THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Mildred Weigley final oral examination for the degree of Master of Science . We recommend that the degree of Master of Science be conferred upon the candidate.

Minneapolis, Minnesota

June 1 1921

C. H. Bailey
Chairman

R. A. Gortner

M. J. Vanwagenen

C. A. Morrow.

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Mildred Weigley for the degree of Master of Science. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science.

C. H. Bailey
Chairman

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June 1 19~~18~~21

THE CARBON DIOXID DIFFUSION RATIO IN DOUGHS AS AN INDEX OF FLOUR STRENGTH

A Thesis submitted to the
Faculty of the Graduate School of the
University of Minnesota
by
Mildred Weigley
In partial fulfillment of the requirements
for the degree of
Master of Science
June 1921

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THE CARBON DIOXID DIFFUSION RATIO IN DOUGHS AS AN INDEX OF FLOUR STRENGTH[1]

Introduction

The importance of flour strength as related to the baking qualities of flour has been generally conceded by scientists and technical men alike. While "strength" has been variously defined by different workers, the definition offered by Humphries and Biffin (1907) is most generally accepted. They define "strength" as follows:

> A strong wheat is one which yields flour capable of making large, well-piled loaves; the latter qualification thus excludes those wheats producing large loaves which do not rise satisfactorily.

This definition is similar to that of Jago (1911) who states that

> "Strength" is the measure of the capacity of the flour for producing a bold, large-volumed, well-risen loaf.

Historical Review

A survey of the literature concerned with the problems of what constitutes flour strength indicates that investigations made group themselves into those dealing with the gluten proteins as the factor affecting strength and those concerned with other constituents of the flour as they relate themselves to yeast activity. In other words, strength is determined by the gas retained as well as by the gas produced. A brief review of some of the important work will serve to indicate the factors with which strength has been associated in the past and those to which particular attention has been given recently.

The proteins have long been considered as bearing some relation to the expansive property of doughs and to the power of the dough to retain the gas produced. In regard to the latter point, Humphries and Simpson (1909)

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[1] Contribution from the laboratories of the Division of Agricultural Biochemistry.

maintained the view that gas retention is of more importance than gas production, and that therefore, the total quantity of gas evolved is not a true index of flour strength. Humphries (1910) indicated that while in most cases a large loaf is an indication of the high gas-yielding capacity of the flour from which it is made, this factor must not be considered apart from the time at which it is produced and the relation to the gas leakage.

Shutt (1907) concludes that a relationship exists between good bread-baking qualities and a high protein content but that there is no evidence of a definite or absolute ratio. Baker and Hulton (1906) maintain that gluten bears a distinct relation to gas retention. Snyder (1904) states that though total nitrogen fails to measure "strength" in any absolute sense, yet that when wheats are grown under the same conditions, the order of the nitrogen content will be the order of their strengths, or very nearly so. Bailey (1913) found that on the average, strength as indicated by loaf volume increased with the percentage of crude protein in flours containing the same percentage of ash. Armstrong (1910) states that gluten content, associated with strength, is not an absolute measure of it. Humphries (1907) found that on the whole those wheats with the highest nitrogen content gave the best baking results, but that the nitrogen content cannot be taken as a definite index of baking value. Snyder (1901) found the properties of gluten to be of much more importance than the percentage.

The lack of definite correlation between the total nitrogen content or gluten content and the baking strength resulted in further investigation on the gluten with a view to determining the explanation for the variations indicated above. Fleurent (1896) claimed that flour strength depends on the proportion of gliadin to glutenin present in the gluten of the flour and gave as an optimum ratio 75 parts of gliadin to 25 parts of glutenin, or 3:1. He assigned certain limits outside of which flours were said to be of poor baking quality. Snyder (1899a) indicated similar results, but fixed his ideal ratio at 65 parts of gliadin to 35 parts of glutenin. He later states (1904) after developing a polariscopic method for determining gliadin, that this substance should constitute 55 to 65% of the total protein in flours of good quality. Snyder (1899b) extracted the gliadin from flour and found that the loaf from the residue was less than half the size of that baked from normal flour. On the other hand, the extraction of the soluble proteins and the globulin resulted in a normal loaf of bread. Shutt (1907), as indicated before, found a relationship existing between the percentage of glutenin and gliadin and the baking strength but with no definite ratio. Later, (1909) he states that the "gliadin number" or "gliadin ratio" is, on the whole, erratic and apparently of little value for diagnostic purposes, though he believes that the percentage of gliadin is decidedly more valuable. Guess (1900) believes that the proper evaluating factor is the <u>percent of gluten x the ratio of gliadin to glutenin.</u> He shows that though the ratios of the various proteins do not indicate the true "baking value" they have some intimate connection with it. Humphries (1907) concludes, on the other hand that it appears to be the quality rather than the quantity of the gluten which determines strength.

Since neither the total nitrogen nor the ratio of gliadin to glutenin had offered a satisfactory explanation of flour strength some more detailed investigations were made concerning the chemical constitution of gliadin and glutenin. Wood (1907) determined the Hausmann numbers of the gluten from both strong and weak flours but could find no chemical difference.

Later, Van Slyke's improved methods of analyses led Blish (1916) to a further study of flour proteins. He determined the nitrogen combinations in the individual proteins of strong and weak flours to be identical in their chemical constitution. The methods up to the present time, therefore, fail to show noticeable differences in the gliadin and glutenin proteins of weak and strong flours so that it is necessary to look further for convincing relations.

The physical qualities of gluten have been studied with particular effort to shed further light on the question of flour strength. Wood (1907) concluded, as indicated before, that there was no difference in the chemical constitution of gliadin and glutenin from strong and weak flours and decided that strength, particularly in so far as it determines the shape of the loaf, is much more clearly related to the physical state of the gluten, which in turn is affected by the presence of electrolytes. He showed that very small quantities of acids and alkalis tend to disperse the gluten, rendering it weak and lacking in elasticity. The addition of salts, however, produces a counteracting effect, rendering the gluten strong and elastic. Phosphates and chlorides were found to be equally efficient in producing coherence; the soluble sulphates were about 50% more effective. The sulphates of Na, Mg, and Al were used and found to be effective in this order. He concluded that the power which dough possesses of retaining the gas formed during fermentation is due to the tenacity and ductility of gluten. Wood and Hardy (1909) studied the effect of electrolytes upon coherence and elasticity of colloids and showed that the concentration of the salts needed to balance the acid increases to a maximum as the concentration of the acid increases and then declines to the zero point where acid alone is sufficient to maintain coherence. White and Beard (1913) maintain that in general larger loaves contain less of all divisions of phosphorus than smaller ones; larger loaves, however, contain a higher percent of organic P_2O_5 than the smaller ones. The role of hydrogen ion concentration is probably of considerable importance as a factor in flour strength. Work has been done to show that gluten proteins have an iso - electric point at which they obtain maximum coherence and that the properties of a gluten are improved by progressive increases in hydrogen ion concentration up to the point at which dough is in optimum condition. This optimum condition is in turn determined by the hydrogen ion concentration. Fessen - Hausen (1911) states that for the dough of any wheat flour there exists a determined concentration in hydrogen ions to which the bread made from the flour would best be brought. He found this optimum concentration to correspond approximately to a PH - 5 though for choice flours it appeared to be a little higher and for poor ones a little lower. Cohn and Henderson (1918) state that among the most important effects of acids, alkalis and salts upon protein is the modification of elasticity, tenacity and cohesiveness. Laudenberger and Morse (1918) in some experiments with barley gluten and salt effect came to the conclusion that with some colloids at least, viscosity is increased by raising the content of inorganic salt.

White (1913) concluded that acid and water extracts of bran had favorable influence on loaf volume. He thinks this is due to the fact that the gluten has become more coherent through the acids and soluble salts. Cohn and Henderson (1918) confirm this view. Shutt (1907) claims no relation between soluble salts and loaf volume, thereby failing to confirm the work of Wood and of Whitel Gortner and Doherty (1918) show that the determining factor in flour strength is not the concentration of soluble acids and salts.

They claim that there is an inherent difference in the glutens from the strong and weak flours, that the physico-chemical properties of the glutens from the different flours are not identical and would not be so even if the flours had originally had the same acid and salt content. Their work leads them to believe that the difference between a strong and a weak gluten is a colloidal difference, and suggests that the differences may be due to the size of the gluten particles and that at least a part of the particles comprising the weak gluten may be nearer the boundary between the colloidal and crystalloidal states of matter than is true with the stronger glutens.

The presence of certain protein splitting enzymes in protein cannot be ignored as possible factors in flour strength. Obviously anything Which would break up the proteins would serve to change the physical characteristics of gluten. Armstrong (1910) maintains that proteoclastic enzymes have been found in flour. Ford and Guthrie (1908) claim that the presence of proteoclastic ferments in flours is an important consideration in flour strength.

So far the literature cited has been concerned particularly with the protein content of flour and its relation to strength. The other line of investigation concerned with flour strength deals with those factors relating to yeast activity and affecting the production of carbon dioxid. Chief among these are the sugar content of the flour, the soluble proteins and the mineral salts.

Sugar in the dough is essential for fermentation. The sugar found in the dough is from two sources; first the sugar originally in the flour, second, the sugar produced through enzym action. The sugar normally present in sound flour is very small. Wood (1907) states that the size of the loaf depends on the amount of sugar contained in the flour, together with that formed in the dough by diastatic action. Shutt (1907) claims that the amount of sugar found in sound flours cannot be regarded as having any marked influence on the resultant loaf. Humphries and Simpson (1909) maintain that the gas produced in the later stage of fermentation is more important than that in the early stages. Diastatic action naturally affects the gas production in the latter stages. Martin (1920) on the other hand considered the gas produced in the later stages of fermentation so erratic that he used only that produced in the earlier stages to indicate the relation to volume. He concludes from his work that a strong flour must possess a minimum gas producing capacity although this statement seems hardly in accord with his previous statement in the same paper to the effect that neither the total gas nor the amount liberated during the proving period determines the size of the loaf. Alway and Hartzell (1910) state that it is improbable that there is any marked connection in the case of somewhat similar flours between the size of the loaf and the amount of gas evolved.

Humphries (1910) did further work in which he concludes that in most cases a large loaf is an indication of the high gas yielding capacity of the flour from which it is made, and also is ordinarily an indication of high diastatic power. Ford and Guthrie (1908) indicate that in developing a method of evaluation the total amylase is an important factor inasmuch as the carbon dioxid is produced largely from sugars formed from the starch by the amylase. Baker and Hulton (1907) do not believe that diastatic activity is closely related to baking quality. Later (1908) they confirm this view and state that a weak flour may have a diastatic power as high or even higher than a strong flour. They believe, however, that gas production follows fairly closely the maltose formed during the fermentation of the dough.

In addition to sugar certain inorganic substances provide food for the yeast. Mineral substances are frequently added to accelerate yeast activity and thus affect gas production. Most of the so-called "flour improvers" belong to this group. Prominent among the mineral salts used are phosphates. Humphries (1910) indicates desirable results from the use of potassium, magnesium, calcium and ammonium phosphates. White (1913) experimented with acid and water extracts of bran and found that both produced marked improvement in the loaf volume. He attributes this beneficial effect to the improved coherence of the dough, and believes with Wood, (1909), that it is the phosphates in the extract which are responsible for coherence.

Kohman and Hoffman (1916) tested the effect of a large number of mineral salts upon the fermentative power of yeast. They concluded that ammonium salts had a particularly desirable effect since they caused the greatest acceleration of yeast activity toward the end of the fermentation period. Hoffman (1917) confirms his previous work and shows how ammonium chloride acts as a yeast food rather than serving as a gluten conditioner. Kohman and Hoffman (1916) state that calcium salts also are favorable in their action. They believe their results indicate that calcium sulphate has an effect upon the gluten of the dough as well as upon the yeast. Their work with potassium bromate showed this substance to act upon dough imparting very desirable properties through the maturing or aging effect which it has upon the dough. Falk and Winslow (1918) believe this favorable effect of potassium bromate to be due to its effect upon enzym action.

Regarding the influence of flour improvers Jessen - Hanson (1911) attributes the favorable effect of neutral salts and "flour improvers" on flour to the increased hydrogen ion concentration which they produce.

Soluble nitrogen compounds, as well as sugar and mineral salts, probably influence yeast activity. Snyder (1899b) found that flour from which the water soluble proteins and the globulin were extracted gave a normal loaf of bread.

Some work has been done on the toxicity of flours to yeast. Baker and Hulton (1909) report that the poisonous effect of wheat flour is exhibited in the retardation that it produces on the fermentation of invert sugar with brewer's yeast. They found at the same time that this effect was counteracted to some extent by the use of potassium sulphate. This toxicity of flour to brewer's yeast is of less significance than it would be if it were also toxic to baker's yeast.

Masters and Manghan (1920) report work on the addition of blood serum on the bread-making properties of flour. They found definite increase in the size of the loaf with fresh serum but this effect diminished rapidly on keeping. They also report work on the use of raw potato, cooked potato and potato flour showing that both raw and cooked potato gave a larger loaf, the increase being greater however, with cooked than with raw potato. Potato flour, on the other hand, was found to diminish the expansion of the dough.

THE PROBLEM

In work reported by Humphries and Simpson (1909) and later by Humphries (1910) the importance of considering gas retention as well as gas production is emphasized. However, neither in this work nor in that of Baker (1906) showing the relation of gluten to gas retention has anything been done to determine the ratio between the gas retention capacity of the dough and gas leakage. It was thought worth while, therefore, to undertake to determine whether the carbon dioxid diffusion ratio, that is, the ratio between the gas retained in the dough and the gas released from the dough, was any index of the strength of flour.

EXPERIMENTAL PROCEDURE

A "strong" and a "weak" flour were selected. The strong flour was a composite "straight" flour; the weak flour was milled at Spokane from the typical soft wheat of that region used for the manufacture of pastry flour. Baker's yeast from one manufacturer was used throughout the work.

Analyses, Viscosity and Baking Tests

Preliminary to the determination of the carbon dioxid loss and the volume increase, baking tests were made on each of the flours in order to decide whether they could be evaluated as strong or weak flours as indicated by their loaf volume.

Analyses of the flours were also made to determine the percent of moisture, protein, and ash present in each.

It will be seen from Table I that in so far as loaf volume is used as a measure of strength the "straight" flour is shown to be markedly stronger than "878". The flour indicated as weak by the baking test shows also a much lower percentage of protein than the strong flour.

Table I Analyses and baking tests of weak and strong flours

Flours	Moisture	Crude Protein (NX5.7)	Ash	Volume of loaf	Color Score	Texture	Expansimeter Test
	Percent	Percent	Percent	c.c.			
Weak("878")	10.88	8.00	0.52	1200	97	85	520
Strong(straight)	8.95	12.00	0.56	15.80	98	100	910

These results are in accord with those of Shutt (1907) and Humphries (1907) who found that while high nitrogen value is not an absolute measure of strength, it is associated with it.

The viscosity of the flours was determined in a MacMichael viscosimeter to see whether their viscosity varied with their strength. This was accomplished by suspending a quantity of flour equivalent to 25 gms. dry weight in the equivalent of 100 c.c. water, allowing it to stand for an hour, then determining the viscosity of this suspension and the same mixture with progressive increase in acidity. Table II shows the results of this test. This procedure used by Gortner and Sharpe* apparently serves to indicate the relative strength in so far as strength is determined by the percentage and character of the gluten.

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*From unpublished work.

Table II Viscosity of Weak ("878") and Strong (straight) Flours

Normal lactic added	Weak flour 28.05 gms. flour + 96.95 c.c. water	Strong flour 27.45 gms. flour + 97.55 c.c. water
C.C.	0° MacMichael	0° MacMichael
.0	32	68
.5	32	73
1.0	38	104
1.5	43	135
2.0	50	161
2.5	53	183
3.0	56	196
4.0	60	212
5.0	-	221
6.0	62	222
8.0	62	222
10.0	61	219

The General Method Employed

The general method used was that of determining the loss of carbon dioxid from the dough during fermentation through the use of carbon dioxid absorption towers, and the determination of the increase in volume of the dough during the same interval of time. The flours were treated in various ways in order to see whether the value of the addition of so-called "flour improvers" bore any relation to the carbon dioxid diffusion ratio.

In order to determine to what extent the quality rather than the quantity of protein might affect the relations being studied, such addition of cornstarch was made to the strong flour as would produce (1) an amount of protein equivalent to that in the weak flour, (2), an amount equivalent to one-half that of the weak flour.

In all, eighteen series of doughs were subjected to the treatment indicated above. These were made from the weak and strong flours as follows:

Series

I Weak flour ("378") - Control.

II Strong flour (straight) - Control.

III Strong flour with addition of cornstarch to give protein content of weak flour.

IV Strong flour with addition of cornstarch to give one-half protein content of weak flour.

V Weak flour with addition of calcium sulphate.

VI Strong flour with addition of calcium sulphate.

VII Weak flour with addition of ammonium chloride.

VIII Strong flour with addition of ammonium chloride.

IX Weak flour with addition of calcium sulphate and ammonium chloride.

X Strong flour with addition of calcium sulphate and ammonium chloride.

XI Weak flour with addition of ammonium phosphate ($NH_4H_2PO_4$).

XII Strong flour with addition of ammonium phosphate ($NH_4H_2PO_4$).

XIII Weak flour with addition of ammonium persulphate.

XIV Strong flour with addition of ammonium persulphate.

XV Weak flour with addition of potassium bromate.

XVI Strong flour with addition of potassium bromate.

XVII Weak flour with addition of Arkady.

XVIII Strong flour with addition of Arkady.

Preparation of the Dough.

The doughs were mixed according to the methods outlined by Bailey (1916), the following amounts of ingredients being used:

Flour	Yeast	Salt	Sugar	Water
350 gms.	4.27 gms.	5.25 gms.	8.75 gms.	sufficient

For convenience in working, a solution of sugar and salt was made. Additional water was used as necessary to produce a dough of the right consistency. The average variation in the additional water added was within 3 c.c. in both flours. In mixing and in subsequent kneading, care was taken to treat doughs uniformly.

As soon as the dough came from the mixing machine three portions, equivalent each to 50 gms. of the flour used, were weighed out. One portion was placed in a small tin container which fitted into a glass chamber (see Diagram I). A square piece of ground glass in which was inserted a tube leading to the carbon dioxid free air was used to cover the chamber. The second was placed in a 250 c.c. graduate 4.5 cm. in diameter. The third portion was used to secure the initial volume of the dough by determining its displacement in water. The remainder of the dough was placed in a jar in a thermostat maintained at a temperature of 28° C (82.4° F) and used later in a manner which will be described.

Determination of Carbon Dioxid and Volume Increase.

The method employed for determining the gas leakage or loss of carbon dioxid was substantially that reported by Truog (1915) whereby the carbon dioxid was absorbed in a barium hydroxide solution contained in an absorption tower. The glass chamber holding the tin receptacle filled with dough

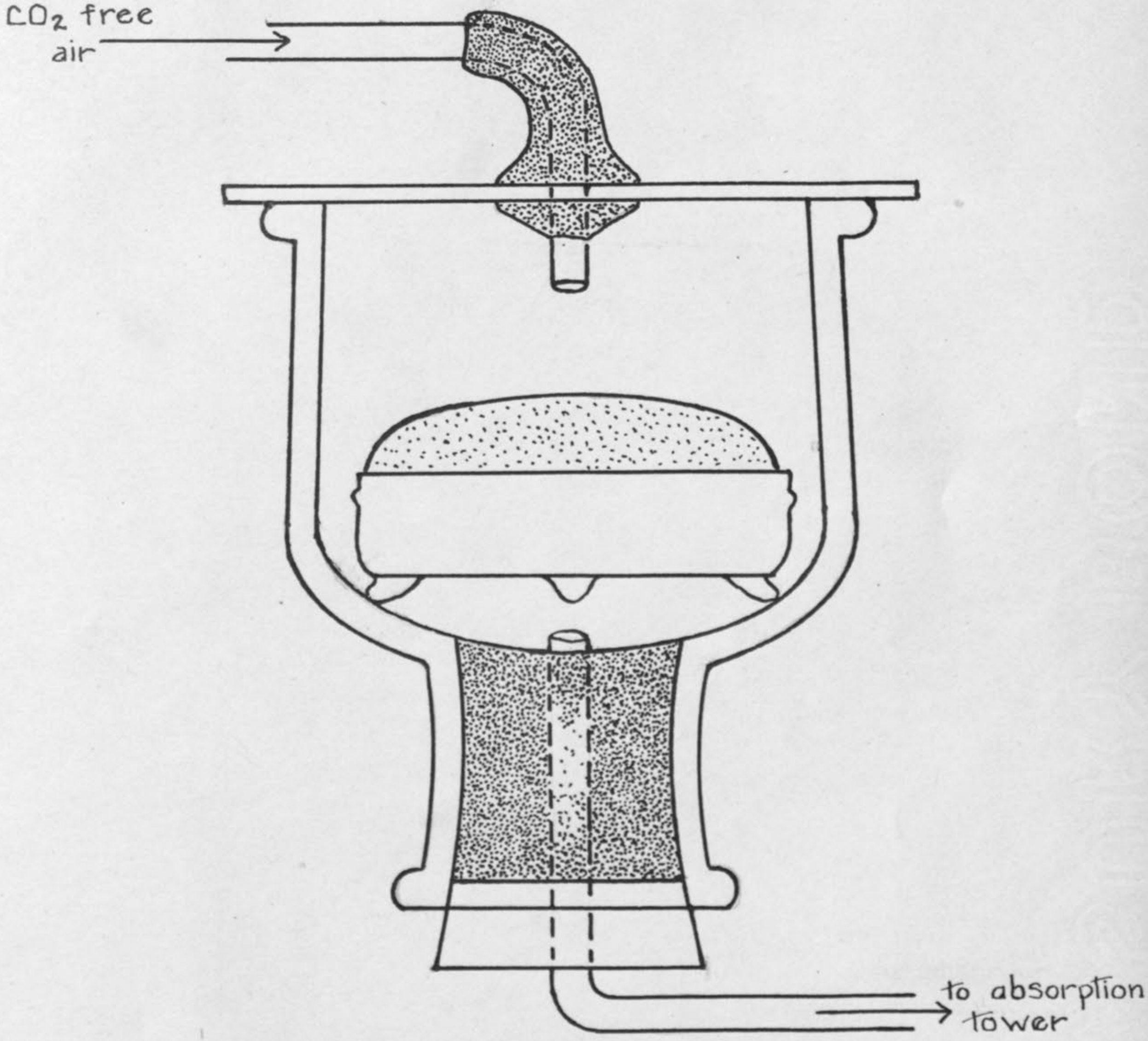

Diagram I
Showing glass chamber in which is placed the tin container filled with dough. The lower portion of the jar is sealed with beeswax and the tube inserted in the cover surrounded with sealing wax.

was placed in a wooden cabinet constructed with glass in the front thereby making the contents visible without opening the door. The temperature of the cabinet was kept constant at 34° C (93°F), the temperature usually employed for the dough after it is in the pan. At the same time the dough in the graduate was also placed in the cabinet. The outlet tube from the glass chamber was first connected with the suction pump and the air surrounding the dough in the glass chamber drawn off for sixty seconds. Without this precaution the initial amount of carbon dioxid lost would appear to be very high. At the conclusion of the sixty seconds the tube from the glass chamber was then connected with the absorption tower outside the cabinet, (see Diagram II) and the carbon dioxid given off measured from this moment.

The loss of carbon dioxid was recorded at thirty minute intervals and at the same time the increase in volume of the dough in the graduate noted. Data on the loss of carbon dioxid and the increase in volume was taken until the dough fell. This point was determined by the actual drop in volume as observed in the dough in the graduate. This end point was not always a sharp one and therefore careful watching was required in the later intervals.

These first portions of the doughs in each series had had no preliminary fermentation before determining loss of carbon dioxid and have therefore been designated as the zero minute (0') fermentation doughs.

The rest of the dough which after mixing had been placed in the thermostat was allowed to ferment about five hours during which time it was broken down three times. In the weak flour the total time of fermentation was about thirty to forty minutes less than in the strong flour.

