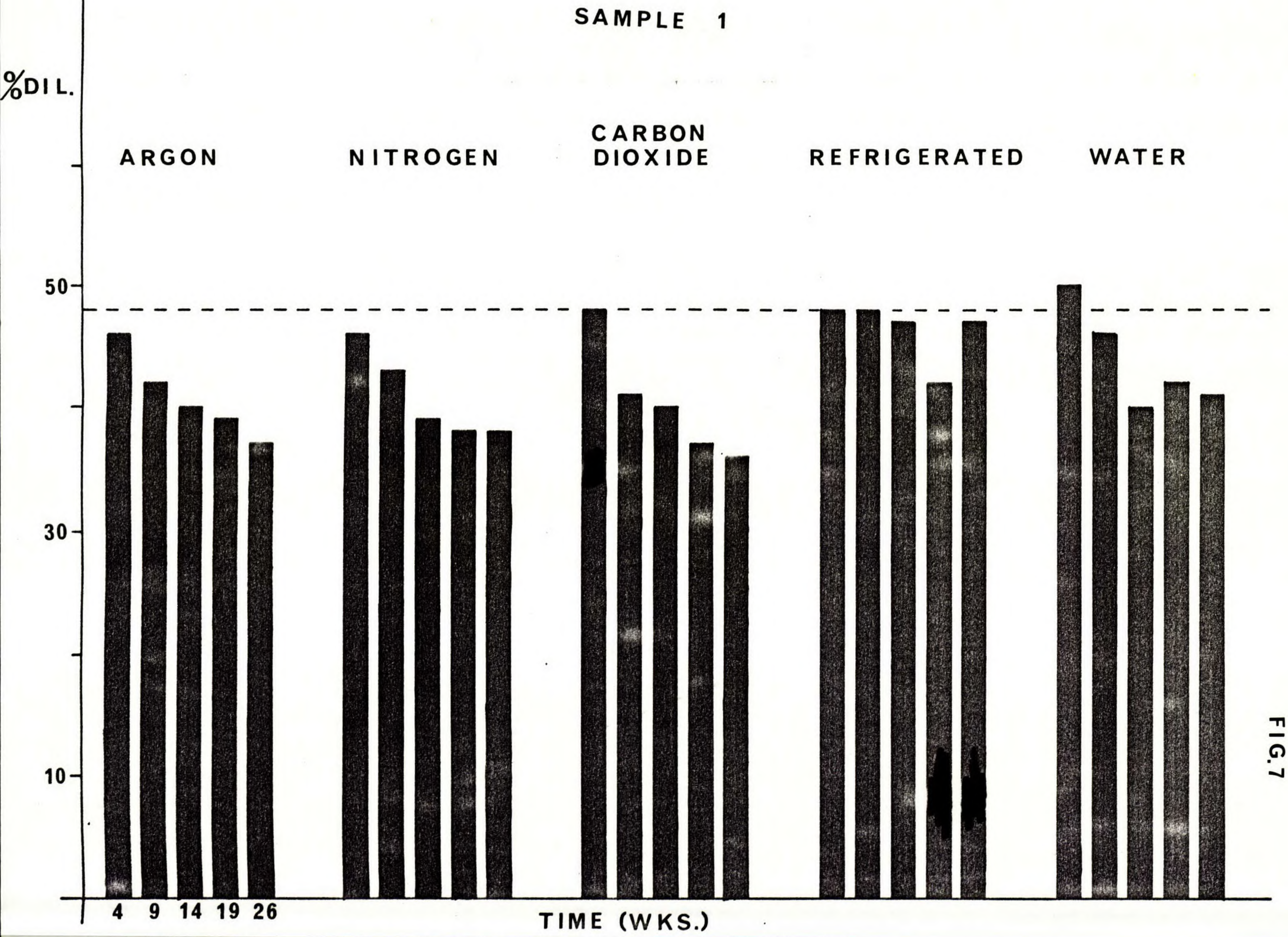

SAMPLE 1
%DIL.
ARGON
NITROGEN
CARBON DIOXIDE
REFRIGERATED
WATER
50
30
10
4 9 14 19 26
TIME (WKS.)