This dough having received the normal amount of fermentation accorded

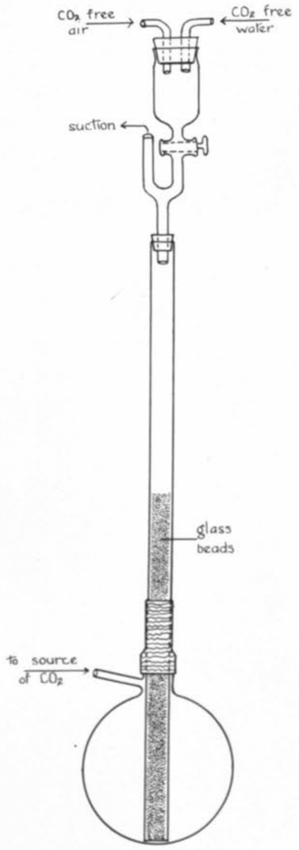

Diagram II

Modified Truog tower used for obsorption of carbon dioxid.

a dough before placing in the pan is spoken of as the total' fermentation dough. At this point portions were weighed off as in the 0' fermentation doughs and placed in the graduate and glass chamber. The carbon dioxid loss and the volume increase were recorded as in the 0' Fermentation doughs.

From two to seven replicates of determinations on each series were made. Plate I (Page 19), gives the results of determinations which were considered as showing satisfactory agreement.

Experimental Data

The average of the results of the determinations in each series given in Table III was used in plotting three curves showing the following relations*

(1) The loss of carbon dioxid in relation to increase in volume.

(2) The loss of carbon dioxid in relation to time.

(3) The increase in volume in relation to time.

The resulting curves are shown in Plates II to XVIII.

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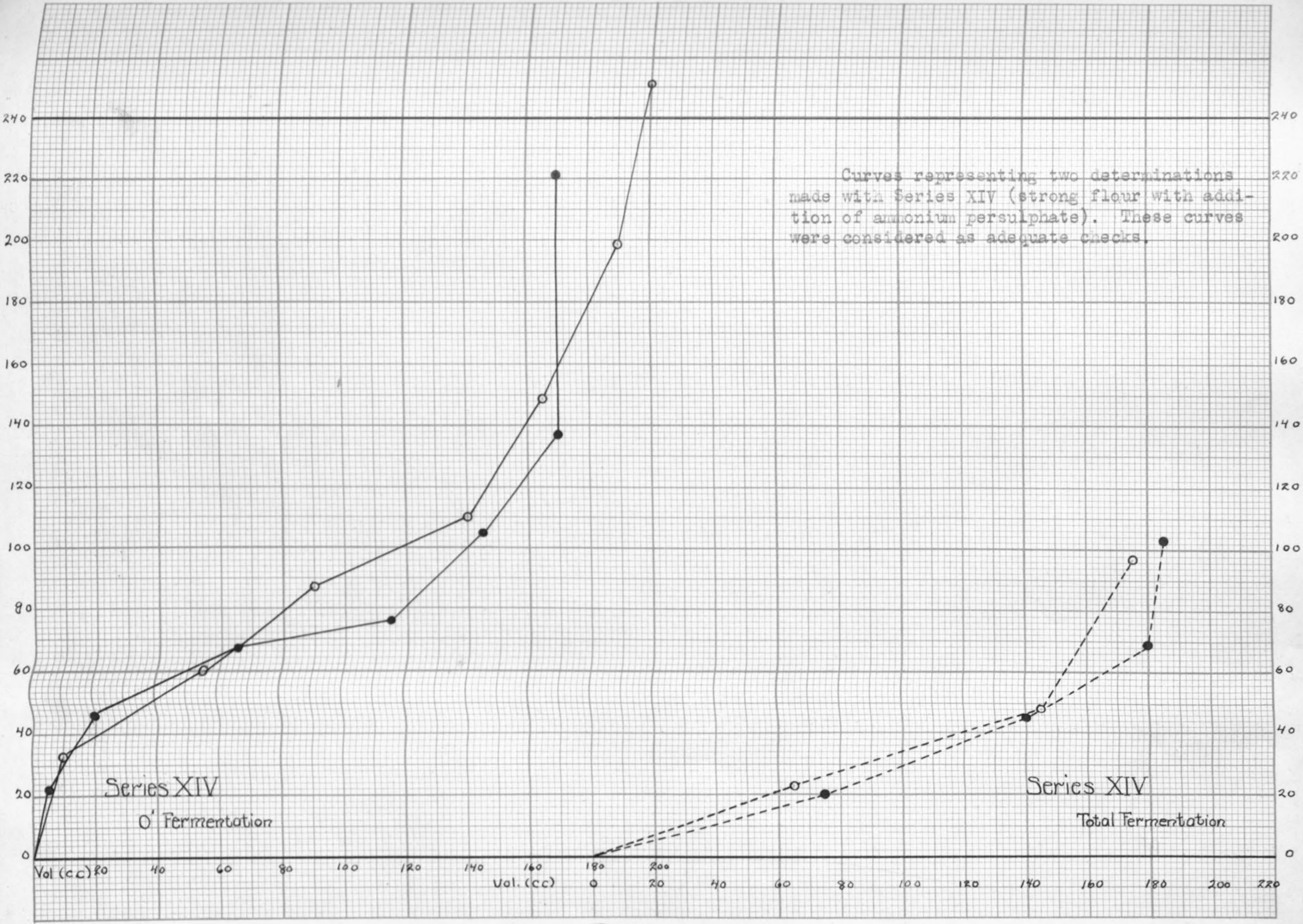
*For individual determinations see Table XIII in appendix.



Curves representing two determinations made with Series XIV (strong flour with addition of ammonium persulphate). These curves were considered as adequate checks.

Plate I

TABLE III. **Averages of determinations** on Series I to XVIII.

Showing loss of carbon dioxid and volume increase.

O' Fermentation

	Series I		Series V		Series VII		Series IX	
Time minutes	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
0		63		63		63		64
30	25.36	74	19.41	71	19.35	72	17.51	79
60	46.33	101	37.56	101	42.62	96	37.52	115
90	73.98	144	54.08	142	58.59	135	54.98	154
120	113.04	183	83.94	165	85.75	172	85.45	174
15 0	154.72	192	136.12	181	129.05	195	172.29	187
180			185.35	183	150.91	197 a	281.57	195 a

Total Fermentation

0		62		65		65		60
30	31.02	128	28.62	122	29.05	132	12.98	146
60	70.97	176	60.55	168	68.29	180	49.49	193
90	133.477	189	129.67	188	122.09	191	127.22	208
120			229.59	193	224.39	194	232.72	208 a

a-average of 2 determinations.

TABLE III. **Averages of determinations on Series I to XVIII**

Showing loss of carbon dioxid and volume increase.

O' Fermentation

	Series II		Series VI		Series VIII		Series X	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm.	c.c.	mgm.	c.c.	mgm.	c.c.	mgm.	c.c.
0'		63		70		67		63
30'	15.08	78	12.03	78	26.02	80	13.46	82
60'	29.56	113	26.41	105	53.58	113	29.18	110
90'	41.89	165	38.58	146	76.09	168	40.90	183
120'	56.64	203	54.78	205	106.52	213	55.63	210
150'	81.79	226	77.04	225	138.35	223	90.25	233
180'	143.91	226	139.91	232a	223.93	232a	187.93	250

Total Fermentation

0'		71		77		72		71
30'	27.38	145	24.46	145	33.71	153	23.79	162
60'	64.86	219	45.14	225	75.38	238	56.72	236
90'	101.56	254	91.37	262	123.24	267	90.97	255
120'	131.36	266	128.67	277a			164.41	265a

a - average of 2 determinations

TABLE III. **Averages of determinations** on Series I to XVIII

Showing loss of carbon dioxid and volume increase.

O' Fermentation

Time minutes	Series XI		Series XIII		Series XV		Series XVII	
	CO_2 mgm.	Volume c.c.	CO_2 mgm.	Volume c.c.	CO_2 mgm.	Volume c.c.	CO_2 mgm.	Volume c.c.
0		62		60		62		60
30	25.36	85	30.49	70	20.75	73	13.07	75
60	37.97	122	65.44	90	40.04	108	26.75	102
90	54.32	162	88.27	122	61.35	153	34.36	165
120	107.98	187	113.52	177	99.59	182	45.92	185
150	193.81	195	133.64	180	125.52	193	63.47	195
180							104.42	198

Total Fermentation

0		63		65		65		63
30	27.27	163	30.36	132	39.49	100	13.94	135
60	72.85	185	66.47	170	69.55	177	65.18	170
90	163.77	193	143.37	182	121.60	193	146.52	176
120			210.37	186	205.18	197	234.06	181
150					252.62	200	272.51	183

TABLE III. Averages of determinations on Series I to XVIII

Showing loss of carbon dioxid and volume increase

0' Fermentation

	Series XII		Series XIV		Series XVI		Series XVIII	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm.	c.c.	mgm.	c.c.	mgm.	c.c.	mgm.	c.c.
0'.		67		63		62		65
30	24.56	76	28.04	70	16.79	75	16.84	80
60	42.71	103	53.58	90	31.31	107	37.11	120
90	64.55	148	77.23	140	47.20	170	50.12	182
120	91.31	196	93.55	190	71.27	210	78.43	217
150	123.48	216	127.25	217	117.84	222	119.52	227
180	132.14*	232	168.48	242	179.16	241	190.35	242
204			236.92	247				
Total Fermentation								
0		78		70		75		72
30	29.44	148	21.97	140	26.79	137	26.76	175
60	57.46	228	46.88	212	57.63	202	78.39	232
90	104.36	256	83.51	247	96.56	243	144.51	267
120	162.94	262			157.03	265	233.88	292
150					241.86	283	327.05	300
180					307.28	295	408.16	305a

* fell at 178 minutes.

a - average of 2 determinations.

TABLE III. **Averages of determinations.**on Series I to XVIII

Showing loss of carbon dioxid and volume increase

O' Fermentation

	Series III		Series IV	
Time	CO_2	Volume	CO_2	Volume
0		65		61
30	15.76	76	15.57	76
60	31.07	104	40.29	101
90	48.40	137	58.76	147
120	73.19	177	85.77	186
150	106.44	200	124.29	200
180	209.03	214	160.00	210
210	308.90	216	296.00	215
240	457.30	220	379.25	222
270	636/92	220		

Total Fermentation

0		66		66
30	28.77	134	17.71	128
60	61.74	182	39.76	193
90	104.33	230	73.26	223
120	173.92	252	126.11	239
150	237.12	266		
180	304.30	268		

Results of the following series are represented graphically in Plates II to XVIII.

Series	
I	Weak flour ("378") - Control.
II	Strong flour (straight) - Control.
III	Strong flour with addition of cornstarch to give protein content of weak flour.
IV	Strong flour with addition of cornstarch to give one-half protein content of weak flour.
V	Weak flour with addition of calcium sulphate.
VI	Strong flour with addition of calcium sulphate.
VII	Weak flour with addition of ammonium chloride.
VIII	Strong flour with addition of ammonium chloride.
IX	Weak flour with addition of calcium sulphate and ammonium chloride.
X	Strong flour with addition of calcium sulphate and ammonium chloride.
XI	Weak flour with addition of ammonium phosphate ($NH_4H_2PO_4$)
XII	Strong flour with addition of ammonium phosphate ($NH_4H_2PO_4$)
XIII	Weak flour with addition of ammonium persulphate.
XIV	Strong flour with addition of ammonium persulphate.
XV	Weak flour with addition of potassium bromate.
XVI	Strong flour with addition of potassium bromate.
XVII	Weak flour with addition of arkady.
XVIII	Strong flour with addition of arkady.

KEY TO PLATE II.

Weak flour Series I, Control	________ - - - - - - - - -	zero fermentation total fermentation
Strong flour Series II, Control	________ - - - - - - - - -	zero fermentation total fermentation

KEY TO PLATES III TO XVIII

Control	________ - - - - - - -	zero fermentation total fermentation
Flour with substance superimposed	________ - - - - - - - -	zero fermentation total fermentation

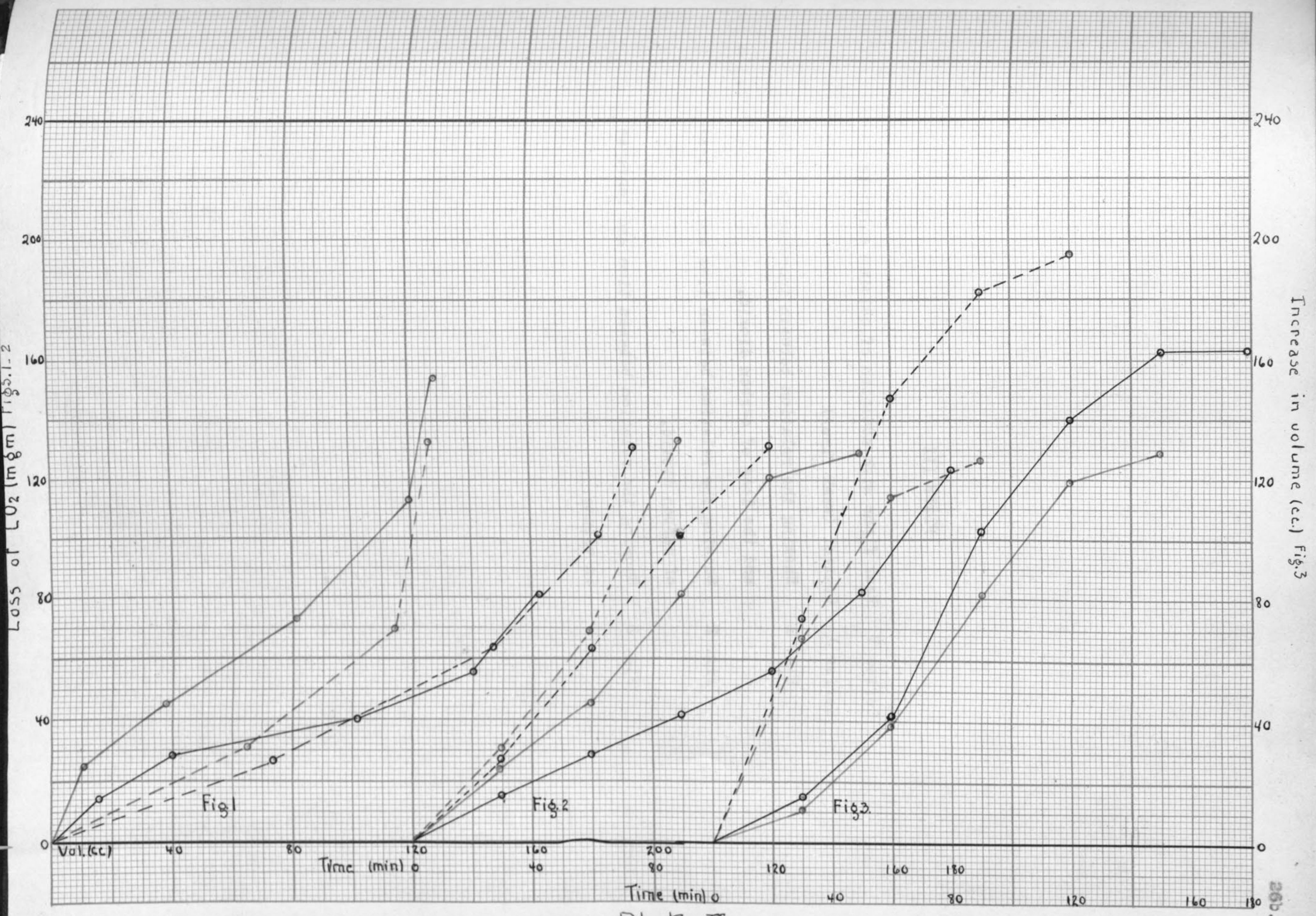

Loss of CO_2 (mgm) Figs. 1. 2
Increase in volume (cc.) Fig. 3
240
200
160
120
80
40
0
Vol. (cc)
Fig 1
Fig. 2
Fig. 3.
40
80
120
160
200
Time (min) 0
40
80
120
160
180
Time (min) 0
40
80
120
160
180

Plate II

PLATE III

Series V Weak flour with addition of calcium sulphate

Series I Control (weak flour)

Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2 Showing the relation between time and the loss of carbon dioxid.

Fig. 3 Showing the relation between time and increase in volume.

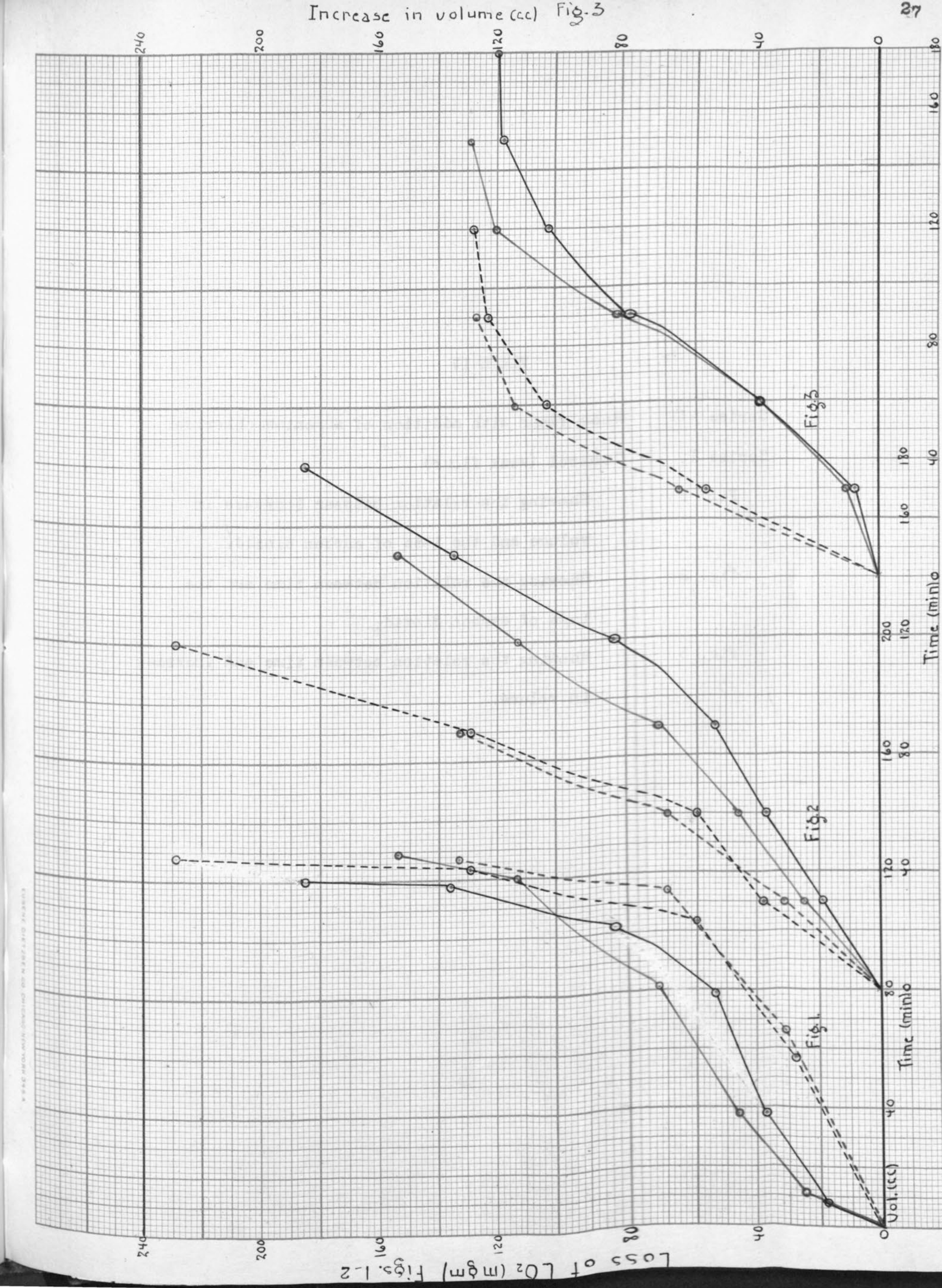

Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
180
160
120
80
40
180
160
120
80
40
Fig. 3
Fig. 2
Fig. 1
Time (min) 0
Time (min) 0
Vol. (cc)
0
40
80
120
160
200
240
Loss of CO2 (mgm) Figs. 1-2

Plate III

PLATE IV

Series VII Weak flour with addition of ammonium chloride.

Series I Control (weak flour)

Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2 Showing the relation between time and the loss of carbon dioxid.

Fig. 3 Showing the relation between time and increase in volume.

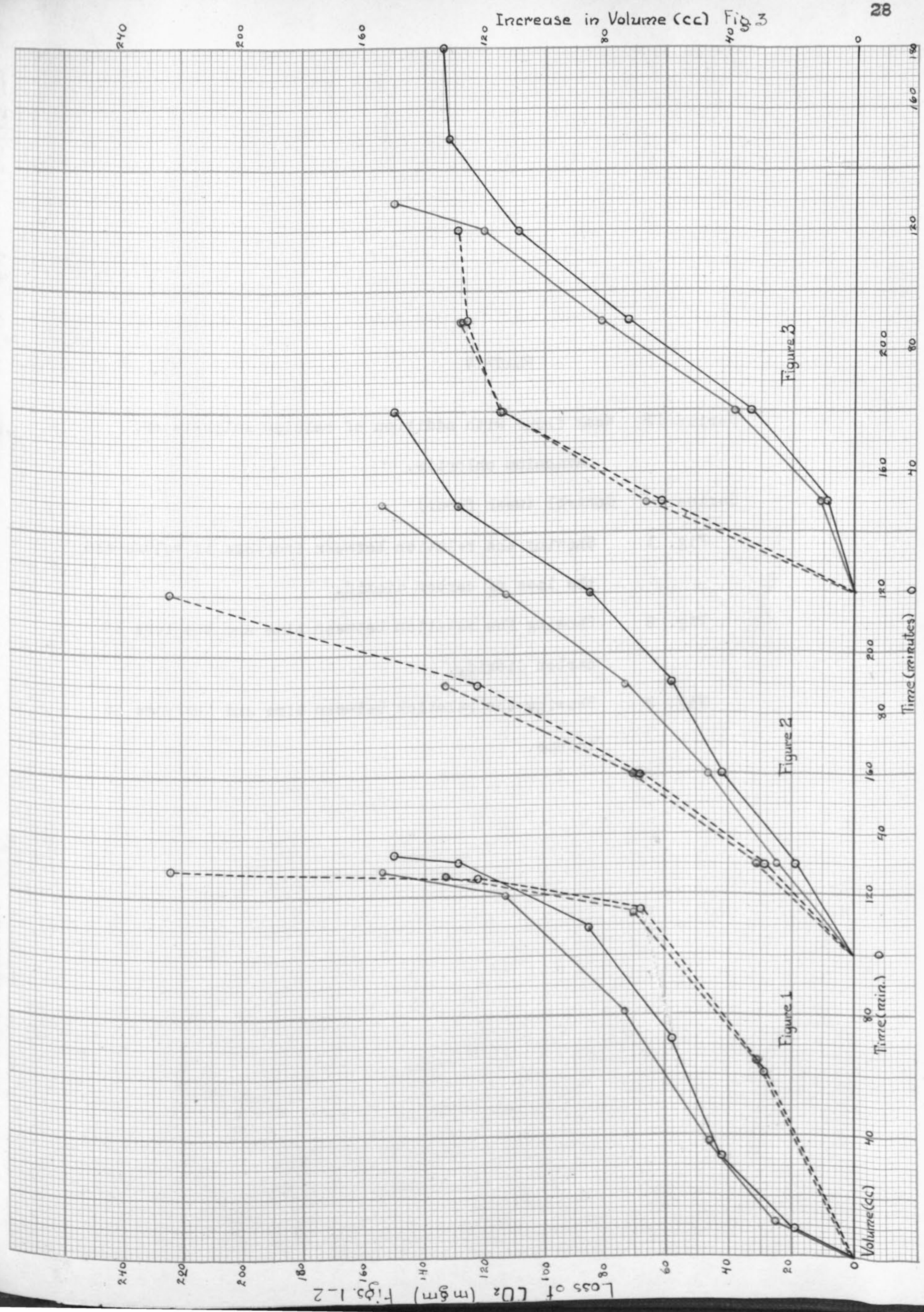

Increase in Volume (cc) Fig. 3
0
40
80
120
160
200
240
Loss of CO₂ (mgm) Figs. 1-2
0
20
40
60
80
100
120
140
160
180
200
220
240
Volume (cc)
Time (min.)
Time (minutes)
Figure 1
Figure 2
Figure 3
0
40
80
120
160
180
200

Plate IV

PLATE V

Series IX Weak flour with addition of calcium sulphate and ammonium chloride.

Series I Control (weak flour)

- Fig. 1. Showing the relation between increase in volume and the loss of carbon dioxid.
- Fig. 2 Showing the relation between time and the loss of carbon dioxid.
- Fig. 3 Showing the relation between time and increase in volume.

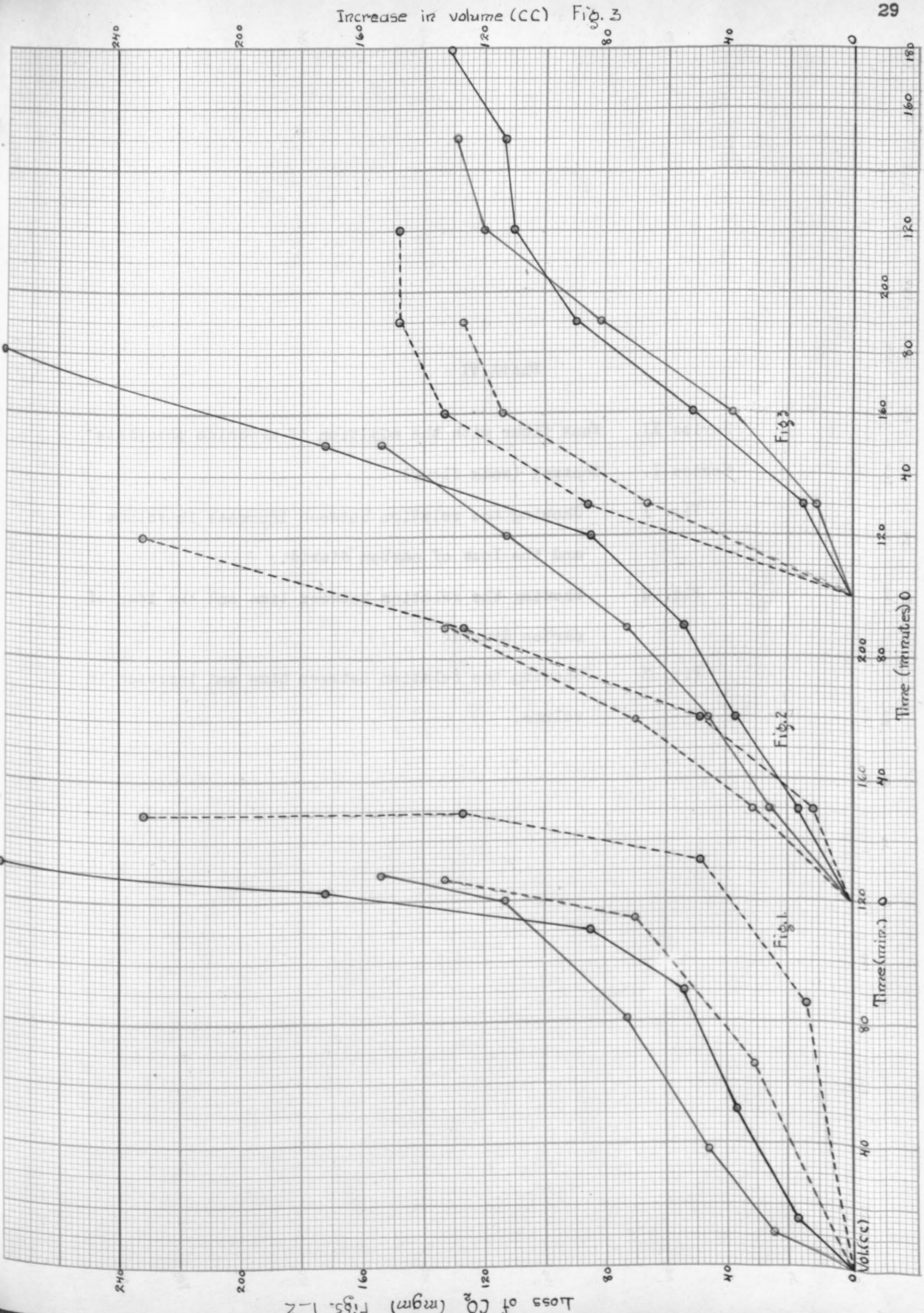

Increase in volume (CC) Fig. 3
240
200
160
120
80
40
0
Loss of CO_2 (mgm) Figs. 1-2
Vol.(cc)
Time (min.)
Time (minutes) 0
0
40
80
120
160
200
180
Fig.1
Fig.2
Fig.3

Plate V

PLATE VI

Series XI. Weak flour with the addition of ammonium phosphate

Series I. Control (weak flour)

- Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxide.
- Fig. 2 Showing the relation between time and the loss of carbon dioxid.
- Fig. 3 Showing the relation between time and increase in volume.

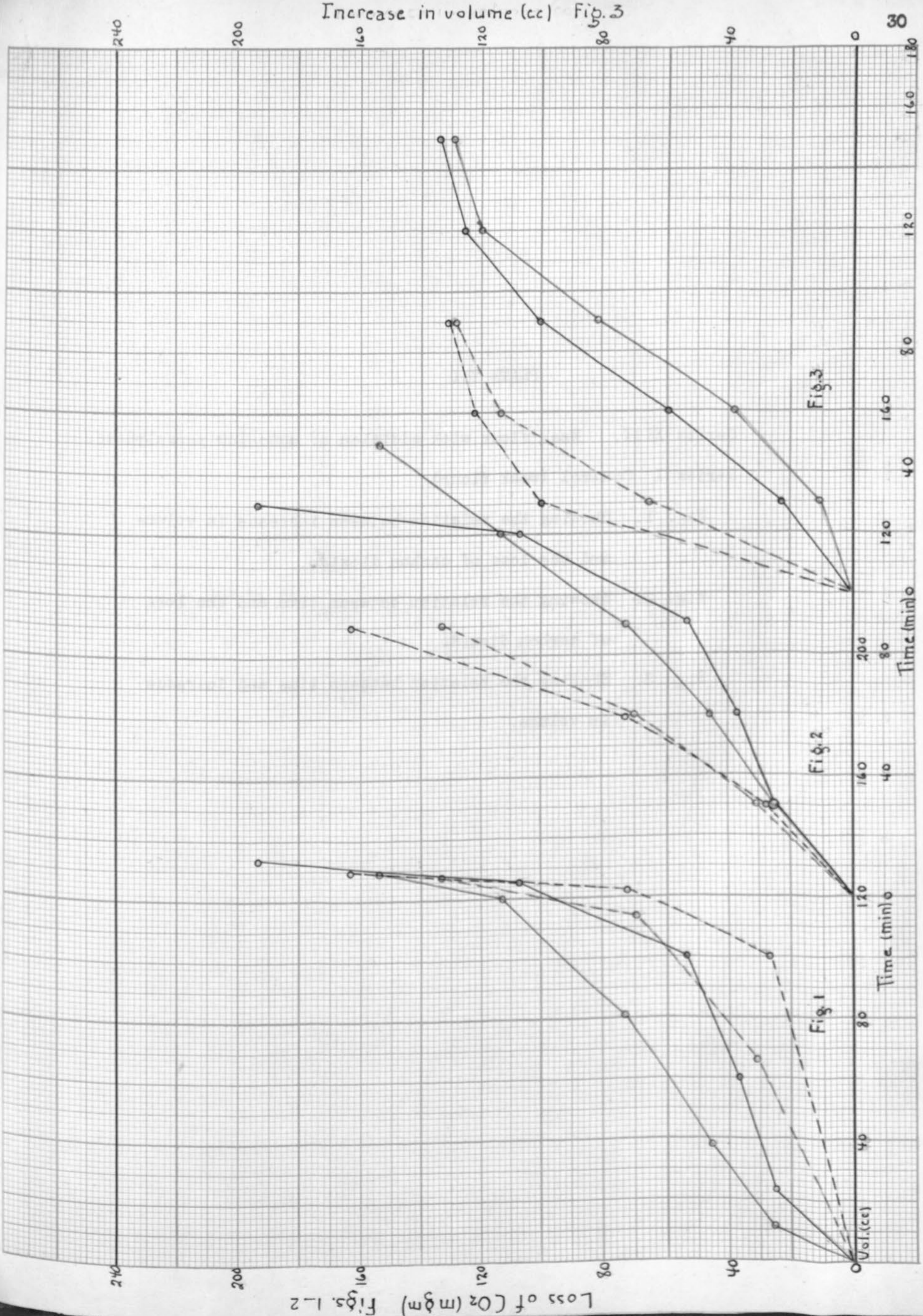

Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
Loss of CO_2 (mgm) Figs. 1-2
240
200
160
120
80
40
0
Vol. (cc)
Time (min)
40
80
120
Time (min)
160
40
200
80
120
160
40
80
120
160
180
Fig. 1
Fig. 2
Fig. 3

Plate VI

PLATE VII

Series XIII. Weak flour with addition of ammonium persulphate.

Series I Control (weak flour)

Fig. 1. Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2. Showing the relation between time and the loss of carbon dioxid.

Fig. 3. Showing the relation between time and increase in volume.

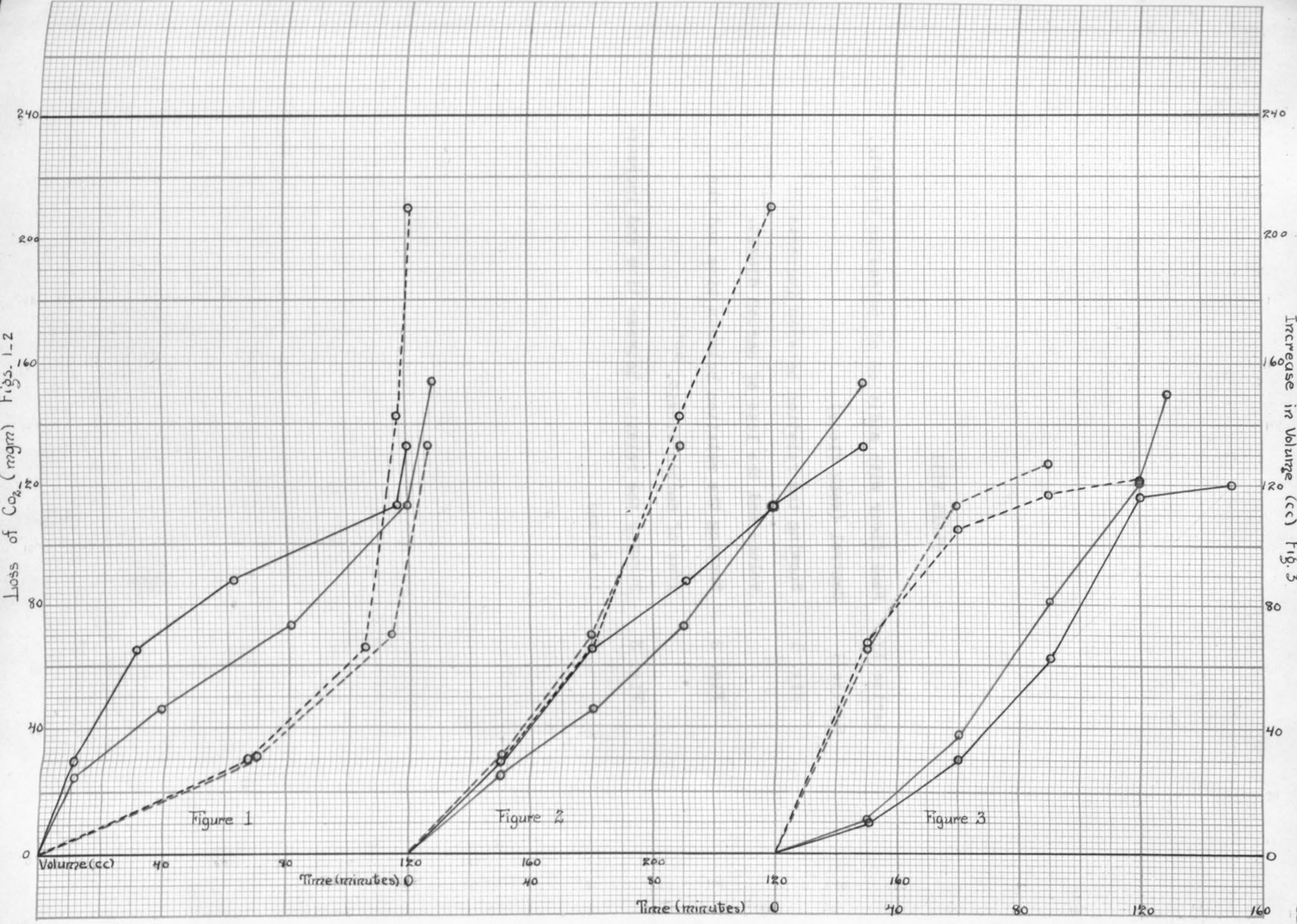

Loss of Co_2 (mgm) Figs. 1-2
Increase in Volume (cc) Fig. 3
240
200
160
120
80
40
0
Volume (cc)
Time (minutes)
Figure 1
Figure 2
Figure 3

Plate VII

PLATE VIII

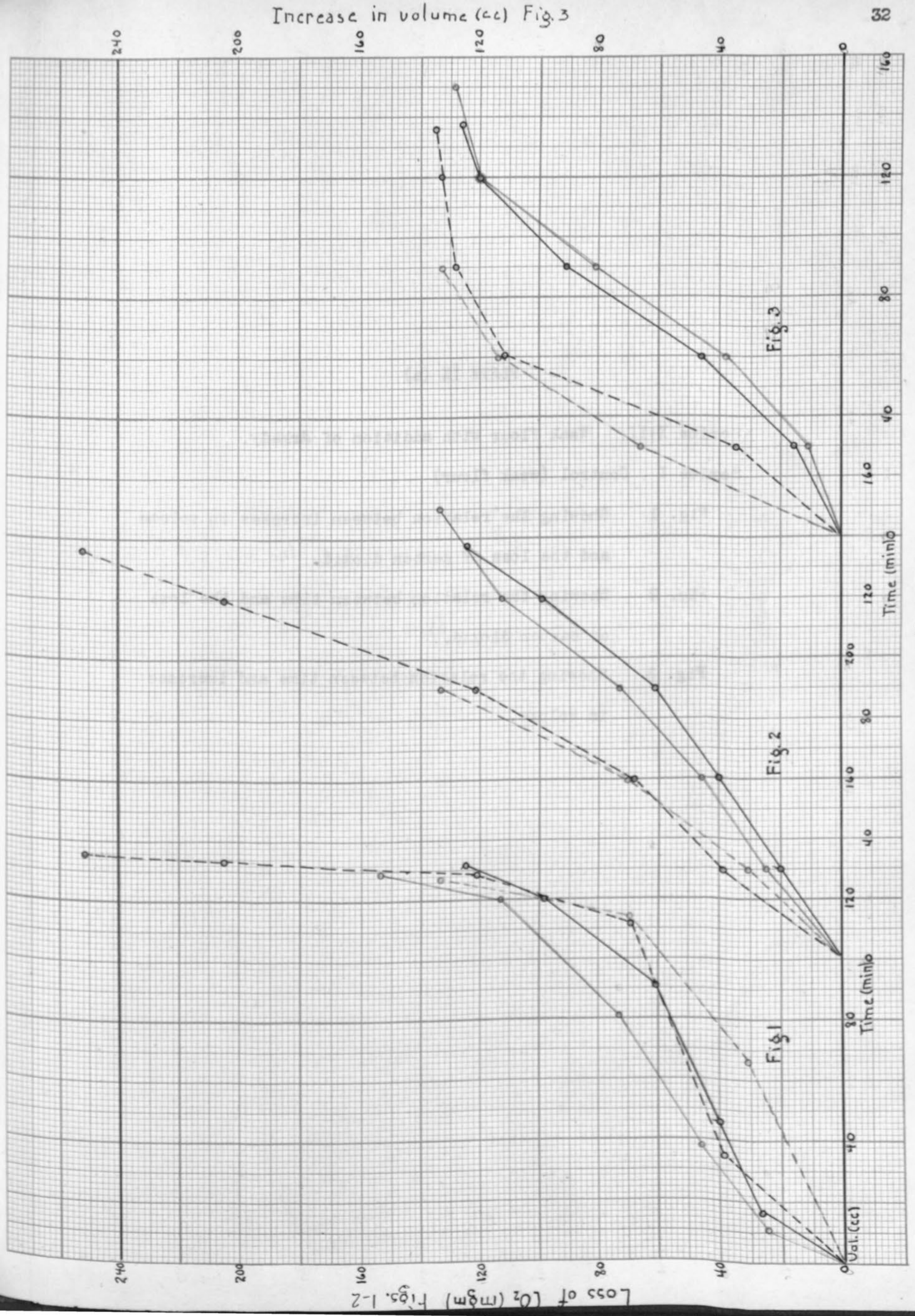
Series XV. Weak flour with addition of potassium bromate.

Series I Control (weak flour)

Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2 Showing the relation between time and the loss of carbon dioxid.

Fig. 3 Showing the relation between time and increase in volume.


Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
Fig. 3
Fig. 2
Fig. 1
Time (min)
Vol. (cc)
160
120
80
40
0
Loss of O_2 (mgm) Figs. 1-2

Plate

PLATE IX (a)

Series XVII.   Weak flour with addition of Arkady.

Series I   Control (weak flour)

Fig. 1   Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2   Showing the relation between time and the loss of carbon dioxid.

Fig. 3   Showing the relation between time and increase in volume.

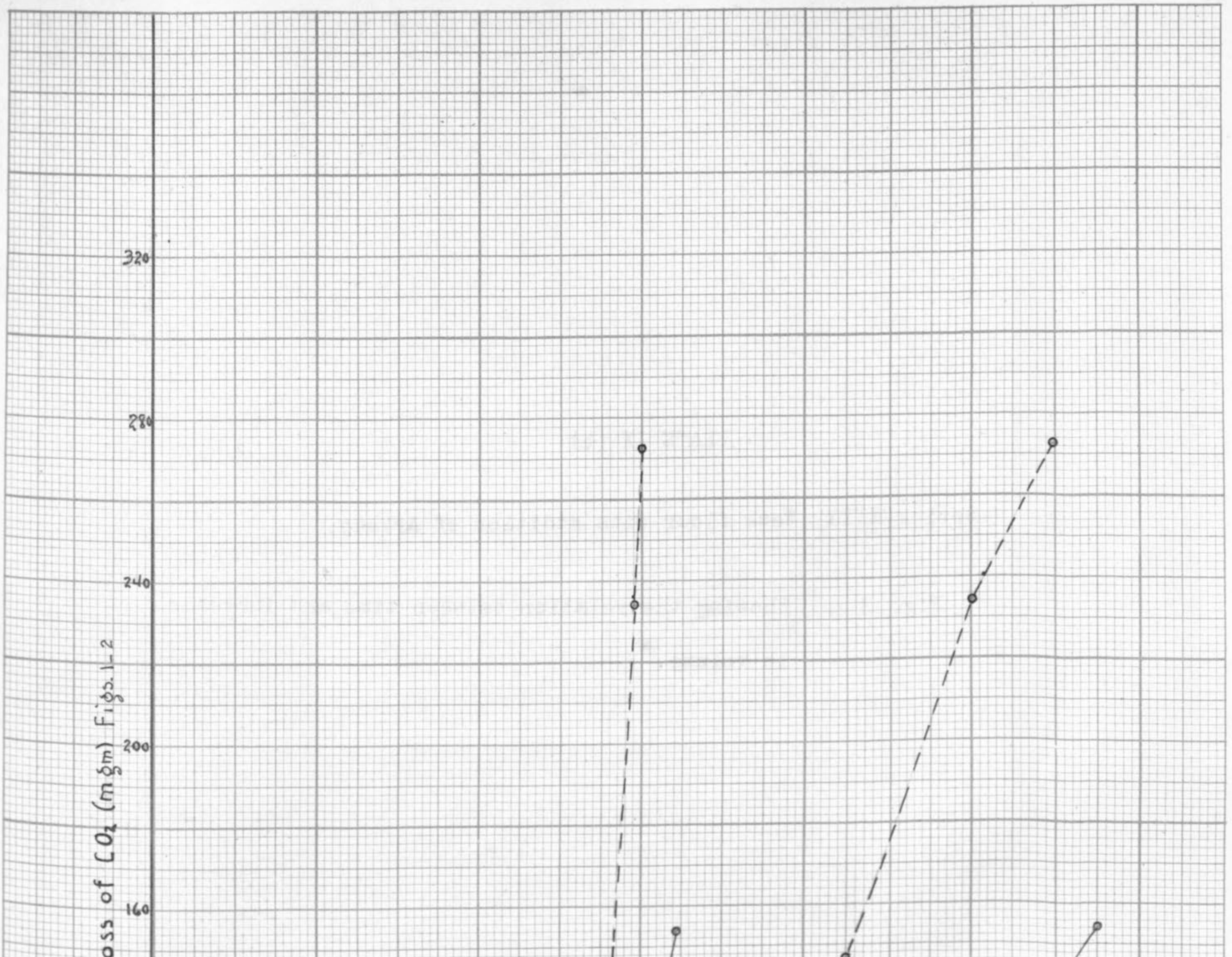

Loss of CO2 (mgm) Figs. 1, 2
320
280
240
200
160
120
80
40
0
Vol. (cc)
40
80
120
160
Time (min) 0
40
80
120
160
180
Fig 1.
Fig. 2

Plate IX a

PLATE IX (b)

Series XVII Weak flour with addition of Arkady,

Fig. 3 Showing the relation between time and increase in volume.

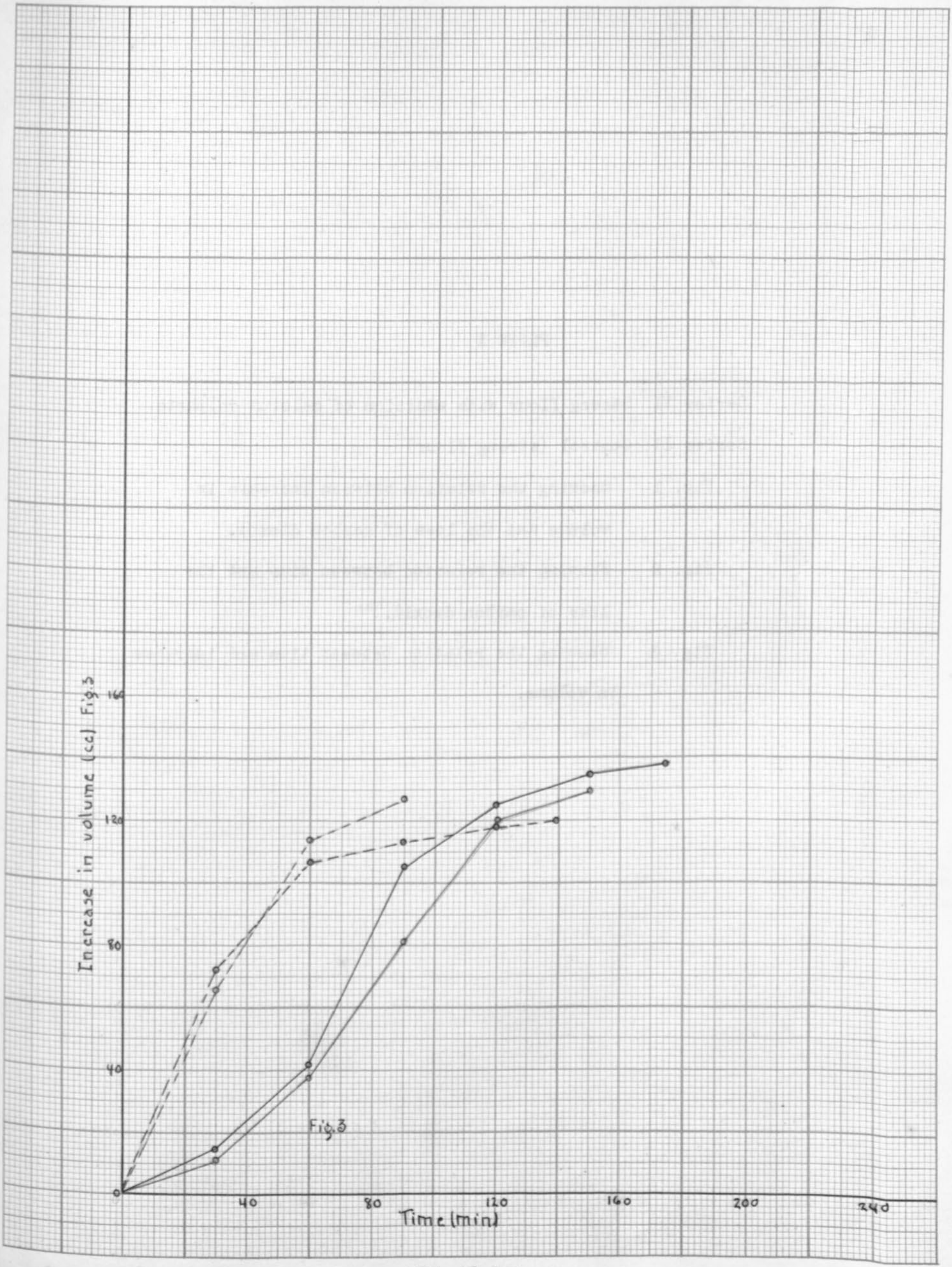

Increase in volume (cc) Fig.3
160
120
80
40
0
40
80
120
160
200
240
Time (min)
Fig.3

Plate IX b

PLATE X

Series VI Strong flour with addition of calcium sulphate.