FIG.7

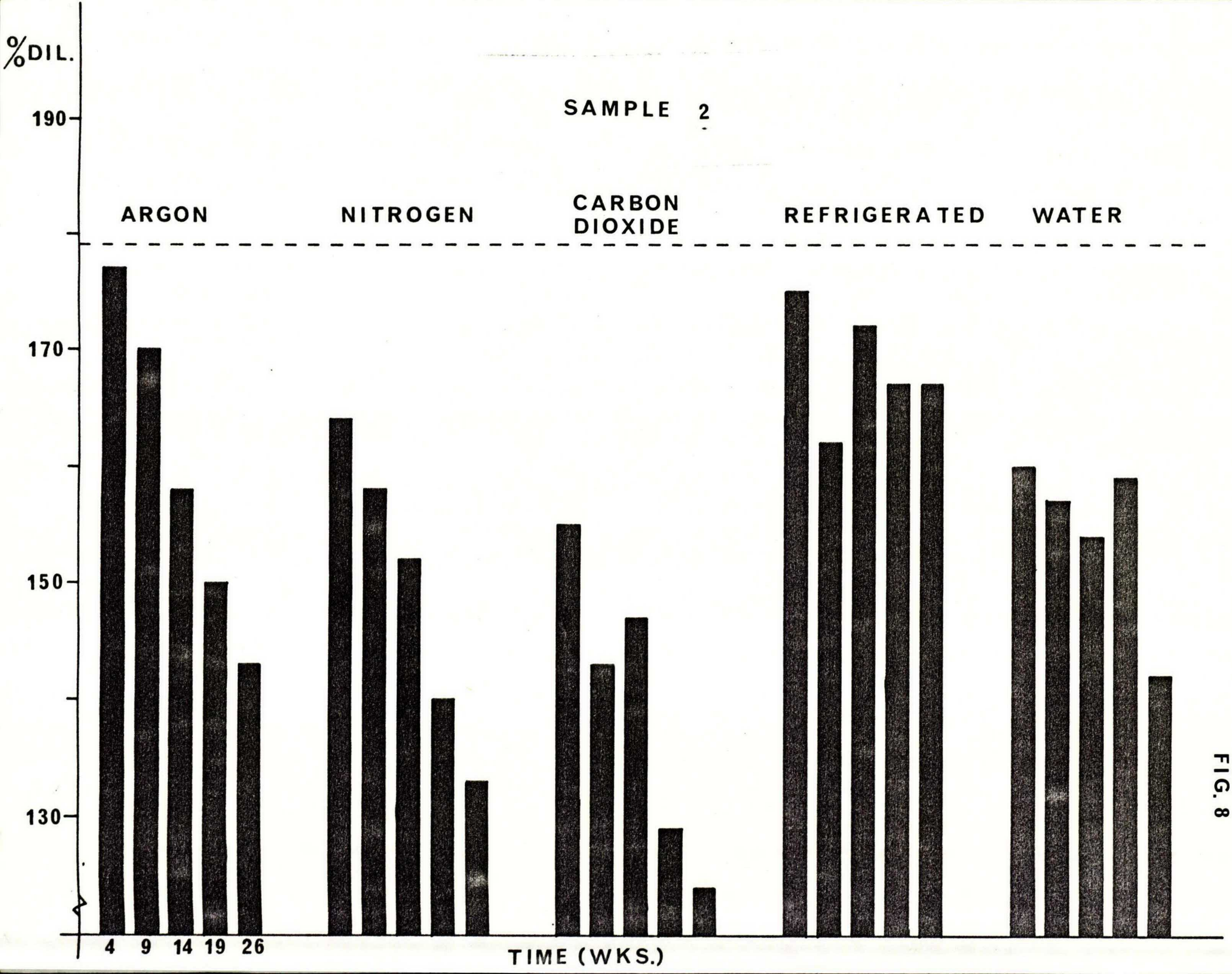

%DIL.
SAMPLE 2
190
170
150
130
ARGON
NITROGEN
CARBON DIOXIDE
REFRIGERATED
WATER
4 9 14 19 26
TIME (WKS.)