Series II. Control (strong flour)

- Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxid.
- Fig. 2 Showing the relation between time and the loss of carbon dioxid.
- Fig. 3 Showing the relation between time and increase in volume.

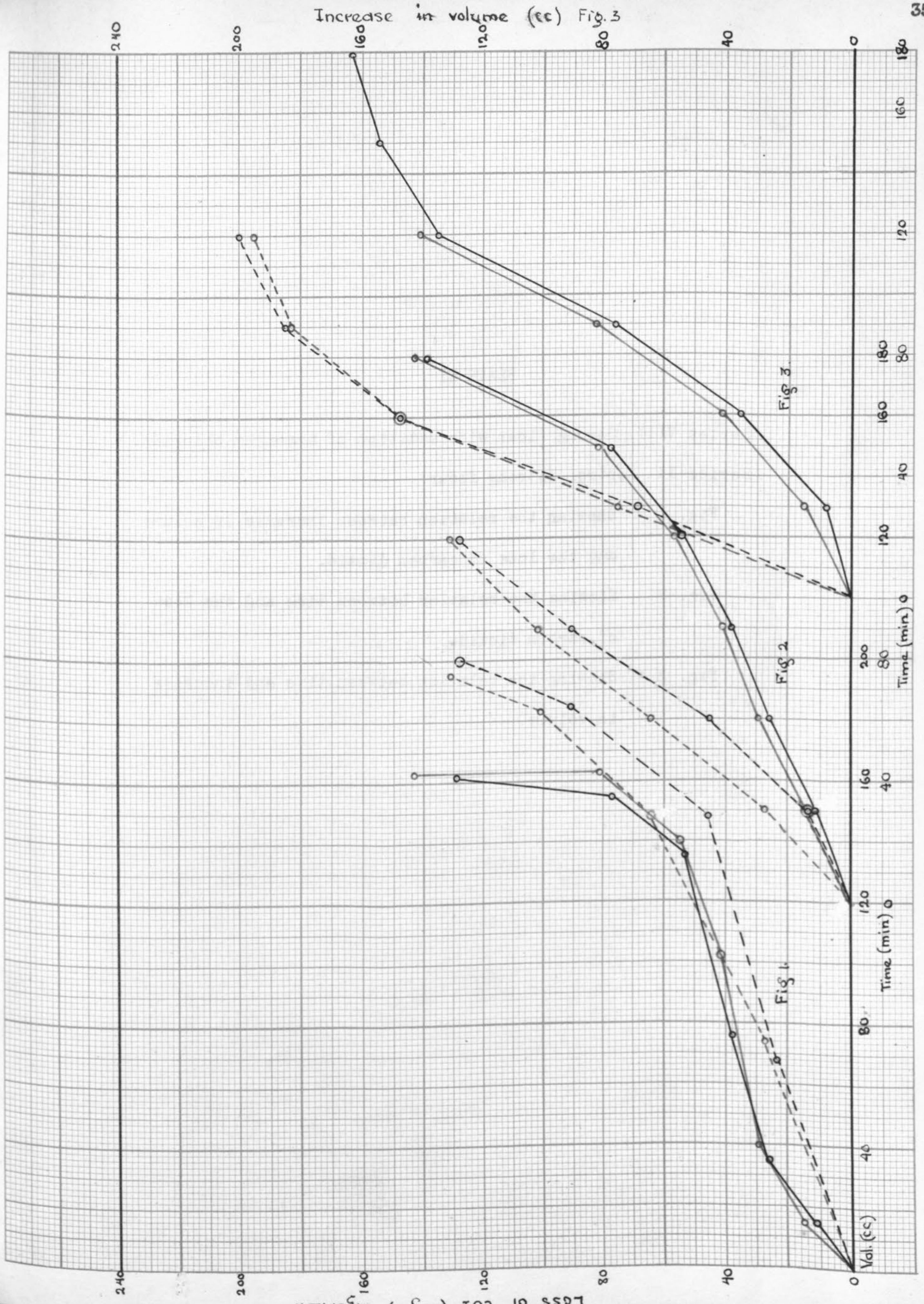

Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
180
160
120
80
40
Fig. 3
Fig. 2
Fig. 1
200
80
160
40
120
Time (min)
Time (min)
Vol. (cc)
Loss of CO2 (mgm) Figs. 1–2

Plate X.

PLATE XI

Series VIII Strong flour with addition of ammonium chloride.

Series II Control (strong flour)

Fig. 1	Showing the relation between increase in volume and the loss of carbon dioxid.
Fig. 2	Showing the relation between time and the loss of carbon dioxid.
Fig. 3	Showing the relation between time and increase in volume.

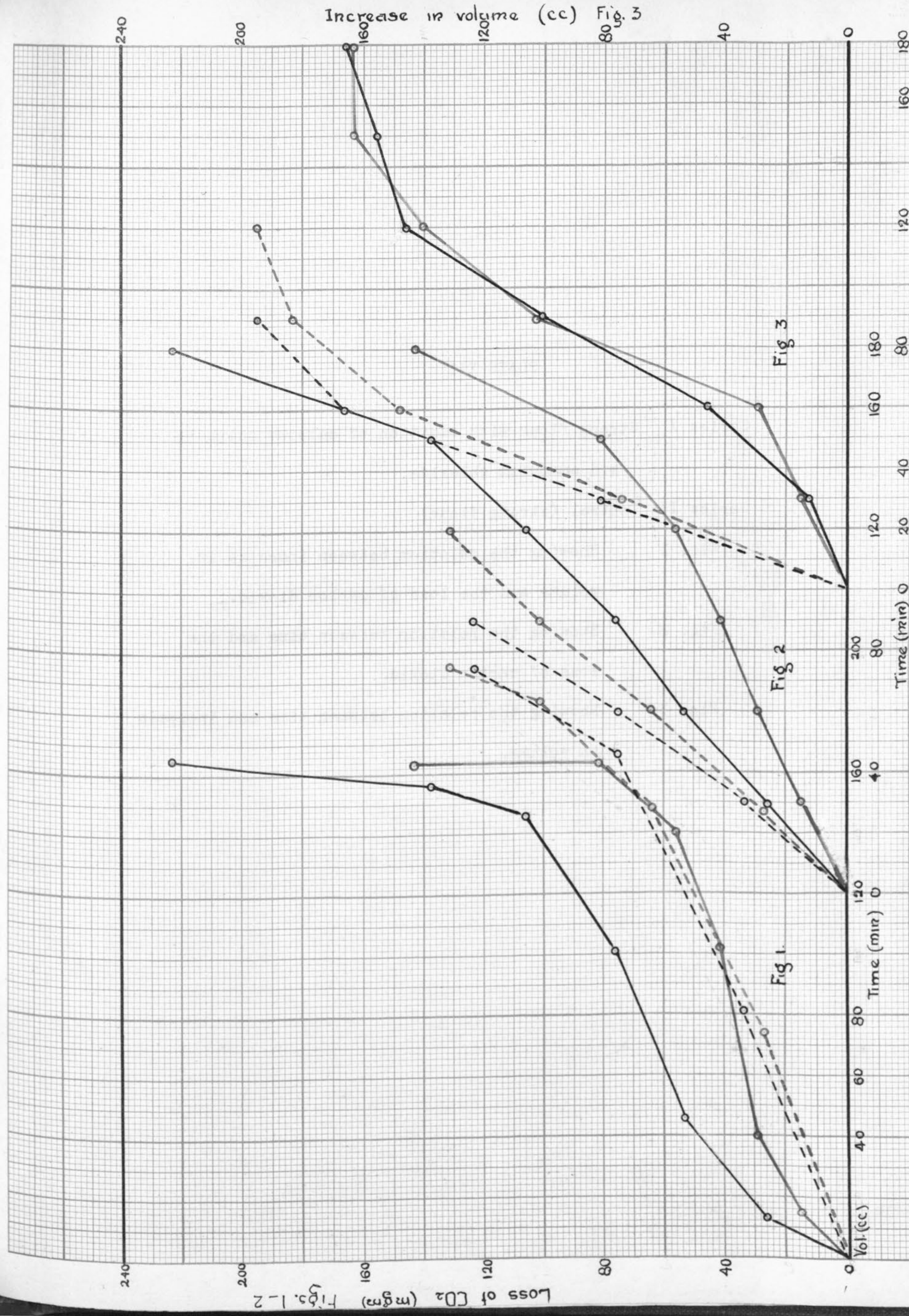

Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
Loss of CO₂ (mgm) Figs. 1-2
Vol. (cc)
Fig 1.
Fig 2
Fig 3
Time (min)
0
20
40
60
80
120
160
180
200
0
40
80
120
160
180

Plate XI

PLATE XII

Series X Strong flour with addition of calcium sulphate and ammonium chloride.

Series II Control (strong flour)

Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2 Showing the relation between time and the loss of carbon dioxid.

Fig. 3 Showing the relation between time and increase in volume.

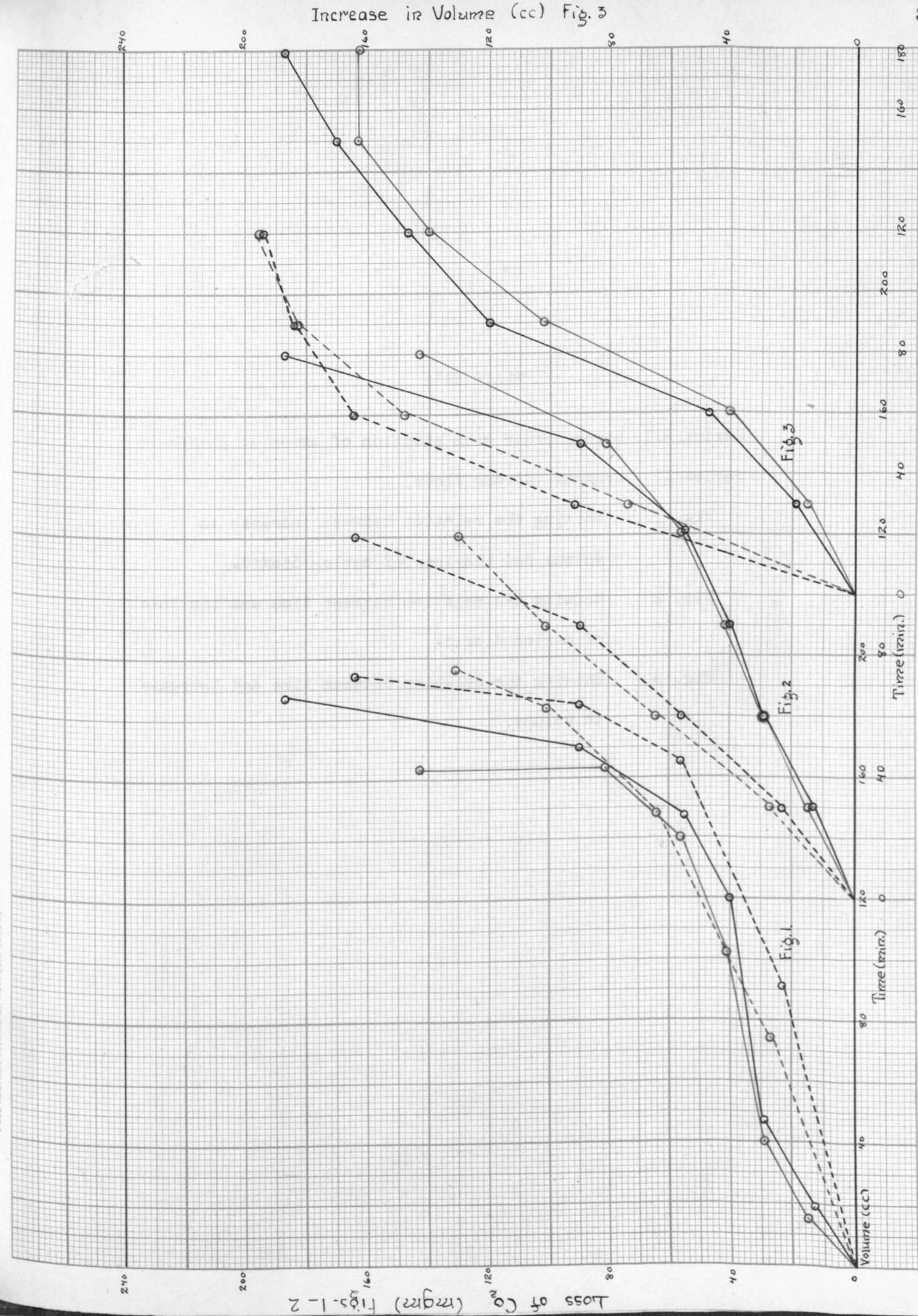

Increase in Volume (cc) Fig. 3
240
200
160
120
80
40
0
Loss of CO_2 (mgm) Figs. 1-2
240
200
160
120
80
40
0
Volume (cc)
40
80
Time (min.)
120 0
160 40
200 80
Time (min.)
0
120 40
160 80
200
120
160
180
Fig. 1
Fig. 2
Fig. 3

Plate XII

PLATE XIII

Series XII Strong flour with addition of ammonium phosphate

Series II Control (strong flour)

Fig. 1 Showing the relation between increase in volume and the loss of carbon dioxid.

Fig. 2 Showing the relation between time and the loss of carbon dioxid.

Fig. 3 Showing the relation between time and increase in volume.

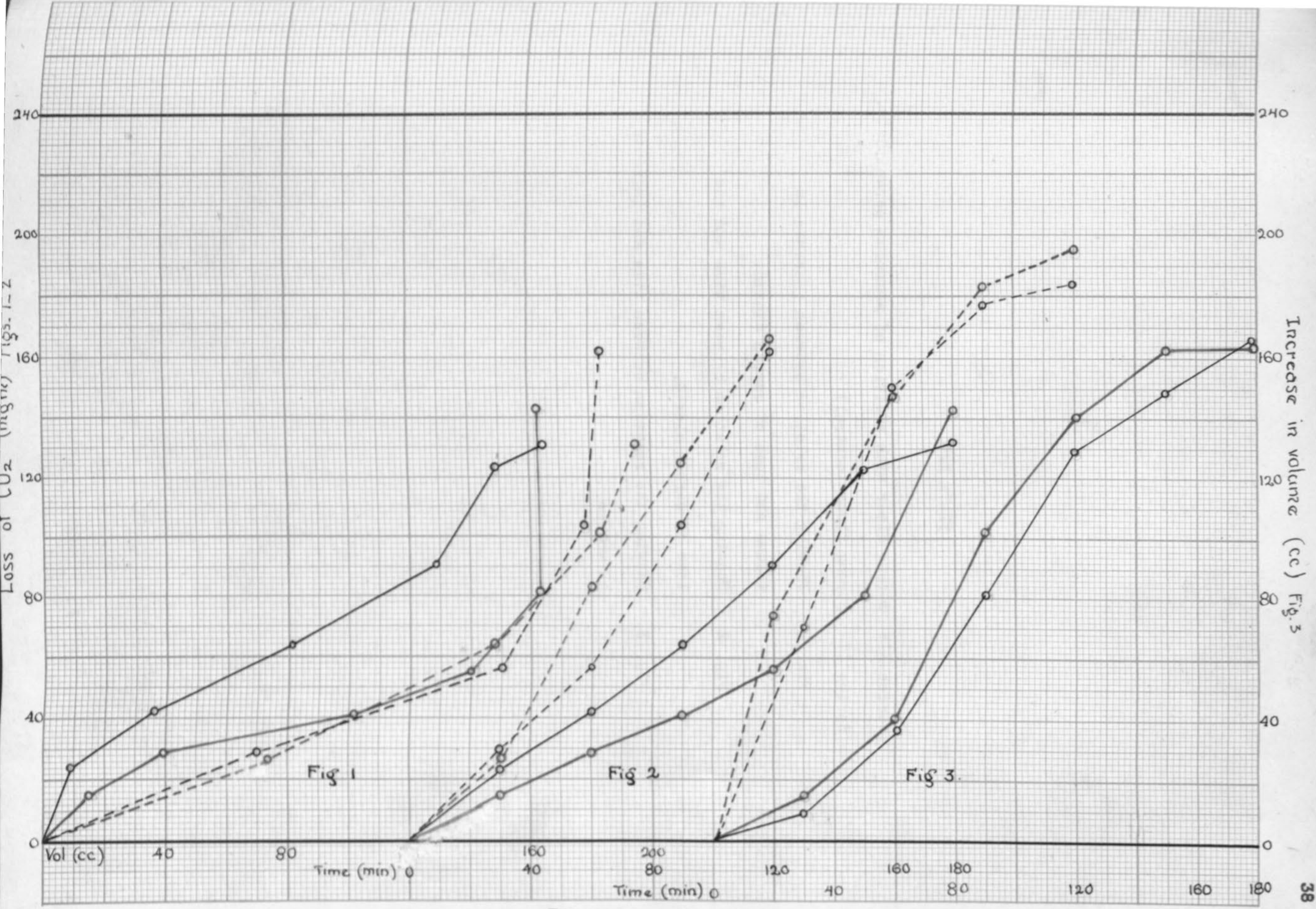

Loss of CO₂ (mg/h) Figs. 1-2
240
200
160
120
80
40
0
Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
Fig 1
Fig 2
Fig 3.
Vol (cc)
40
80
160
200
Time (min) 0
40
80
120
160
180
Time (min) 0
40
80
120
160
180

Plate XIII.

PLATE XIV

Series XIV	Strong flour with addition of ammonium persulphate.
Series II	Strong flour (control)

Fig. 1	Showing the relation between increase in volume and loss of carbon dioxid.
Fig. 2	Showing the relation between time and the loss of carbon dioxid.
Fig. 3	Showing the relation between time and increase in volume.

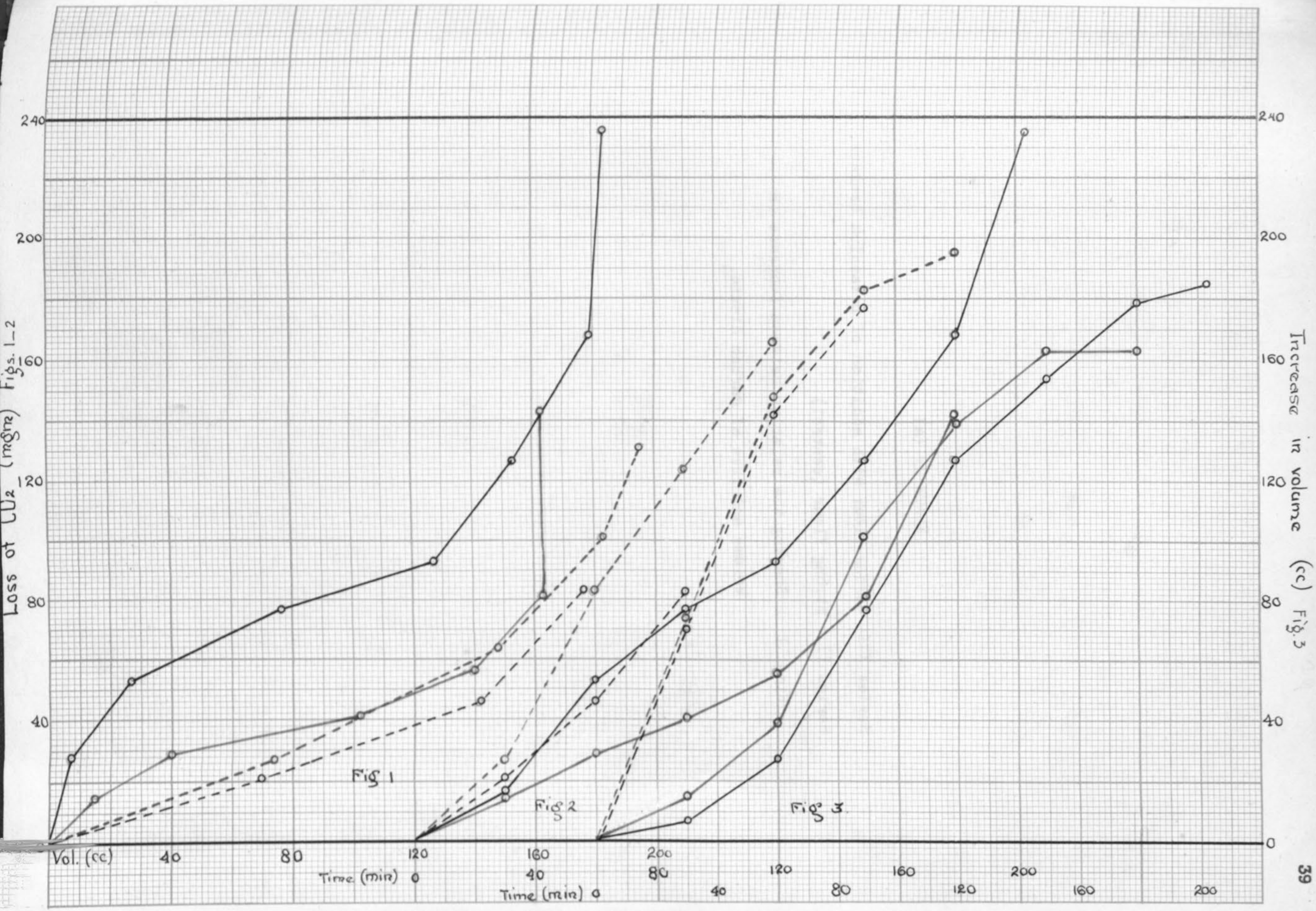

Loss of CO2 (mgm) Figs. 1–2
240
200
160
120
80
40
Increase in volume (cc) Fig. 3
240
200
160
120
80
40
0
Vol. (cc)
40
80
120
160
200
Time (min) 0
40
80
120
160
200
Time (min) 0
40
80
120
160
200
Fig 1
Fig 2
Fig 3.

Plate XIV

PLATE XV (a)

Series XVI Strong flour with addition of potassium bromate.

Series II. Strong flour (control)

Fig. 1 Showing the relation between increase in volume and loss of carbon dioxide.

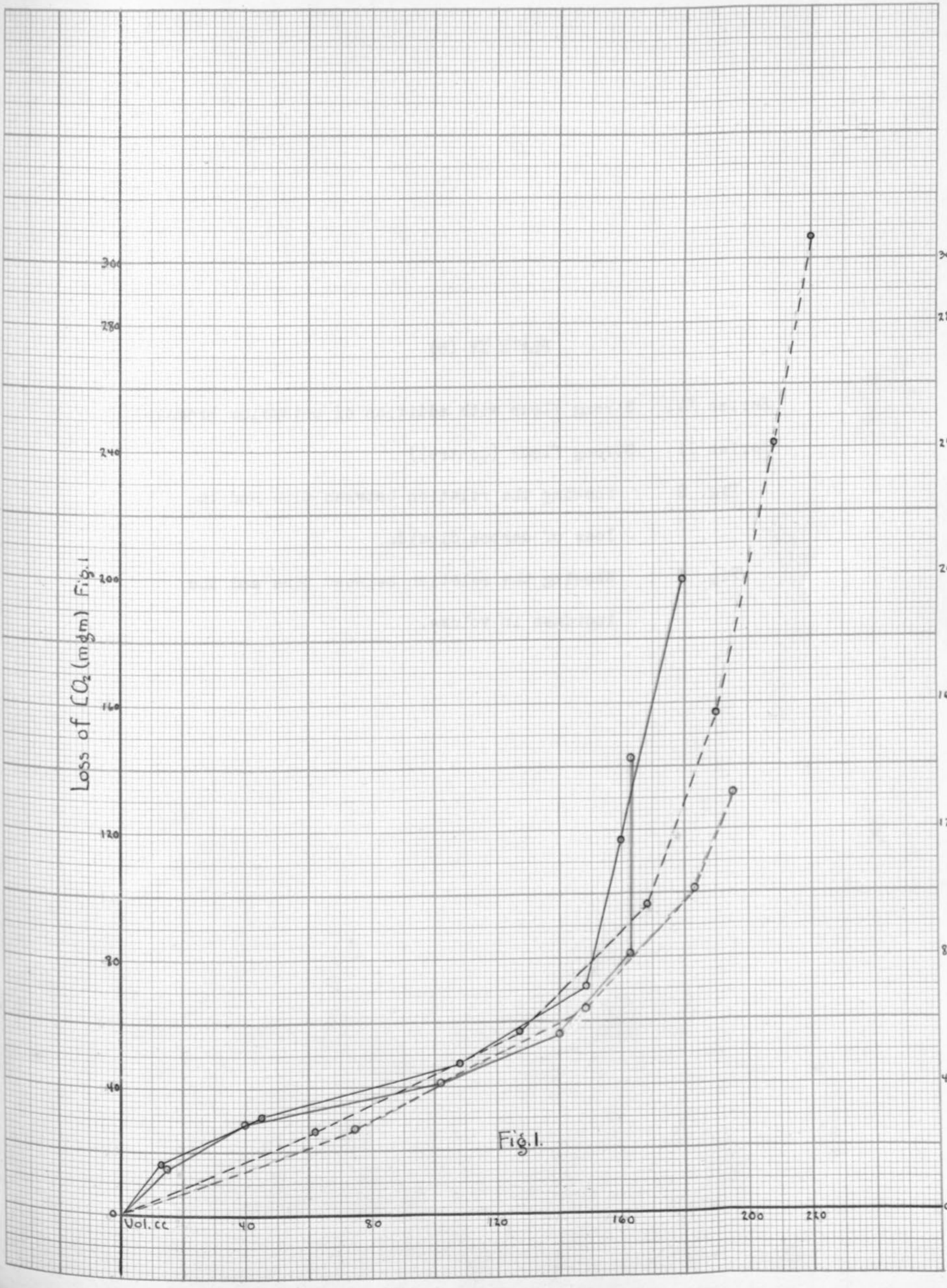


Fig. 1.

Plate XVa

PLATE XV (b)

Series XVI Strong flour with addition of potassium bromate.

Series II Strong flour (control)

Fig. 2 Showing the relation between time and the loss of carbon dioxide.

Fig. 3 Showing the relation between time and the increase in volume.

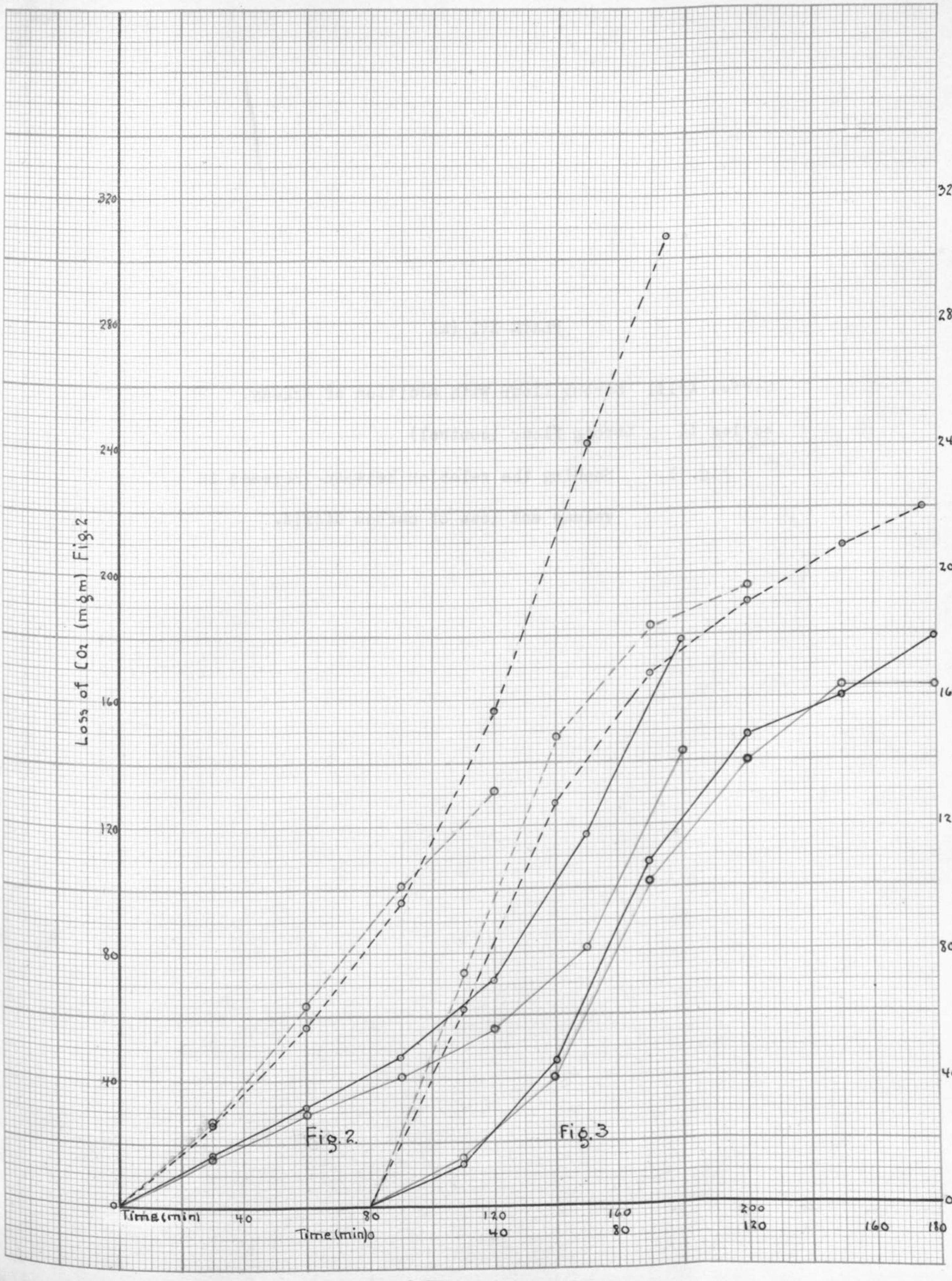

Loss of CO2 (mgm) Fig.2
Increase in volume (cc) Fig.3
320
280
240
200
160
120
80
40
0
Fig.2.
Fig.3
Time(min)
40
80
120
160
200
Time(min)0
40
80
120
160
180

Plate XV b

PLATE XVI (a)

Series XVIII Strong flour with addition of Arkady.

Series II Strong flour (control)

Fig. 1 Showing the relation between increase in volume and loss of carbon dioxide.

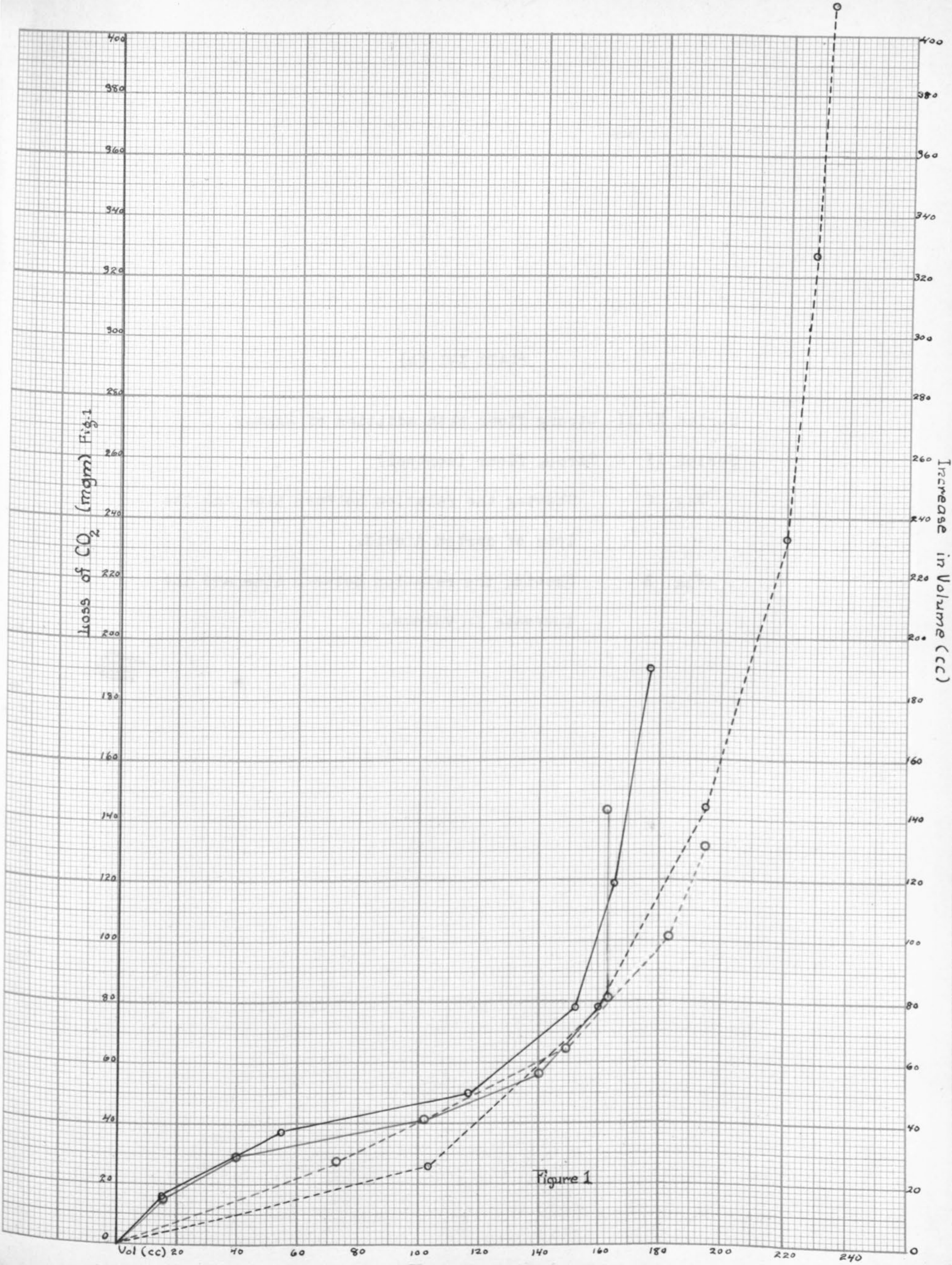

Loss of CO_2 (mgm) Fig. 1
Increase in Volume (cc)
Figure 1
Vol (cc)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
400

Plate XVI a

PLATE XVI (b)

Series XVIII	Strong flour with addition of Arkady.
Series II	Strong flour (control)
Fig. 2	Showing the relation between time and the loss of carbon dioxide.
Fig. 3	Showing the relation between time and the increase in volume.

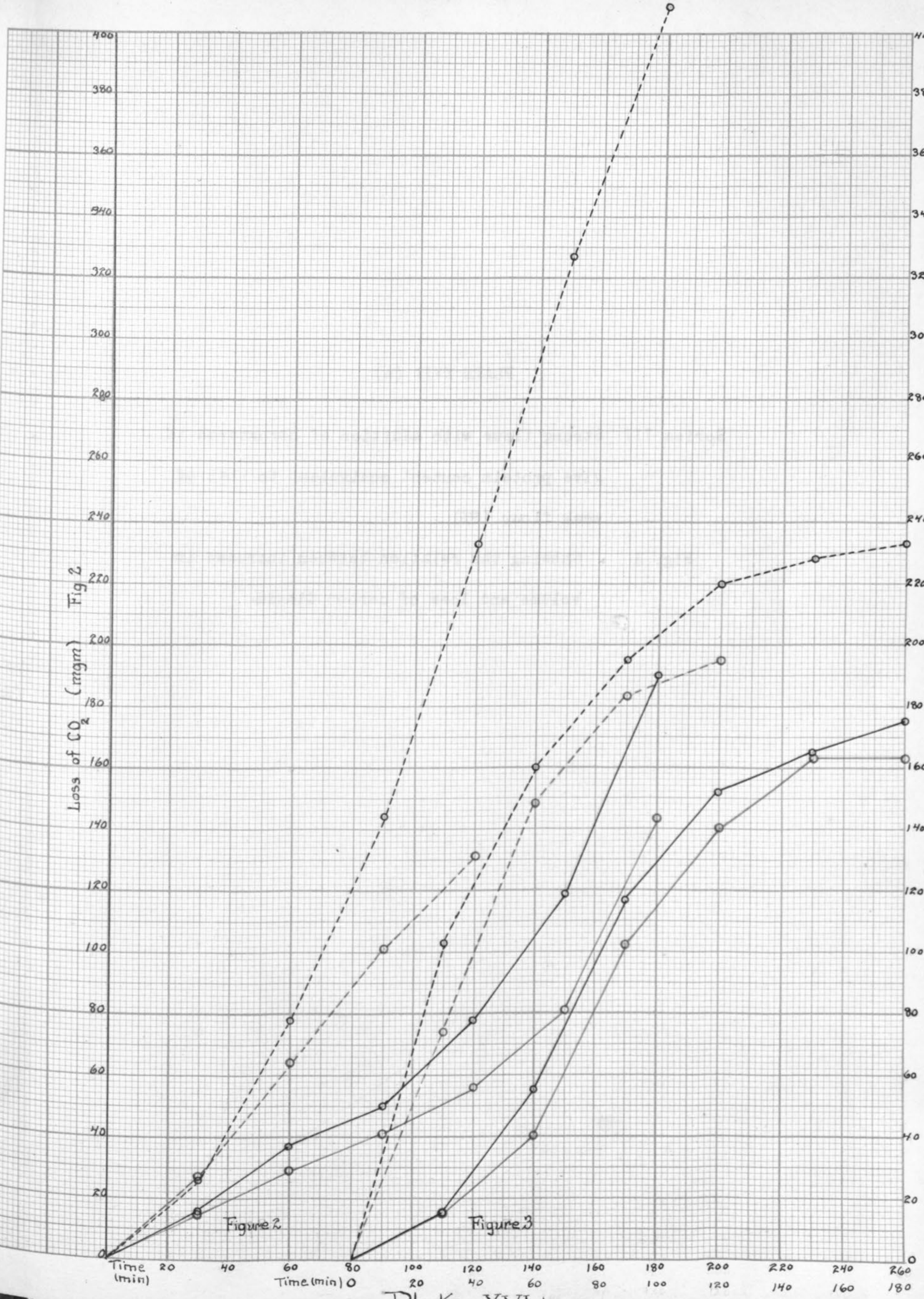

Loss of CO_2 (mgm) Fig 2
Increase in Volume (cc) Fig. 3
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Time (min) 20 40 60 80 100 120 140 160 180 200 220 240 260
Time (min) 0 20 40 60 80 100 120 140 160 180
Figure 2
Figure 3

Plate XVI b

PLATE XVII (a)

Series III Strong flour with addition of cornstarch to give protein content equivalent to that of weak flour (8%)

Fig. 1 Showing the relation between increase in volume and loss of carbon dioxid.

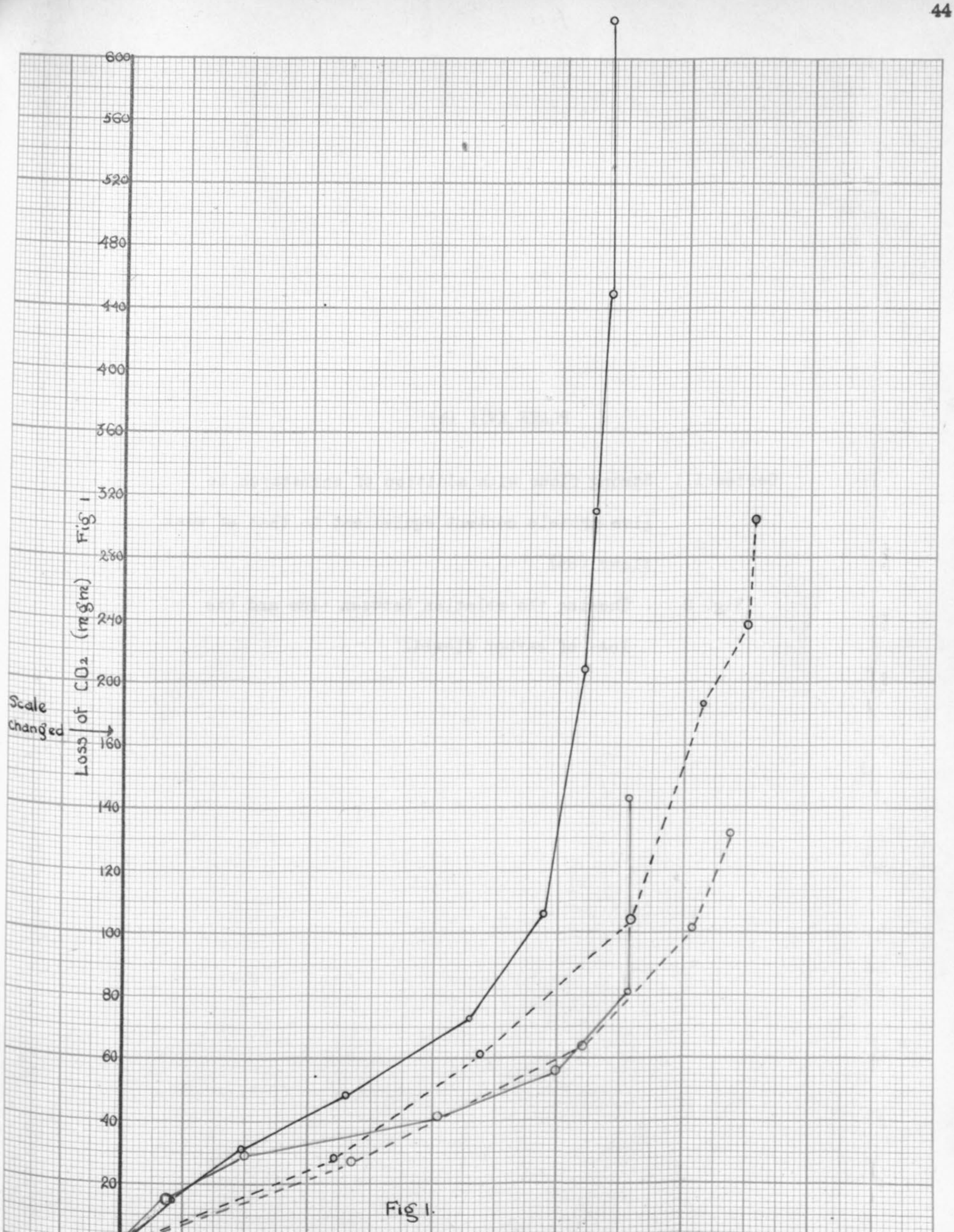
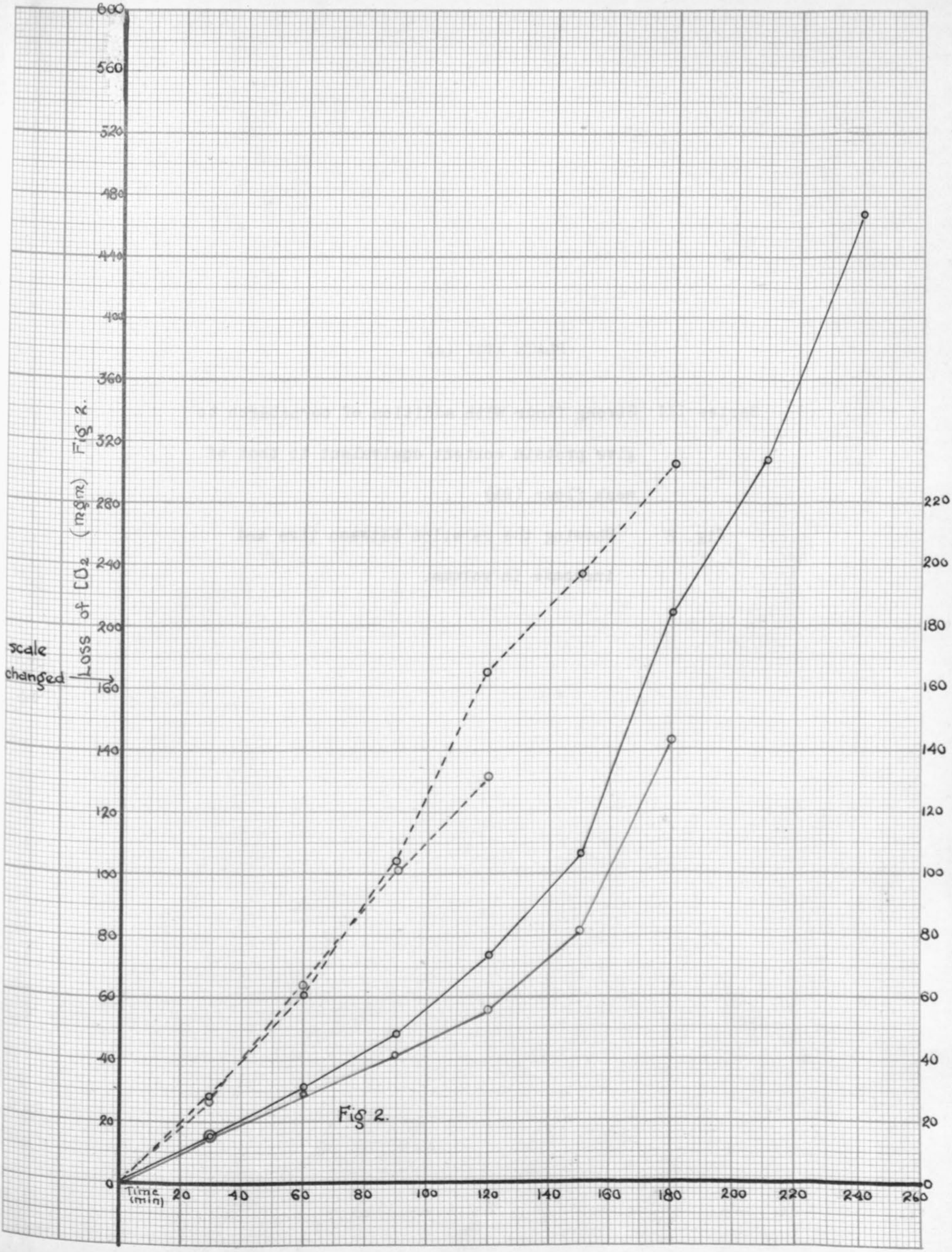

600
560
520
480
440
400
360
320
280
240
200
160
140
120
100
80
60
40
20
0
Loss of CO2 (mgm) Fig 1
Scale changed
Vol.(cc) 20
40
60
80
100
120
140
160
180
200
Fig 1.

Plate XVII a

PLATE XVII (b)

Series III Strong flour with addition of cornstarch to give protein content equivalent to that of weak flour (8%)

Fig. 2 Showing the relation between time and the loss of carbon dioxid. .



600
560
520
480
440
400
360
320
280
240
200
160
140
120
100
80
60
40
20
0
Loss of CO₂ (mgm) Fig 2.
scale changed
220
200
180
160
140
120
100
80
60
40
20
0
Time (min)
20
40
60
80
100
120
140
160
180
200
220
240
260
Fig 2.

Plate XVII b.

PLATE XVII (c)

Series III Strong flour with addition of cornstarch to give protein content equivalent to that of weak flour (8%)

Fig. 3 Showing the relation between time and increase in volume.