FIG. 8

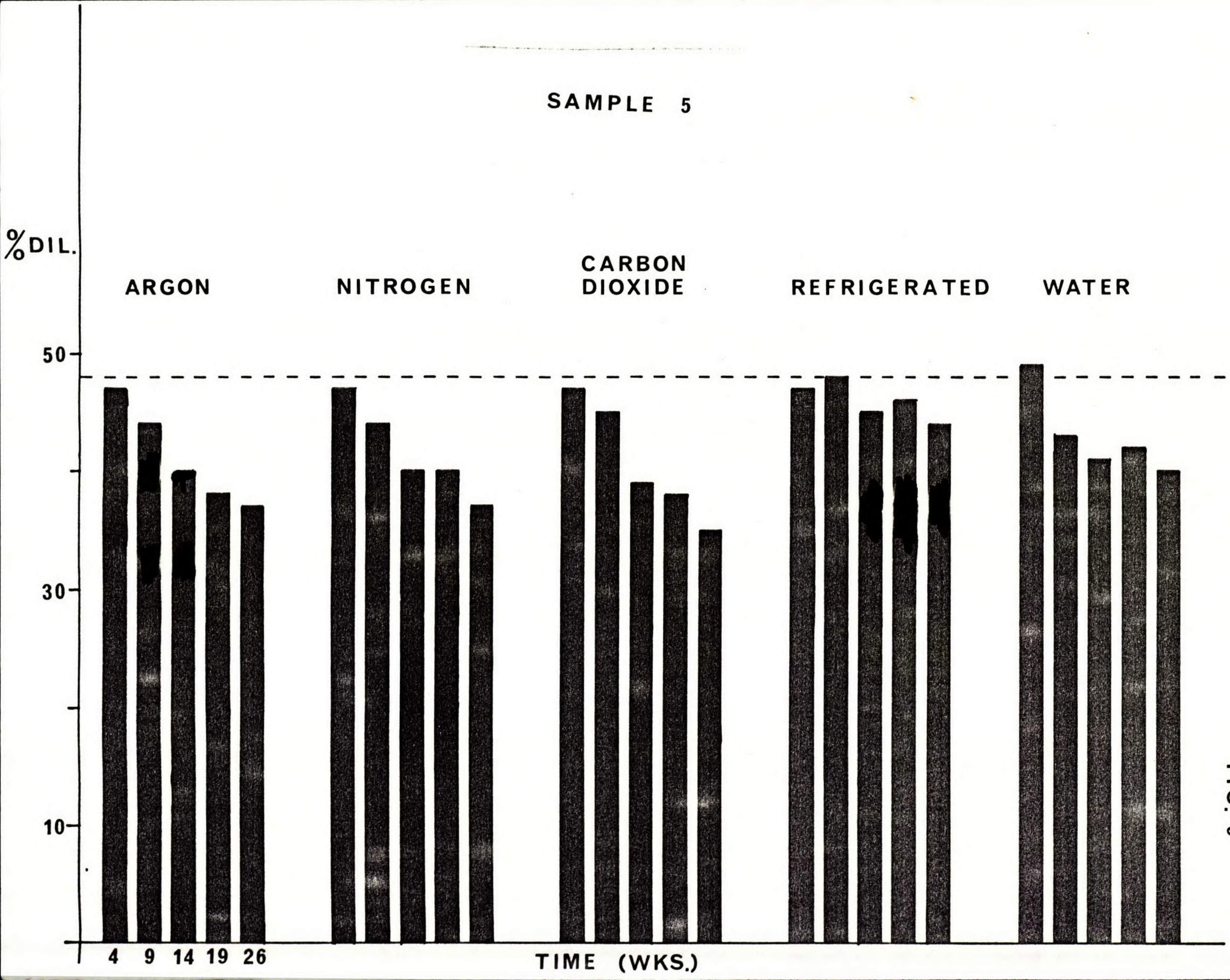

SAMPLE 5
%DIL.
ARGON
NITROGEN
CARBON DIOXIDE
REFRIGERATED
WATER
50
30
10
4
9
14
19
26
TIME (WKS.)