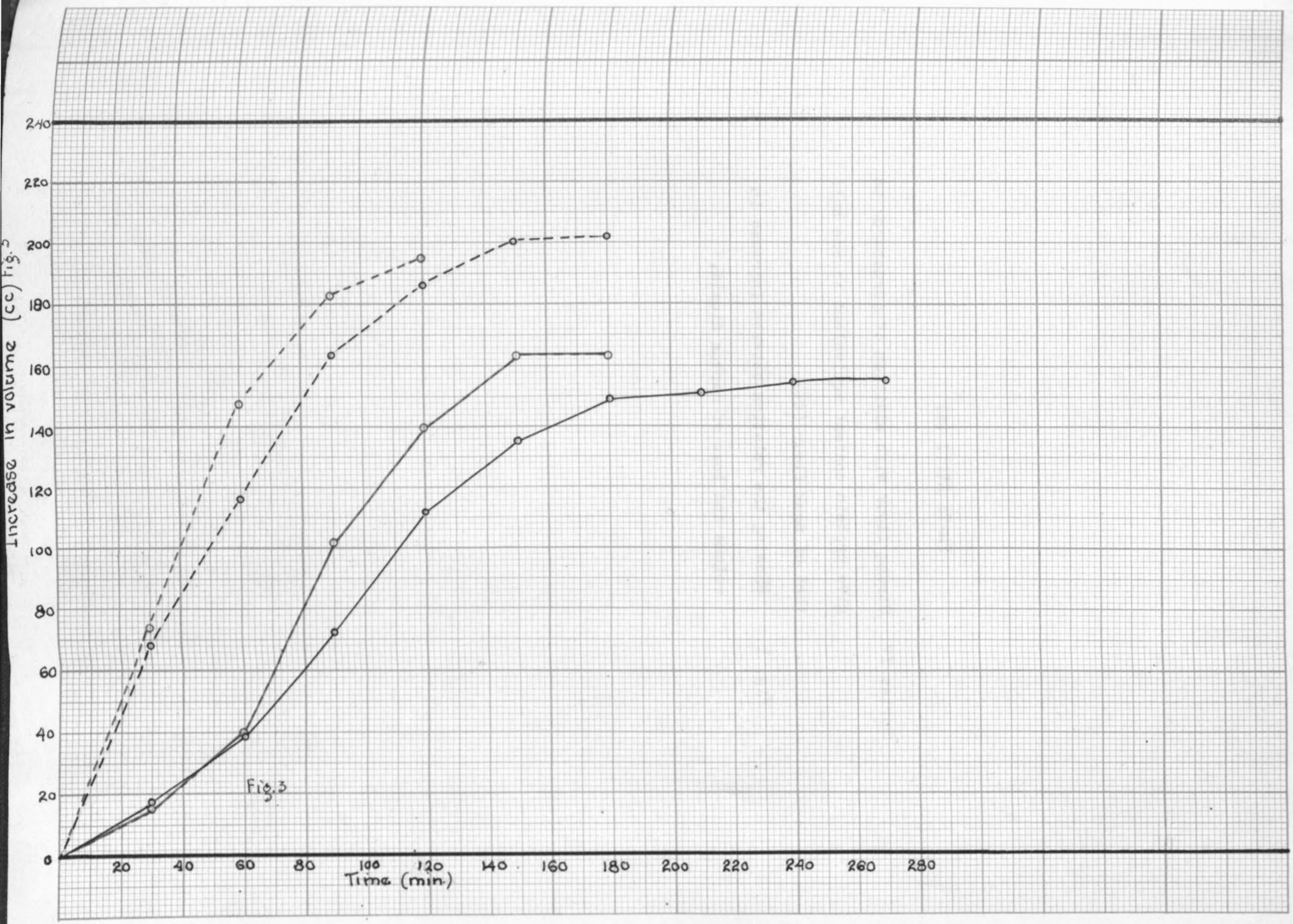

Increase in volume (cc) Fig.3
240
220
200
180
160
140
120
100
80
60
40
20
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Time (min.)
Fig.3

Plate XVII c

PLATE XVIII (a)

Series IV Strong flour with addition of cornstarch to give protein content equivalent to one half that of weak flour (4%)

Fig. 1 Showing the relation between increase in volume and loss of carbon dioxid.

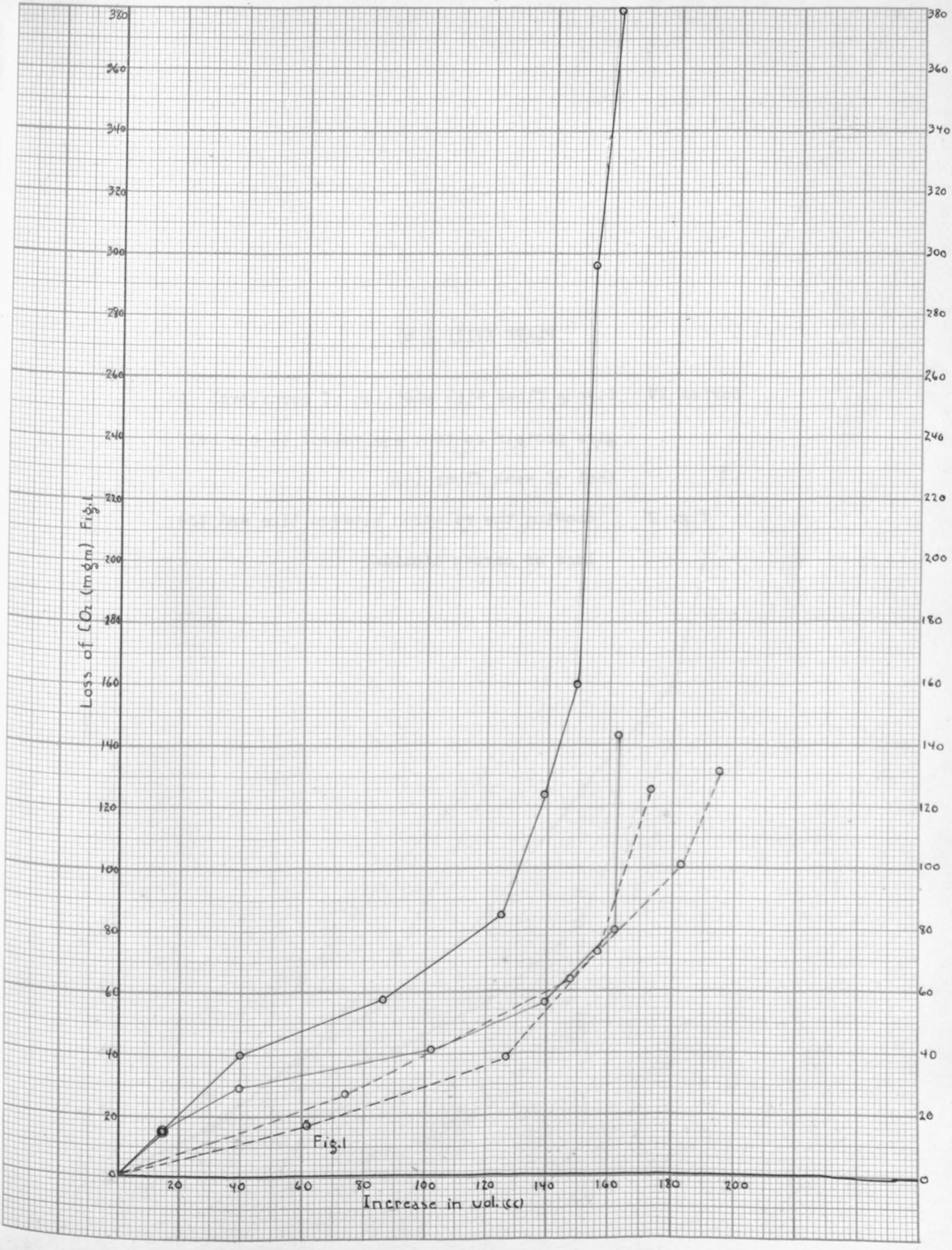


Plate XVIII a.

PLATE XVIII (b)

Series IV Strong flour with addition of cornstarch to give protein content equivalent to one half that of weak flour (4%)

Fig. 2 Showing the relation between time and the loss of carbon dioxide.

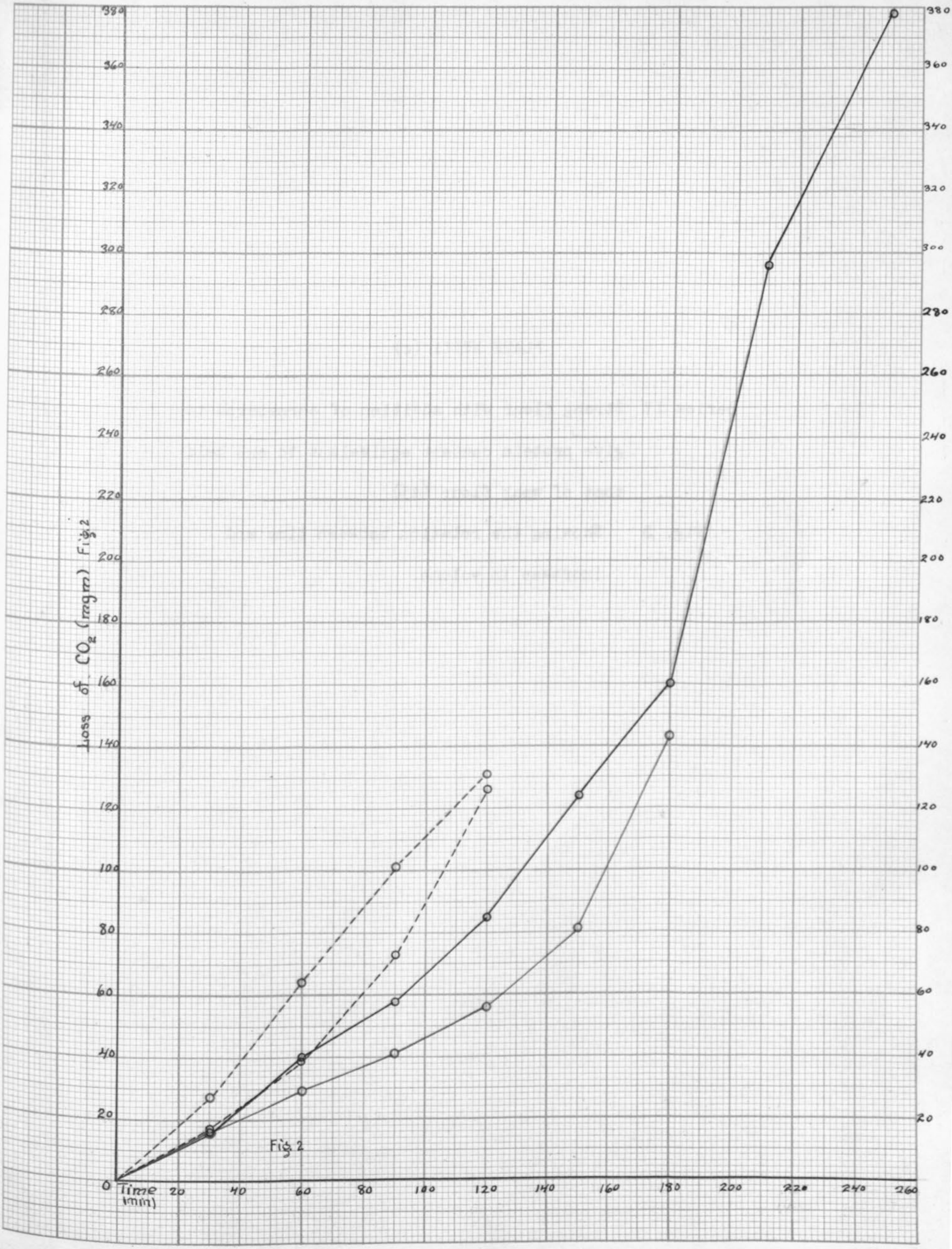


Plate XVIIIb

PLATE XVIII (b)

Series IV Strong flour with addition of cornstarch to give protein content equivalent to one half that of weak flour (4%)

Fig. 2 Showing the relation between time and the loss of carbon dioxid.

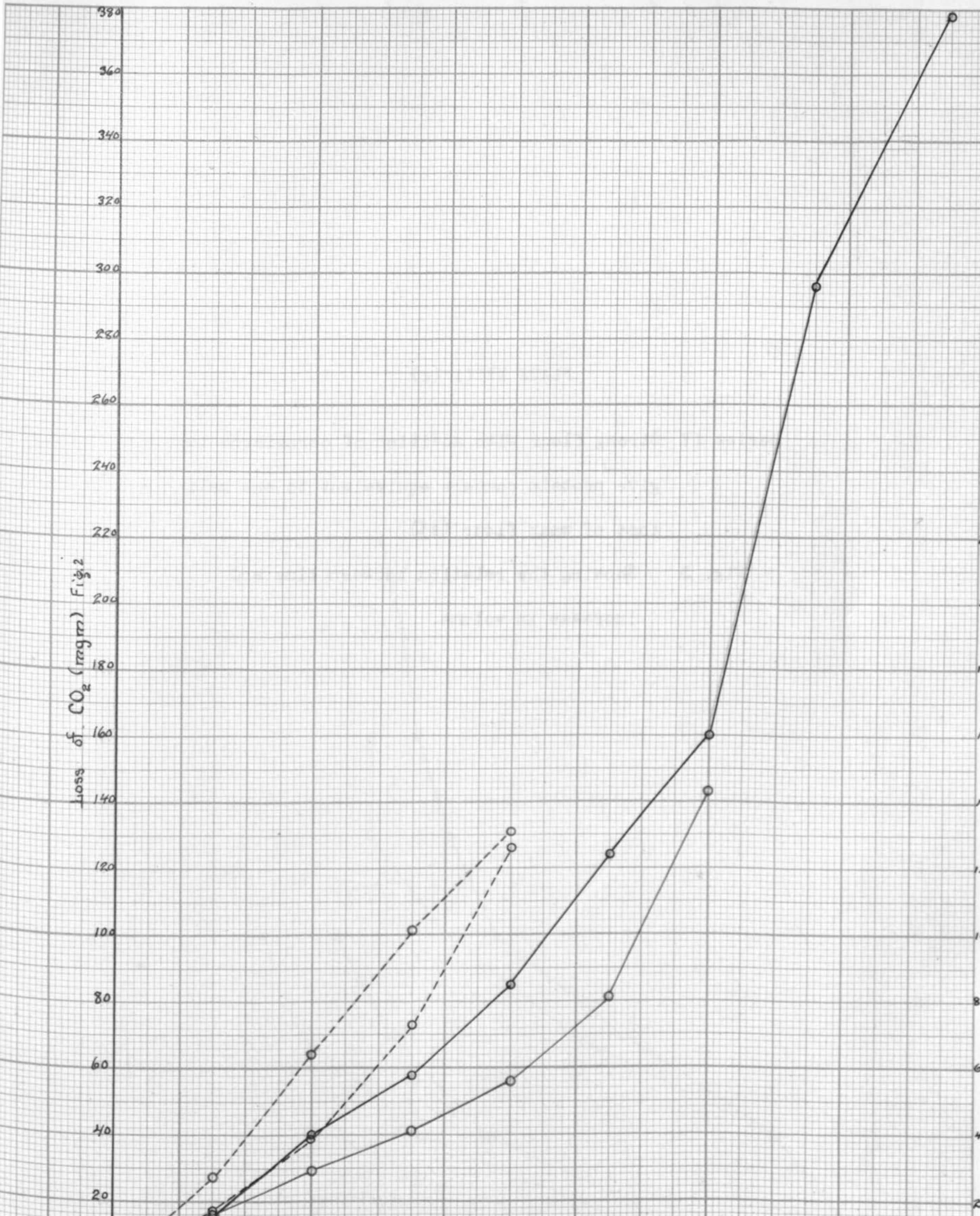


Plate XVIIIb

PLATE XVIII (c)

Series IV Strong flour with addition of cornstarch to give protein content equivalent to one half that of weak flour (4%)

Fig. 3 Showing the relation between time and increase in volume.

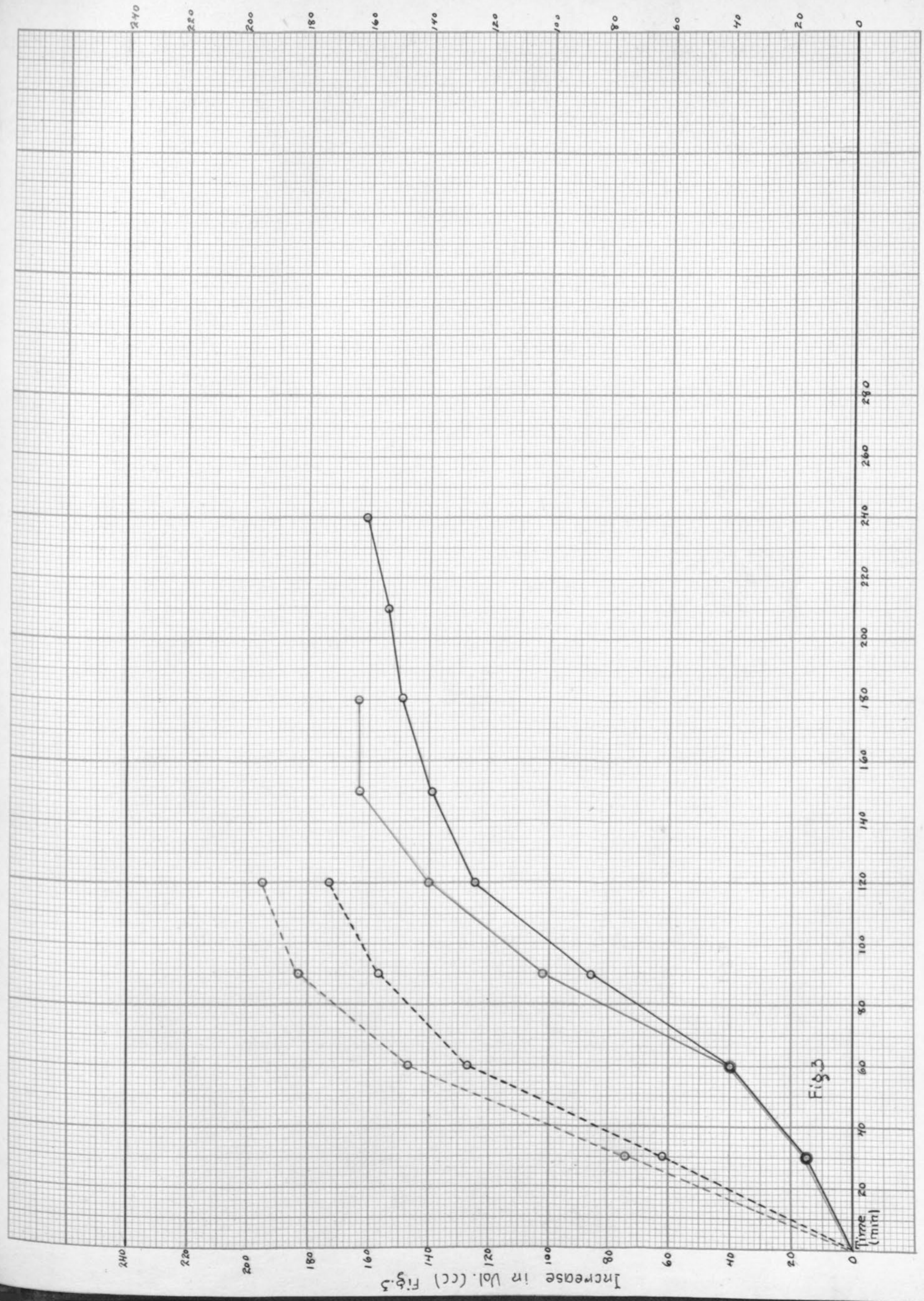


Plate XVIII c

DISCUSSION OF RESULTS

Treatment of Data

Careful observation of the curves in Figs. 1 and 2 in each series shows the breaking point in the curve frequently appearing before the falling point. A study of Table IV showing the average loss of carbon dioxide per c.c. increase in volume during thirty minute periods, indicates very erratic losses occuring after the point corresponding to the breaking point in the curve. This is accounted for by the sudden explosion of gas when the dough begins to weaken but often while it is still maintaining its volume. In the case of doughs like those in Series III and IV where cornstarch was added the loss of carbon dioxid after the breaking point in the curve was out of all proportion to the total increase in volume due to the unusual length of time during which the doughs held up before actually falling. In the light of these observations it seemed justifiable to consider the data up to the breaking point of the curve, which is the point at which the loss of carbon dioxid per c.c. increase in volume becomes markedly greater. (Plates II to XVIII and Tables IV, V, and VI.)

While the data bearing upon the falling point of the dough is included in the appendix the discussion of results here is confined to the data up to the breaking point in the curve.

Where grouping of data appears in the tables it has been done on the basis of what seemed to be significant variations as determined by securing the mean deviation of results in the replicates of experiments.

The mathematical treatment to which the data has been subjected and which is included in Tables IV to XXV does not always show the relations as clearly as does the graphic treatment in Plates II to XVIII.

TABLE IV THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series I Weak flour			Series V Weak flour, Addition of $CaSO_4$			Series VII Weak flour, Addition of NH_yCl		
Time minutes	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods
				0' Fermentation					
30	11	25.36	2.30	8	19.41	2.42	9	19.35	2.15
60	27	20.97	0.79	30	18.15	0.60	24	23.27	0.97
90	43	27.65	0.64	41	16.52	0.40	39	15.97	0.41
120	39	39.06	1.00	23	29.86	1.29	37	27.16	0.73
150	9	41.68	4.63	16	52.18	3.26	23	43.30	1.88
180				2	49.23	24.61	2	21.86	10.93
210									
240 270				Total Fermentation					
30	66	31.02	0.47	57	28.62	0.50	67	29.05	0.43
60	48	39.95	0.83	46	31.93	0.69	48	39.24	0.82
90	13	62.50	4.81	20	69.12	3.45	11	53.80	4.89
120				5	99.92	19.98	3	102.30	34.10

TABLE IV. THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series IX Weak flour, Addition of $CaSo_4$ and NH_ycl			Series XI Weak flour, Addition of NH_y H_2PO_y			Series XIII Weak flour, Addition of $(NH_4)_2$ S_2O_8.		
Time minutes	Increase invol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 minute periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 minute periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods
				O' Fermentation					
30	15	17.51	1.17	13	25.36	1.95	10	30.49	3.05
60	36	20.01	0.56	37	12.61	0.34	20	34.95	1.75
90	39	17.46	0.45	40	16.35	0.41	32	22.83	0.71
120	20	30.47	1.52	25	53.66	2.15	55	25.25	0.46
150	13	86.84	6.68	8	85.83	10.73	3	20.12	6.71
180	8	109.28	13.66						
210									
240									
270				Total Fermentation					
30	86	12.98	0.15	100	27.27	0.27	67	30.36	0.45
60	47	36.51	0.78	23	45.58	1.98	38	36.11	0.95
90	15	77.73	5.18	8	90.92	11.36	12	76.90	6.41
120	-	105.50	105.50				4	67.00	16.75

TABLE IV

THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series XV Weak flour, Addition of K Br O_3			Series XVII Weak flour, Addition of Arkady			
Time minutes	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	
				O' Fermentation			
30	11	20.75	1.89	15	13.07	0.87	
60	35	19.29	0.55	27	13.68	0.51	
90	45	21.31	0.47	63	7.61	0.12	
120	29	38.24	1.32	20	11.56	0.58	
150	11	25.93	2.36	10	17.55	1.75	
180				3	40.95	13.65	
210							
240							
270							
				Total Fermentation			
30	35	39.49	1.13	72	13.94	0.19	
60	77	30.06	0.39	35	51.24	1.47	
90	16	52.05	3.25	6	81.34	13.56	
120	4	83.58	20.89	5	87.54	17.51	
150	3	47.44	15.81	2	38.45	19.22	
180							

TABLE IV

THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series II Strong Flour			Series VI Strong flour, addition of $CaSO_4$			Series VIII Strong flour, addition of NH_ycl		
Time minutes	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods
				0' Fermentation					
30	15	15.08	1.01	8	12.03	1.50	13	26.02	2.00
60	25	14.48	0.58	27	14.38	0.54	33	27.56	0.84
90	62	12.33	0.20	41	12.17	0.30	55	22.51	0.41
120	38	14.75	0.39	59	16.20	0.27	45	30.43	0.67
150	23	25.15	1.09	20	22.26	1.11	10	31.83	3.18
180	0	62.12	62.12	7	62.87	8.98	9	85.58	9.51
210									
				Total Fermentation					
30	74	27.38	0.37	68	24.46	0.36	81	33.71	0.42
60	74	37.48	0.51	80	20.68	0.26	85	41.67	0.49
90	35	36.70	1.05	37	46.23	1.25	29	47.86	1.65
120	12	29.80	2.48	15	37.30	2.49			

TABLE IV

THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series X Strong flour, addition of $CaSO_4$ and NH_ycl			Series XII Strong flour, addition of $NH_yH_2PO_4$			Series XIV Strong flour, addition of $(NH_y)_2S_2O_8$		
Time minutes	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods
				0' Fermentation					
30	19	13.46	0.71	9	24.56	2.73	7	28.04	4.01
60	28	15.72	0.56	27	18.15	0.67	20	25.54	1.28
90	73	11.72	0.16	45	21.84	0.49	50	23.65	0.47
120	27	14.73	0.55	48	26.76	0.56	50	16.32	0.33
150	23	34.62	1.50	20	32.17	1.61	27	33.70	1.25
180	14	97.68	6.98	16	8.66	0.54	25	41.23	1.65
210							5	68.44	13.69
				Total Fermentation					
30	91	23.79	0.26	70	29.44	0.42	70	21.97	0.31
60	74	32.93	0.44	80	28.02	0.35	72	24.91	0.35
90	19	34.25	1.80	28	46.90	1.67	35	36.63	1.05
120	10	73.44	7.34	6	58.58	9.76			

TABLE IV

THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series XVI Strong flour, addition of $KbrO_3$			Series XVIII Strong flour, addition of Arkady		
Time minutes	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods
			O' Fermentation			
30	13	16.79	1.29	15	16.84	1.12
60	32	14.52	0.45	40	20.27	0.51
90	63	15.89	0.25	62	13.01	0.21
120	40	24.07	0.60	35	28.31	0.81
150	12	46.57	3.88	10	41.09	4.11
180	19	61.32	3.23	15	70.83	4.72
210						
			Total Fermentation			
30	62	26.79	0.43	103	26.76	0.26
60	65	30.84	0.47	57	51.63	0.91
90	41	38.93	0.95	35	66.12	1.89
120	22	60.47	2.75	25	89.37	3.57
150	18	84.83	4.71	8	93.17	11.65
180	12	65.42	5.45	5	81.11	16.22

TABLE IV.