FIG. 9

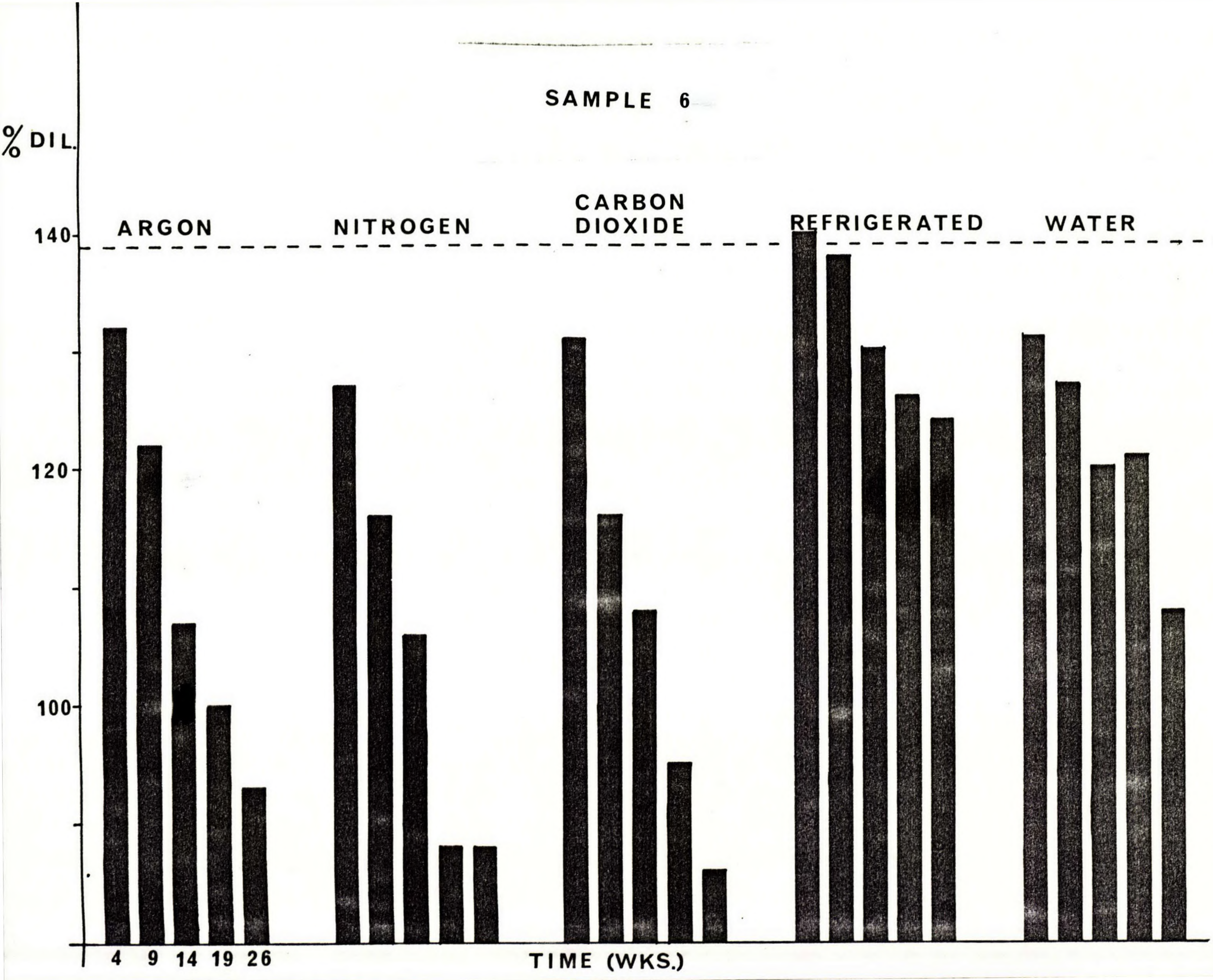

SAMPLE 6
% DIL.
ARGON
NITROGEN
CARBON DIOXIDE
REFRIGERATED
WATER
140
120
100
4
9
14
19
26
TIME (WKS.)

FIG. 10

SAMPLE 7

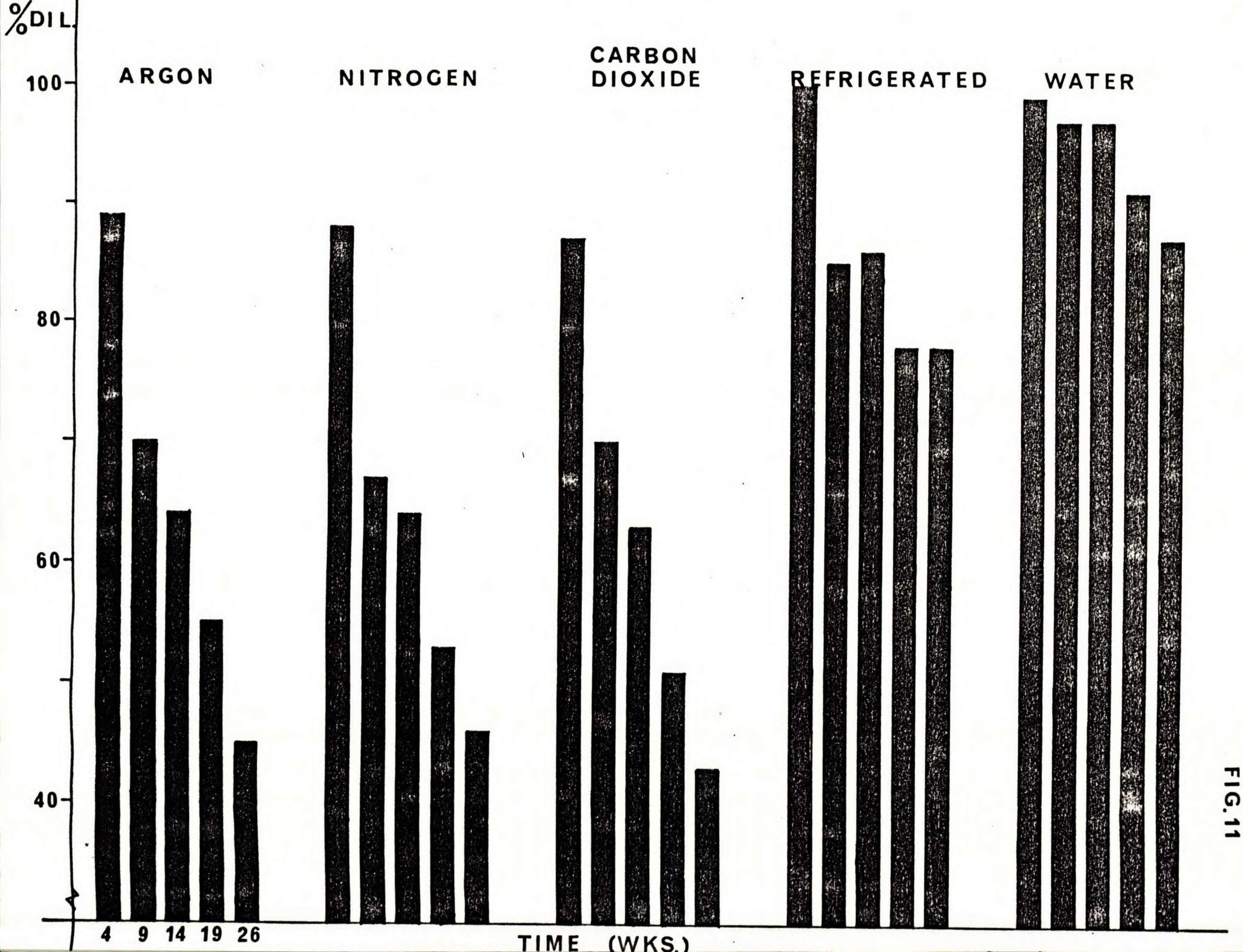


FIG.11