THE AVERAGE LOSS OF CARBONDIOXIDE PER C.C. INCREASE IN VOLUME DURING 30 MINUTE PERIODS

	Series III Strong flour, addition of cornstarch to give protein content of 8%			Series IV Strong flour, addition of cornstarch to give protein content of 4 %		
Time minutes	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min. periods	Increase in vol. c.c.	Loss of CO_2 mgm	Loss per c.c. increase in vol. during 30 min.periods
				0' Fermentation		
30	11	15.76	1.43	15	15.57	1.04
60	28	15.31	0.55	25	24.72	0.99
90	23	17.33	0.52	46	18.47	0.40
120	40	24.79	0.62	39	27.01	0.69
150	23	33.25	1.45	14	38.52	2.75
180	14	102.59	7.33	10	35.71	3.57
210	2	99.87	49.93	5	136.00	27.20
240	4	148.40	37.10	7	83.25	11.89
270	0	179.62	179.62			
				Total Fermentation		
30	70	28.77	0.41	62	17.71	0.29
60	48	32.97	0.68	65	22.05	0.34
90	48	42.59	0.89	20	33.50	1.67
120	22	69.59	3.16	16	52.85	3.30
150	14	63.20	4.51			
180	2	67.18	33.59			

TABLEV. Showing total time to breaking point in curve
(In order of decreasing time)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. mgm.	Series	Total Fer. mgm.	Series	O' Fer. mgm.	Series	Total Fer. mgm.
$CaSO_4$÷ NH_4Cl	150	Control	60	$(NH_4)_2S_2O_8$	180	Control	90
$CaSO_4$	150	$CaSO_4$	60	Arkady	180	$CaSO_4$	90
NH_4Cl	150	NH_4Cl	60	Control	150	NH_4Cl	90
$KBrO_3$	138	$CaSO_4$÷ NH_4Cl	60	$CaSO_4$÷ NH_4Cl	150	$CaSO_4$÷ NH_4Cl	90
Control	120	$(NH_4)_2S_2O_8$	60	$NH_4H_2PO_4$	150	$(NH_4)_2S_2O_8$	90
$NH_4H_2PO_4$	120	$KBrO_3$	60	$CaSO_4$	120	$KBrO_3$	90
(NH) S O	120	Arkady	60	NH Cl	120	Arkady	90
Arkady	90	$NH_4H_2PO_4$	60	$KBrO_3$	120	$NH_4H_2PO_4$	60

TABLE V. Showing total time to breaking point in curve
(In order of decreasing time)

STRONG FLOUR WITH CORNSTARCH MIXTURE

Series	O' Fer. mgm.	Series	Total Fer. mgm.
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	180	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120
Strong control	150	Strong control	90
Weak control	120	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	90
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120	Weak control	60

CONTROLS

Strong flour	150	Strong flour	90
Weak flour	120	Weak flour	60

TABLE VI. Showing total time to breaking point in curve Series grouped.
(In order of decreasing time)

WEAK FLOUR						STRONG FLOUR					
O' Fermentation			Total Fermentation			O' Fermentation			Total Fermentation		
Series	Time Min.	Percent*$\pm$	Series	Time Min.	Percent*$\pm$	Series	Time Min.	Percent*$\pm$	Series	Time Min.	Percent*$\pm$
$CaSO_4$+ NH_4Cl	180	+50	Control $CaSO_4$ NH_4Cl $CaSO_4$ + NH_4Cl $(NH_4)_2S_2O_8$ $KBrO_3$ Arkady $NH_4H_2PO_4$	60		$(NH_4)_2S_2O_8$ Arkady	178	+18	Control $CaSO_4$ NH_4Cl $CaSO_4$+ NH_4Cl $(NH_4)_2S_2O_8$ $KBrO_3$ Arkady	90	
$CaSO_4$ NH_4Cl	150	+25				Control $CaSO_4$+ NH_4Cl $NH_4H_2PO_4$	150		$NH_4H_2PO_4$	60	-33
$KBrO_3$	138	+15				$CaSO_4$ NH_4Cl $KBrO_3$	120	-20			
Control $NH_4H_2PO_4$ $(NH_4)_2S_2O_8$	120										
Arkady	90	-25									

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*Percent(+ or -)is in relation to control.

TABLE VI. Showing total time to breaking point in curve
(In order of decreasing time)

STRONG FLOUR WITH CORNSTARCH MIXTURE					
O' Fermentation			Total Fermentation		
Series	Time Min.	Percent ± *	Series	Time Min.	Percent ± *
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	180	+20	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120	+25
Strong Control	150		Strong Control Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	90	
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120	-20			
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	180	+33	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120	+100
Weak Control Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120		Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	90	+50
			Weak Control	60	
CONTROLS					
Strong flour	150	+25	Strong flour	90	+50
Weak flour	120		Weak flour	60	

*Percent (+ or -) is in relation to control.

The Fermentation Periods

The results with doughs having no preliminary fermentation (the 0' fermentation doughs) is probably of limited value except as an indirect indication of what fermentation does for a dough. In the discussion of results, therefore, more emphasis should be laid upon the doughs which have undergone normal fermentation, designated total fermentation doughs. A comparison of these two fermentation periods, however, shows some interesting points bearing upon the contribution which fermentation makes to a dough.

A study of Plate II, Figs. 2 and 3, reveals the fact that there is a lag in volume expansion in the 0' fermentation period. This lag appears consistently throughout all the series and would seem to indicate that fermentation is responsible for accelerating the production of gas with consequent acceleration of volume in relation to time (See Plate II, Fig. 3). Fig. 2 shows that not only has fermentation been responsible for accelerating the rate of gas production but it has also improved the retention of gas.

The figures in Table VII serve to emphasize this fact. While the volume in the total' fermentation dough increases about three and a half times that of the 0' fermentation dough yet the loss of carbon dioxid is only about twice as great. This is shown more clearly by noting the loss per unit increase in volume and the ratio of loss between the 0' fermentation and the total' fermentation doughs.

Table VII Comparison of O' and total' fermentation with reference to volume increase and loss of carbon dioxid.

Series II Strong flour	Minutes	Volume	Loss of CO_2	Loss per unit increase in volume	Ratio of Loss
O' Fermentation	60	40	29.56	0.74	3
Total Fermentation	60	148	64.80	0.44	1

One important factor in the difference between the O' fermentation and the total' fermentation doughs may be that of the solution of carbon dioxid in the dough. It is possible that in the dough with no preliminary fermentation, a large amount of the carbon dioxid formed goes into solution in the water in the dough thereby rendering the volume increase less. This might easily account for the sag in the curve noticed in Plate II, Fig. 3 and other O' fermentation curves. As the water becomes saturated with carbon dioxid the excess of carbon dioxid present exercises its function of increasing the volume. This would account for the recovery of the curve during the latter portion of the O' fermentation and for the distinctly straighter curve in the total' fermentation.

This explanation suggests another problem of interest in this connection, namely, distilling out the carbon dioxid from the dough to determine the amount which has gone into solution.

The Loss of Carbon Dioxid in Relation to Increase in Volume.

The loss of carbon dioxid per c.c. increase in volume is shown graphically in Plates II to XVIII, Figs. 1.

Comparing the loss of carbon dioxid with the increase in volume in the weak and strong flours it will be observed that on the average the loss is greater in the weak than in the strong flours. Plate II showing weak and strong flour controls and Plates III and XI showing weak and strong flours with calcium sulphate treatment superimposed clearly indicate this relationship. The exception to this is in the Arkady series.

This same relation is seen where the volume of carbon dioxid diffused out per volume increase in dough has been computed for the weak and strong control flours. The results are shown in Table VII. The weak flour considered to the breaking point in the curve shows a distinctly larger ratio of volumes of gas diffused to volumes of gas retained than does the strong flour. Reference to Figs. 3 in the plates, and to Tables IX and X shows a greater maximum volume increase in the strong flours than in the weak. A typical instance of this is found in Plates VI and XIII, Figs. 3 illustrating the weak and strong flours with ammonium phosphate added.

The weak flours, with the exception of the ammonium chloride and ammonium persulphate series, show a greater proportional response to flour improvers than the strong flours . This is shown clearly by comparing Plates V and XII, Figs. 1 and 2.

The effect of the substances superimposed upon the weak flours may be seen by an examination of Plates III to IX, Figs. 1, and Tables XI and XII. In the 0' fermentation periods while no marked difference is noted between the control and the ammonium chloride, ammonium phosphate, ammonium persulphate, and potassium bromate series as shown by the mathematical treatment given the data, yet in each case there is a slight increase in volume in relation to the loss of carbon dioxid in favor of the flour to which the so called "improvers" have been added. The series where arkady is used shows a striking decrease in loss of carbon dioxid per c.c. of volume increase as compared with the control, the decrease in loss being approxi-

TABLEVIII.Volume of carbon dioxid diffused out from dough per volume increase in dough.

	Weak Flour O' Fermentation				Strong Flour O' Fermentation			
Time Min.	Carbon dioxid lost		Volume increase	Volume carbon dioxid diffused out per vol. increase	Carbon dioxid lost		Volume increase	Volume carbon dioxid diffused out per vol. increase.
Min.	mgm.	c.c.	c.c.	c.c.	mgm.	c.c.	c.c.	c.c.
0								
30	25.36	14.51	11	1.33	15.08	8.75	15	0.58
60	46.33	26.87	27	0.99	29.56	17.14	25	0.68
90	73.98	42.91	43	1.00	41.89	24.30	62	0.39
120	113.04	65.56	39	1.68	56.64	32.75	38	0.86
150					81.79	47.44	23	2.06
180								
	Total' Fermentation							
0								
30	31.02	17.99	66	0.27	27.38	15.88	74	0.21
60	70.97	41.16	48	0.86	64.86	37.62	74	0.51
90					101.56	58.90	35	1.68

TABLE IX. Showing maximum volume increase before breaking point in curve.
(In order of decreasing volume)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fe r. mgm.	Series	Total Fer. mgm.	Series	O' Fer. mgm.	Series	Total Fer. mgm.
NH_4Cl	132	$CaSO_4$+ NH_4Cl	133	$(NH_4)_2S_2O_8$	179	NH_4Cl	195
$KBrO_3$	131	$NH_4H_2PO_4$	122	$CaSO_4$	[illegible]	$NH_4H_2PO_4$	[illegible]
$CaSO_4$+ NH_4Cl	123	NH_4Cl	115	Arkady	177	Arkady	195
Control	120	Control	114	$CaSO_4$+ NH_4Cl	170	$CaSO_4$	185
$CaSO_4$	118	$KBrO_3$	112	Control	163	$CaSO_4$+ NH_4Cl	184
$(NH_4)_2S_2O_8$	117	Arkady	107	$NH_4H_2PO_4$	149	Control	183
Arkady	105	$(NH_4)_2S_2O_8$	105	$KBrO_3$	148	$(NH_4)_2S_2O_8$	177
$NH_4H_2PO_4$	100	$CaSO_4$	103	NH_4Cl	146	$KBrO_3$	168
				$CaSO_4$	135	$NH_4H_2PO_4$	150

TABLE IX. Showing maximum volume increase before breaking point in curve.
(In order of decreasing volume)

		STRONG FLOUR AND CORNSTARCH MIXTURE	
Series	O' Fer. mgm.	Series	Total Fer. mgm.
Strong control	163	Strong control	183
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	149	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	173
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	125	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	164
Weak control	120	Weak control	114
		CONTROLS	
Strong flour	163	Strong flour	183
Weak flour	120	Weak flour	114

TABLE X.Showing maximum volume increase before breaking point in curve. Series grouped.
(In order of decreasing volume)

WEAK FLOUR						STRONG FLOUR					
O' Fermentation			Total Fermentation			O' Fermentation			Total Fer mentation		
Series	Volume c.c.	Percent*$\pm$	Series	Volume c.c.	Percent*$\pm$	Series	Volume c.c.	Percent*$\pm$	Series	Volume c.c.	Percent*$\pm$
NH_4Cl $CaSO_4$+ NH_4Cl $KBrO_3$	131	+11	$CaSO_4$+ NH_4Cl $NH_4H_2PO_4$	127	+11	$(NH_4)_2S_2O_8$ Arkady $CaSO_4$+ NH_4Cl	175	+7	NH_4Cl Ar kady	195	+7
Control $CaSO_4$ $(NH_4)_2S_2O_8$	118		NH_4Cl Control $KBrO_3$	114		Control	163		$CaSO_4$ $CaSO_4$ + NH_4Cl Control $(NH_4)_2S_2O_8$	182	
Arkady $NH_4H_2PO_4$	103	-12	Arkady $(NH4)_2S_2O_8$ $CaSO_4$	105	-7	$KBrO_3$ NH_4Cl	147	-9	$KBrO_3$	168	-7
						$CaSO_4$	135	-17	$NH_4H_2PO_4$	150	-17

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*Percent (+ or -) is in relation to control.

TABLE X. Showing maximum volume increase before breaking point in curve.
(In order of decreasing volume)

STRONG FLOUR WITH CORNSTARCH MIXTURE					
O' Fermentation			Total Fermentation		
Series	Volume c.c.	Percent ± *	Series	Volume c.c.	Percent ± *
Strong control	163		Strong Control	183	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	149	-9	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	173	-5
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	125	-23	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	164	-10
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	149	+22	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	173	+52
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	122		Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	164	+44
Weak Control			Weak Control	114	
CONTROLS					
Strong flour	163	+26	Strong flour	183	+38
Weak flour	120		Weak flour	114	

*Percent (+ or -) is in relation to control.

TABLE XI. Showing loss of Carbon dioxid per c.c. increase in volume before breaking point.
(In order of increasing loss)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. mgm.	Series	Total Fer. mgm.	Series	O'Fer. mgm.	Series	Total Fer. mgm.
Arkady	0.33	$CaSO_4$ + NH_4Cl	0.37	$CaSO_4$	0.41	$(NH_4)_2S_2O_8$	0.47
Control	0.94	$NH_4H_2PO_4$	0.59	$KBrO_3$	0.48	$NH_4H_2PO_4$	0.48
$KBrO_3$	0.96	NH_4Cl	0.59	Control	0.50	$CaSO_4$ + NH_4Cl	0.49
$(NH_4)_2S_2O_8$	0.97	$CaSO_4$	0.59	$CaSO_4$ + NH_4Cl	0.53	$CaSO_4$	0.49
NH_4Cl	0.98	Arkady	0.61	Arkady	0.59	Control	0.56
$NH_4H_2PO_4$	1.08	$KBrO_3$	0.62	NH_4Cl	0.73	$KBrO_3$	0.59
$CaSO_4$	1.15	Control	0.62	$NH_4H_2PO_4$	0.83	NH_4Cl	0.63
$CaSO_4$ + NH_4Cl	1.40	$(NH_4)_2S_2O_8$	0.63	$(NH_4)_2S_2O_8$	0.94	Arkady	0.75

TABLE XI. Showing loss of carbon dioxid per c.c. increase in volume before breaking point. (In order of increasing loss)

STRONG FLOUR AND CORNSTARCH MIXTURE			
Series	O'Fer. mgm.	Series	Total Fer. mgm.
Strong Control	0.50	Strong Control	0.56
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.68	Weak Control	0.62
Weak Control	0.94	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	0.63
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.40	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.73
		CONTROLS	
Strong flour	0.50	Strong flour	0.56
Weak flour	0.94	Weak flour	0.62

TABLE XII Showing loss of Carbon dioxid per c.c. of increase in volume before breaking point in curve. Series grouped. (In order of increasing amount)

WEAK FLOUR						STRONG FLOUR					
O' Fermentation			Total Fermentation			O' Fermentation			Total Fermentation		
Series	Loss CO_2 mgm.	Percent ±*	Series	Loss CO_2 mgm.	Percent ±*	Series	Loss CO_2 mgm.	Percent ±*	Series	Loss CO_2 mgm.	Percent ±*
Arkady	0.33	-66	$CaSO_4$+ NH_4Cl	0.37	-39	$CaSO_4$ $KBrO_3$ Control $CaSO_4$+ NH_4Cl Arkady NH_4Cl	0.54		$(NH_4)_2S_2O_8$ $NH_4H_2PO_4$ $CaSO_4$+ NH_4Cl $CaSO_4$ Control $KBrO_3$	0.51	
Control $KBrO_3$ $(NH_4)_2S_2O_8$ NH_4Cl $NH_4H_2PO_4$	0.98		$NH_4H_2PO_4$ NH_4Cl $CaSO_4$ Arkady $KBrO_3$ Control $(NH_4)_2S_2O_8$	0.61		$NH_4H_2PO_4$	0.83	+53	NH_4Cl	0.63	+23
$CaSO_4$	1.15	+17				$(NH_4)_2S_2O_8$	0.94	+74	Ar kady	0.75	+47
$CaSO_4$+ NH_4Cl	1.40	+43									

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*Percent (+ or -) is in relation to control.

TABLE XII Showing loss of carbon dioxid per c.c. of increase in volume before breaking point in curve.
(In order of increasing amount)

STRONG FLOUR WITH CORNSTARCH MIXTURE					
0' Fermentation			Total Fermentation		
Series	Loss of CO_2 mgm.	Percent ± *	Series	Loss of CO_2 mgm.	Percent ± *
Strong Control	0.50		Strong Control		
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.68	+36	Strong flour with cornstarch addedto give ½ protein equivalent of weak flour (8%)	0.59	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.40	+180	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.73	+24
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.68	-28	Weak Control		
Weak Control	0.94		Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	0.62	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.40	+49	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.73	+18
		CONTROLS			
Strong flour	0.50	+47	Strong flour Weak flour	0.59	
Weak flour	0.94				

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*Percent (+ or -) is in relation to control.

mately 66 percent below that of the control. On the other hand the series with calcium sulphate and ammonium chloride shows an increase in loss of 43 percent. This series would, however, like the rest show a decrease in loss over the control if the last thirty minute period were not considered.

In the total' fermentation period all of the series show some decrease in loss over the control, that of the ammonium persulphate series being very slight however. (Plate VIII, Fig. 1). Series IX with calcium sulphate and ammonium chloride added (Plate V, Fig. 1) shows the most marked decrease with 39 percent less loss than the control.

Examination of Plates XVII and XVIII, Figs. 1 giving the results of the cornstarch mixtures shows a greater increase in volume in relation to loss of carbon dioxid in both the mixture with protein content equivalent to that of weak flour and in that with protein content equivalent to one-half that of weak flour than does the weak flour control. This suggests that the quantity of protein is not the factor that determines the carbon dioxid diffusion ratio.

A study of the strong flours, 0' fermentation period, shows a decrease in loss of carbon dioxid per c.c. increase in volume over the control in all of the series except that of ammonium phosphate and ammonium persulphate which show an increase of 53 and 74 percent respectively.

In the total' fermentation period there is again a decrease in the loss of carbon dioxid in relation to volume increase except in the case of the ammonium chloride and arkady series. Even in the arkady series the loss is less until the last thirty minute period.

It has been impossible to make a complete analysis of the results secured. The tables included in the appendix will warrant further study.

SUMMARY

There are presented here data which show the losses in carbon dioxid and the retention of gas in doughs made from weak and strong flours with and without the addition of "flour improvers". The results of analyses and baking tests on these flours are also presented.

From a study of these data the following conclusions have been drawn:

(1) There is a lag in volume expansion in the dough with no preliminary fermentation indicating that fermentation is responsible for accelerating the production of gas in relation to time and improving of the retention of gas.

(2) Weak flours show less maximum increase in volume in relation to time than the strong flours.

(3) Weak flours show a greater proportional response to flour improvers than do the strong flours.

(4) Quantity of protein does not bear a definite relation to volume increase.

(5) Quantity of protein in the flour is apparently not the sole determining factor in the loss of carbon dioxid in relation to the increase in volume.

(6) Strong flours show a smaller loss of carbon dioxid per c.c. increase in volume than the weak flours.

(7) Effect of the substances superimposed upon the weak and strong flours in these experiments is to decrease the loss of carbon dioxid in relation to volume increase.

(8) Cornstarch and flour mixtures exhibit a tendency to decrease the loss of gas in relation to that retained compared with the weak and strong control flours.

(9) The smaller loss of carbon dioxid per c.c. increase in volume in the strong than in the weak flours, and the decrease in the loss of carbon dioxid per c.c. increase in volume when improvers are added to weak or strong flours lead to the general conclusion that the carbon dioxid diffusion ratio may be taken as an index of flour strength.

LITERATURE CITED

Alway, F. J., and Hartzell, Stella.
1910 On the strength of wheat flour. In Nebr. Agri. Sta. Rpt., p. 100-110.

Armstrong, E. F.
1910. The chemical properties of wheaten flour. In Jour. Bd. Agr. (Eng.) Sup. No. 4, V. 17, No. 3, p. 45-52.

Bailey, C. H.
1913. Relation of the composition of flour to baking quality. In Canadian Miller and Cerealist, V. 5, p. 208, 209.

Bailey, C. H.
1916. A method for the determination of the strength and baking qualities of wheat flour. In Jour. Ind. and Engin. Chem., V. 8, No. 1, p. 53.

Baker, J. L. and Hulton, H. F. S.
1907. Some considerations determining the strength of flour. In Rpt. Brit. Assoc. Adv. Sci. 1907, p. 488, 489.

Baker, J. L. and Hulton, H. F. S.
1908. Some considerations affecting the "strength" of wheat flour. In Jour. Soc. Chem. Ind., V. 27, No. 8, p. 368-376.

Baker, J. L. and Hulton , H. F. S.
1909. On the behaviour of wheaten flours toward bakers' and brewers' yeasts. In Proc. 7th Int. Cong. App. Chem. Sec. VI, b, p. 132-134, 1910.

Baker, J. L. and Hulton, H. F. S.
1909. The toxicity of flours toward saccharomyces cerivisiae, In Proc. 7th Int. Cong. App. Chem., Sec. VI. b, p 135, 1910.

Blish, M. J.
1916. On the Chemical constitution of the proteins of wheat flour and its relation to baking strength. In Jour. Ind. and Eng. Chem., V. 8, No. 2, p. 138-144.

Cohn, E. J. and Henderson, L. J.
1918 The physical chemistry of bread-making. In Science, V. 48, p. 501-505.

Falk, I. S. and Winslow, E. E. A.
1918. The effect of potassium bromate upon enzyme action. In Jour. Biol. Chem., V. 33, No. 3, p. 453-462.

Fleurent, E.
1896. Etude de la constitution immediate du gluten des different cereals; Influence de cette constitution sur la valeur Boulangere des farines. In 2nd Cong. Inter-nat. Chm., Appl. 2, p. 64-70.

Ford, J. S. and Guthrie, J. M.
1908. The amyolytic and proteolytic ferments of wheaten flour and their relation to "baking" value. In Jour. Soc. Chm. Ind., V. 27, p. 389-393.

Gortner, R. A. and Doherty, E. H.
1918. Hydration capacity of gluten from "strong" and "weak" flours. In Jour. Agri. Research, V. 13, No. 8, p. 389-417.

Guess, H. A.
1900. The gluten constituents of wheat and flour and their relation to bread-making qualities. In Jour. Am. Chem. Soc., V. 22, p. 263-268.

Gurjar, A. M.
1917. The adaptation of Truog's method for the determination of carbon dioxid to plant respiration studies. The Plant World, V. 20, No. 9, p. 288-293.

Hall, A. D.
1904. The question of quality in wheat. In Jour. Bd. of Agri. (Eng.), 1904, V. 11, p. 321-337.

Hoffman, C. H.
1917. The utilization of ammonium chloride by yeast. In Jour. Ind. and Eng. Chem., Vol. 9, p. 148-151.

Humphries, A. E. and Biffen, R. H.
1907. The improvement of English wheat. In Jour. Agri. Sci., V. 2, p. 1-16.

Humphries, A. E. and Simpson, A. G.
1909. Gas-making capacity as a factor in the estimation of strength of wheaten flours. In Proc. Int. Cong. Appl. Chem. Sect., VI a, p. 27-38.

Humphries, A. E.
1910. Quality in wheaten flour. In Jour. Bd. Agr. (Eng.) Sup. No. 4, V. 17, No. 3, p. 39-45.

Jago, W.
1911. The science and art of bread making. London, Lemikin, Marshall and Company, p. 291.

Jessen-Hansen, H.
1911. Etudes sur la farine de froment. 1. Influence de la concentration en ions hydrogene sur la valeur boulangere de la farine. In Comp. rend. trov. lab. Carlsberg, T. 1, p. 150-206. (Original not seen).

Kohman, H. A., Hoffman, C., Godfrey, T. M., Ash, L. H., and Blake, A. E.
1916. On the use of certain yeast nutrients in bread making. In Jour. Ind. and Eng. Chm., V. 8, p. 781-789.

Laudenberger, L. L. and Morse, W.
1918. Barley bread, optimum reaction and salt effect. In Science, V. 48, p. 269-70.

Martin, F. J.
1920. Properties affecting strength in wheaten flour. In Jour. Soc. Chm. Industry, V. 39, No. 14, p. 246-251.

Masters, H. and Maughan, M.
1920. An experimental study of the effect of certain organic and inorganic substances on the bread-making properties of flour and on the fermentation of yeast. In Biochem. Jour., V. 14, No. 5, p. 586-602.

Shutt, F. T.
1907. The relationship of composition to bread-making value. Cent. Exp. Farm (Can.) Bul. 57, p. 37-51.

Shutt, F. T.
1909 Flour: The relationship of composition to bread-making value. In Proc. 7th Int. Cong. Appl. Chm. Sec. VII, p. 108-135.

Snyder, H.
1899 a. The proteids of wheat flour. Minn. Sta. Bul. 63, p. 519-533.

Snyder, H.
1899 b. Studies on bread and bread-making. In U. S. Dept. Agr. Office, Exp. Sta. Bul. 67, p. 21-27.

Snyder, H.
1901. Studies on bread and bread making. In U. S. Agri. Office Exp. Sta.Bul. 101, p. 56-59.

Snyder, H.
1904. The determination of gliadin in wheat flour by means of the polariscope. In Jour. Amer. Chem. Soc., V. 26, p. 263-266.

Truog, E.
1915. Method for the determination of carbon dioxide and a new form of absorption tower adapted to the titrimetric method. In Jour. Ind. and Eng. Chem., V. 7, No. 12, p. 1045-1049.

White, H. L.
1913. The influence of bran extracts on the baking qualities of flour. In No. Dak. Sta. Bul. 106, p. 47-58.

White, H. L. and Beard, R. F.
1913. The phosphorus content of wheat and of wheat flour; and its relation to the baking qualities of the flour. In No. Dak. Sta. Bul., 106, p. 59-64.

Wood, T. B.
1907. The chemistry of flour strength. In Jour. Agri. Sci. V. 2, p. 139-161, 267-277.

Wood, T. B. and Hardy, W. B.
1909. Electrolytes and colloids - The physical state of gluten. In Proceedings of the Royal Soc. of London, Series B., V. 81, p. 38-43.

APPENDIX

TABLE XIII. Individual determinations showing loss of carbon dioxid and volume increase.

SERIES I CONTROL - WEAK FLOUR (#878)

O' Fermentation

	First Determination		Second Determination		Third Determination		Fourth Determination	
Time	CO2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		50		70		65		
30	7.31	60	16.74	85	28.05	70		
60	17.51	95	31.60	105	54.00	110		
90	25.20	135	47.51	140	111.67	175		
120	56.14	160	72.21	195	137.62	205		
150	124.90	165	103.18	205	173.20	210		
180								

Total Fermentation

0		60		65		65		70
30	25.35	145	20.51	155	20.72	140	15.49	115
60	41.68	185	40.60	180	45.00	195	34.33	170
90	87.01	180	76.18	200	90.42	210	85.82	195
120					161.58	210	112.61d	206

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES I CONTROL - WEAK FLOUR (#878)

O' Fermentation

Fifth Determination		Sixth Determination		Seventh Determination		Eighth Determination		Ninth Determination		Average	
CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	cc
	65		60		60		65		60		63
24.91	80	24.42	70	33.48	70	27.18	75	40.97	70	45.36	74
37.47	105	52.78	95	49.24	95	51.60	105	76.42	95	46.33	101
65.93	155	75.63	135	67.15	140	79.57	140	118.17	135	73..98	144
98.37	190	106.55	170	96.31	185	166.23	180	170.95	175	113.04	183
		170.36	190	130.97	195			225.70	190	154.72	192
		203.05	190b					298.18	200c		

Total Fermentation

	70		60		65		60		70		62
15.19	115	32.23	110	26.00	115	58.69	130	43.72	120	31.02	128
34.33	1170	49.39	170	70.12	170	163.47	170	114.42	175	70.97	176
85.82	195	96.69	185	122.22	190	239.89	175	208.56	185	133.47	189
112.61	200a							333.82	200		

a - Fell at 105 minutes
b - Fell at 158 minutes
c - Fell at 170 minutes
d - Fell at 105 minutes

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES II CONTROL - STRONG FLOUR (straight)

	First Determination		Second Determination		Third Determination		Fourth Determination	
Time	CO$_2$	Volume	CO$_2$	Volume	CO$_2$	Volume	CO$_2$	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
O' Fermentation								
0		70		60		60		65
30	10.72	80	13.60	85	18.0	70	19.67	75
60	18.04	105	23.23	145	37.67	90	42.27	100
90	27.79	155	25.54	205	52.32	135	53.99	150
120	34.02	190	41.44	240	67.39	165	67.97	205
150	60.55	215	81.21	250	82.04	210	82.04	225
180	134.80	225			134.36	215		
Total Fermentation								
0		80		70		65		70
30	13.65	150	29.93	160	31.81	140	9.63	110
60	30.22	220	45.03	245	67.81	215	61.12	215
90	50.21	260	69.31	285	109.67	235	135.63	245
120	84.82	280	141.73	300	181.48	240	226.47	260
150			226.29	310				

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES II CONTROL - STRONG FLOUR (straight)

Fifth Determination		Average	
CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
	60		65
13.40	80	16.59	75
26.80	115	34.31	85
49.83	180	49.46	110
73.48	215	101.55	155
101.13	230	138.49	205
162.57	240		
	70		70
53.16	160	26.12	130
100.88	230	83.98	190
119.72	260	124.83	235
		166.68	250

TABLE XIII Individual determinations showing loss of carbon dioxide and volume increase.

SERIES III - Strong flour with cornstarch added to produce a protein content equivalent to the weak flour (8.00 %)

0' Fermentation

	First Determination		Second Determination		Third Determination		Fourth Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		70		60		60		70		65
30	21.77	80	8.00	75	19.88	65	13.39	85	15.76	76
60	30.56	95	16.00	105	40.02	90	37.69	125	31.07	104
90	36.42	110	24.0	145	70.58	120	62.60	175	48.2	137
120	53.16	145	34.04	180	108.25	175	97.34	210	73.19	177
150	69.91	210	64.18	200	166.02	180	185.66	210	106.44	200
180	115.95	2225	140.36	210	271.51	205	308.31	215	209.03	214
210	202.60	225	239.99	215	365.28	205	428.03	220	308.9	216
240			336.27	225	524.13	210	511.75	225	457.3	, 220
270					682.57	215	591.28	225	636.92	220

Total Fermentation

0		60		65		70		70		66
30	22.60	135	20.51	130	44.37	145	27.63	125	28.77	134
60	60.28	185	49.81	160	72.83	190	64.05	175	61.74	182
90	98.79	235	92.93	235	121.36	225	104.24	225	104.33	230
120	146.93	205	185.02	265	200.89	235	162.84	245	173.92	252
150	214.74	275	257.44	295	254.89	245	221.44	250	237.12	266
180				305	298.84	250	309.76	250	304.30	268
210				305			372.55	250		

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES IV - Strong flour with cornstarch added to produce a protein content equivalent to one-half of the weak flour

O' Fermentation

	First Determination		Second Determination		Third Determination		Fourth Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		60		65		55		65		61
30	8.79	75	9.63	75	21.77	75	22.19	80	15.57	76
60	28.67	100	19.68	100	43.54	100	69.28	105	40.29	101
90	41.65	135	28.05	155	62.38	140	102.98	160	58.76	147
120	59.65	175	45.68	190	86.66	190	151.12	190	85.77	186
150	123.70	195	75.82	200	93.38	205	199.26	200	124.29	200
180		205	175.03	210	151.12	215	312.28	210	160.00	210
210					194.23	215	397.26	215	296.00	215
					238.60	220	519.91	225	379.25	222
					289.67	220	565.54	225		

Total Fermentation

0		60		65		70		70		66
30	5.86	120	8.37	105	40.18	150	16.33	140	17.71	128
60	27.21	190	39.35	175	64.46	205	28.05	205	39.76	193
90	63.63	230	51.94	210	106.74	235	70.75	220	73.26	223
120	128.09	245	109.71	245	163.25	245	103.40	220	126.11	239
150				260	245.7	260				
180					270					
210					270					

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES V - Weak flour with calcium sulphate added

(12 gm. $CaSO_4$ to 100 gm. flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Fourth Determination	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
MINUTES	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		70				60		60
30	10.47	75			27.21	70	20.51	65
60	22.18	115			42.91	85	34.32	95
90	32.17	160			54.63	110	46.04	145
120	58.99	170			69.07	140	74.50	185
150	143.56	180			87.70	160	140.64	200
180	257.63	185			114.07	180		
210					161.37	185		
240					230.23	185		

Total Fermentation

0		60		60		60		65
30	34.72	140	24.28	115	17.79	100	27.63	130
60	87.75	175	53.16	165	37.04	150	55.88	180
90	167.69	180	97.53	185	66.76	165	131.65	195
120	277.38	190	244.46	185	109.88	170	234.21	205
150			312.95	190	158.86	175		
180					221.23	175		
210					268.55	175		

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES V - Weak flour with calcium sulphate added

(12 gm. $CaSO_4$ to 100 gm. flour)

Fifth Determination		Average	
CO_2	Volume	CO_2	Volume
mgm.	c.c.	mgm.	c.c.
	65		63
19.46	75	19.41	71
50.85	110	37.56	101
83.50	155	54.08	142
133.22	165	83.94	165
172.57	185	136.12	181
		185.35	183*
	70		65
38.67	125	28.62	122
68.94	170	60.55	168
184.72	215	129.67	188
262.06	215	225.59	193

* Average of 2 determinations

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES VI - Straight flour with calcium sulphate added

(12 gm. Ca SO_4 to 100 gm. flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time minutes	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
0		70		70		70		70
30	12.19	80	14.23	75	9.69	80	12.03	78
60	25.35	105	28.04	90	25.84	120	26.41	105
90	35.59	150	46.25	105	33.91	185	38.58	146
120	51.67	215	64.25	180	48.44	220	54.78	205
150	80.68	230	87.27	210	62.97	235	77.04	225
180	159.97	235	122.85	230			139.91	232a
210	271.55	240						

Total Fermentation

0		75		75		80		77
30	37.05	150	21.14	135	15.18	150	24.46	145
60	48.75	225	57.14	225	29.55	225	45.14	225
90	126.75	260	100.05	265	47.31	260	91.37	262
120	172.57	275			84.78	280	128.67	277b
150	235.94	280						

a - average of 2 determinations
b - average of 2 determinations

TaBLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES VII - Weak flour with ammonium chloride added

(.06 gm. NH_y Cl to 100 gm. flour)

0' Fermentation

	First Determination		Second Determination		Third Determination	
Time minutes	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
0						65
30					10.46	70
60					21.34	95
90					38.08	135
120					52.94	170
150					81.82	200
180					121.59	200
210						

Total Fermentation

0		65		70		60
30	27.52	140	31.60	140	20.09	115
60	74.07	170	78. 92	180	43.95	180
90	142.56	185	153.01	190	52.13	190
120	261.51	195	246.78	190	159.48	190
150					273.34	190

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES VII - Weak flour with ammonium chloride added

(.06 gm. NH_yCl to 100 gm. flour)

Fourth Determination		Fifth Determination		Average	
CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
-	65		60		63
20.81	70	26.79	75	19.35	72
54.93	90	51.61	105	42.62	96
72.30	115	65.40	155	58.59	135
99.93	150	104.40	195	85.75	172
133.42	185	171.91	200	129.05	195
180.23	195			150.91	197*
	65		65		65
38.09	125	27.97	140	29.05	132
88.37	185	56.14	185	68.29	180
183.76	200	78.99	190	122.09	191
229.80	205	83.32	190	224.39	194

* average of 2 determinations

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES VIII - Strong flour with ammonium chloride

added (.06 gm. NH_ycl to 100 gm. flour)

0' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time minutes	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
0'		65		70		65		67
30	24.70	75	32.65	75	20.73	90	26.02	80
60	43.12	100	65.72	110	51.91	130	53.58	113
90	56.10	155	96.28	170	75.90	180	76.09	168
120	72.43	200	134.79	225	112.33	215	106.52	213
150	99.64	220	177.07	230	151.24	220	138.35	223
			262.04	240	185.83	225	223.93	232*

Total Fermentation

0'		80		65		70
30	41.86	155	31.18	165	28.10	140
60	74.93	245	83.50	230	67.73	240
	111.77	280	164.29	250	93.67	270

* average of 2 determinations

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES IX - Weak flour with calcium sulphate and ammonium chloride added (12 gm. Ca SO_4 and .06 gm. NH_ycl to 100 gm.flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Fourth Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		65		70		60		60		64
30	17.16	85	27.63	85	17.79	70	7.48	75	17.51	79
60	31.39	120	51.49	130	40.81	100	26.39	110	37.52	115
90	46.46	165	72.00	165	67.18	145	34.27	140	54.98	154
120	73.95	185	85.37	185	108. 83	175	73.66	150	85.45	174
150	167.30	195	196.32	200	199.11	180	126.44	175	172.29	187
180			294.27	210	268.88	180			281.57	195a

Total Fermentation

0		60		60		75		70		60
30	10.05	145	15.91	150	36.84	135	57.90	135	12.98	146
60	33.49	205	92.82	190	90.42	165	64.86	150	49.49	193
90	132.70	215	177.38	200	121.40	175	103.86	155	127.22	208
120	464.53	215			159.91	175	134.98	165	232.72	208b
150					226.68	175				

a - average of 2 determinations

b - average of 2 determinations

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES X - Strong flour with calcium sulphate and ammonium chloride added (.12 gm. Ca SO_4 and .06 gm. to 100 gm. flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Fourth Determination		Average	
Time minutes	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.	CO_2 mgm	Volume c.c.
0		60		70				65		63
30	9.63	80	12.98	85			17.76	80	13.46	82
60	19.67	95	35.58	115			32.29	120	29.18	110
90	27.63	160	51.49	110			43.59	150	40.90	183
120	43.95	190	67.39	225			55.54	215	55.63	210
150	51.90	230	135.20	240			83.64	230	90.25	233
180	187.54	240	220.60	250			155.67	260	187.93	250

Total Fermentation

0		70		70		75		70		71
30	17.18	150	20.09	180	27.21	160	30.68	160	23.79	162
60	37.06	215	46.88	265	82.88	235	60.07	230	56.72	236
90	57.58	240	93.45	280	126.41	265	86.56	255	90.97	255
120	100.69	250			228.13	280			164.41	265a

a - average of 2 determinations

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XI - Weak flour with ammonium phosphate added (.125 gm. to 100 gm. flour)

0' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0'		60				65		62
30'	21.94	85			25.19	85	25.36	85
60'	33.15	130			42.79	115	37.97	122
90'	46.80	170			61.85	155	54.32	162
120'	112.12	190			103.84	185	107.98	187
150'	241.80	200			145.83	190	193.81	195

Total Fermentation

0		65		60		65		63
30	32.66	180	31.39	160	17.76	150	27.27	163
60	77.51	195	74.51	180	66.53	180	72.85	185
90	195.48	195	142.74	195	153.09	190	163.77	193
120			224.37	195				

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XII - Strong flour with ammonium phosphate added

(.125 gm.$NH_yH_2PO_4$ to 100 gm. flour)

O'Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	Co_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		70		60		70		67
30	37.67	75	60.33	75	19.70	80	24.56	76
60	53.16	100	27.84	90	47.15	120	42.71	103
90	73.45	150	38.20	125	82.10	170	64.55	148
120	87.90	200	50.23	175	135.80	215	91.31	196
150	131.21	215	68.23	215	171.01	220	123.48	216
180	162.14	245	103.39	220			132.14	232
200			168.48	230				
220			231.27	235				

Total Fermentation

0		75		80		80		63
30	20.93	145	37.05	135	30.36	165	27.27	163
60	53.16	240	54.63	215	64.60	230	73.85	185
90	128.09	265	66.77	245	118.42	260	163.77	193
120	220.60	270	105.28	255				

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XIII - Weak flour with ammonium persulphate

added (.025 gm. to 100 gm. flour)

0' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0'		6		60		60		60
30			29.72	65	34.27	75	30.49	70
60			55.25	80	75.63	100	65.44	90
90			81.62	105	94.93	140	88.27	122
120			109.67	185	117.38	170	113.52	177
150			133.53	175	133.76	185	133.64	180
180					145.18	195a		
Total Fermentation								
0		60		65		70		65
30	29.25	150	29.63	125	31.91	120	30.36	132
60	74.10	180	62.70	170	62.63	160	66.47	170
90	174.03	195	155.26	180	100.84	170	143.37	182
120	285.18	195	196.70	190	148.31	175	210.37	186
150					186.91b	180		

A - Fell at 170 minutes
b - Fell at 145 minutes

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XIV - Strong flour with ammonium persulphate

added (.025 gm. to 100 gm. flour)

O' Fermentation

	First Determination		Second Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		60		65		63
30	33.49	70	22.60	70	28.04	70
60	60.28	95	46.88	85	53.58	90
90	87.07	150	67.39	130	77.23	140
120	110.51	200	76.60	180	93.55	190
150	149.02	225	105.48	210	127.25	217
180	199.25	250	137.71	235	168.48	242
204	251.99	260	221.85	235	236.92	247

Total Fermentation

0		70		70		70
30	20.93	145	23.02	135	21.97	140
60	45.21	210	48.55	215	46.88	212
90	69.49	250	97.53	245	83.51	247
120	103.81	255				

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase

SERIES XV - Weak flour with potassium bromate added

(.0015 gm K Br O_3 to 100 gm. flour)

0' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c/c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		60		60		65		62
30	9.63	70	25.95	75	26.79	75	20.75	73
60	21.77	110	45.37	110	54. 00	105	40.04	108
90	49.19	160	61.95	155	81.93	145	61.35	153
120	85.82	180	93.44	185	119.60	180	99.59	182
150			106.32	190a	144.73	195c	125.52	193e

Total Fermentation

0		65		65		65		65
30	38.51	115	46.46	120	33.49	75	39.49	100
60	59.53	180	84.55	190	64.88	160	69.55	177
90	94.18	200	153.83	200	116.79	180	121.60	193
120	133.95	205	267.27	205	214.33	180	205.18	197
150	213.07	210	299.92	205b	244.88	185d	252.62	200f

a - Fell at 132 minutes
b - Fell at 125 minutes
c. -Fell at 145 minutes
d - Fell at 135 minutes
e - Fell at 138 minutes
f - Fell at 136 minutes

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XVI - Strong flour with potassium bromate added

(.0015 gm. K br O_3 to 100 gm. flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0				65		60		62
30			17.58	75	15.91	75	16.99	75
60			33.91	110	29.72	105	31.31	107
90			48.35	175	46.05	165	47.20	170
120			77.86	215	64.68	205	71.27	210
150			146.51	225	89.17	220	117.84	222
180			208.04	245a	150.29	245	179.16	241
210					249.50	250		

Total Fermentation

0		80		70		75		75
30	33.49	145	29.30	135	17.58	130	29.79	137
60	59.93	200	77.02	215	38.93	190	57.63	202
90	106.32	250	123.07	240	60.28	240	96.56	243
120	178.32	275	199.42	265	93.35	255	157.03	265
150	282.55	275	281.88	275	161.16	300	241.86	283
180			345.51	285b	269.06	305	307.28	295 d

a - Fell at 170 minutes
b - Fell at 170 minutes
c - Fell at 238 minutes
d - Fell at 295 minutes

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XVII - Weak flour with Ardady added

(.12 gm. Ca SO_4, .06 gm.NH_4 cl and .0015 $KbrO_3$ to 100 gm.flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c.c.	mgm	c.c.
0		60				60		60
30	15.91	80			10.24	70	13.07	75
60	32.24	100			21.27	105	26.75	102
90	43.12	180			25.60	150	34.36	165
120	54.42	190			37.42	180	45.92	185
150	75.35	195			51.60	195	63.47	195
180	108.42	200			100.05	195	104.42	198d

Total Fermentation

0		65		65		60		63
30	17.58	130	20.90	150	3.35	125	13.94	135
60	48.50	175	112.18	165	34.86	170	65.18	170
90	164.51	190	214.99	165	60.07	175	146.52	176
120	324.83	195	281.04	170	96.31	180	234.06	181
150	390.97	200a	310.58	170b	116.00	180c	272.51	183e

a - Fell at 144 minutes
b - Fell at 133 minutes
c - Fell at 140 minutes
d - Fell at 175 minutes
e - Fell at 139 minutes

TABLE XIII Individual determinations showing loss of carbon dioxid and volume increase.

SERIES XVIII - Strong flour with Arkady added

(.12 gm. Ca SO_4, .06 gm. NH_y cl and .0015 K br O_3 to 100 gm. flour)

O' Fermentation

	First Determination		Second Determination		Third Determination		Average	
Time	CO_2	Volume	CO_2	Volume	CO_2	Volume	CO_2	Volume
minutes	mgm	c.c.	mgm	c.c.	mgm	c,c.	mgm	c.c.
0		60				75		65
30	16.23	80			17.46	80	16.84	80
60	32.24	115			41.99	125	37.11	120
90	48.57	175			51.66	190	50.12	182
120	79.96	210			76.91	225	78.43	217
150	136.89	220			102.16	235	119.52	227
180	252.42	230			128.28	255	190.35	242
210					209.95	260		

Total Fermentation

0		70		80		65		72
30	38.09	170	20.42	185	15.01	170	26.76	175
60	87.07	235	107.61	235	50151	225	78.39	232
90	146.51	275	190.48	265	96.55	260	144.51	267
120	244.04	300	254.13	295	203.48	280	233.88	292
150	346.18	310	357.90	300	277.07	290	327.05	300
180	455.85	315			360.48	300	408.16	305a

a - average of 2 determinations

TABLE XIV. Showing total loss Carbonadioxid before breaking point in curve
(In order of increasing amounts)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. gm.	Series	Total Fer. gm.	Series	O' Fer. gm.	Series	Total Fer. gm.
Arkady	34.36	$CaSO_4$ ÷ NH_4Cl	49.49	$CaSO_4$	54.78	$NH_4H_2PO_4$	57.46
$NH_4H_2PO_4$	107.98	$CaSO_4$	60.55	$KBrO_3$	71.27	$(NH_4)_2S_2O_8$	83.51
Control	113.04	Arkady	65.18	Control	81.79	$CaSO_4$ ÷ NH_4Cl	90.97
$(NH_4)_2S_2O_8$	113.32	$(NH_4)_2S_2O_5$	66.47	$CaSO_4$+ NH_4Cl	90.25	$KBrO_3$	96.56
$KBrO_3$	125.52	NH_4Cl	68.29	Arkady	104.42	Control	101.56
NH_4Cl	129.05	$KBrO_3$	69.55	NH_2Cl	106.52	$CaSO_4$	91.37
$CaSO_4$	136.12	Control	70.97	$NH_4H_2PO_4$	123.48	NH_4Cl	122.09
$CaSO_4$+ NH_4Cl	281.57	$NH_4H_2PO_4$	72.85	$(NH_4)_2S_2O_8$	168.48	Arkady	146.52

TABLE XIV. Showing total loss carbon dioxid before breaking point in curve
(In order of increasing amounts)

		STRONG FLOUR AND CORNSTARCH MIXTURE	
Series	O' Fer. gm.	Series	Total Fer. gm.
Strong control	81.79	Weak control	70.97
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	85.77	Strong control	101.56
Weak control	113.04	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	104.33
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	209.03	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	126.11
		CONTROLS	
Strong flour	81.79	Weak flour	70.97
Weak flour	113.04	Strong flour	101.56

TABLE XV. Showing total loss Carbon dioxid before breaking point in curve Series grouped.
(In order of increasing amount)

WEAK FLOURS						STRONG FLOURS					
0' Fermentation			Total Fermentation			0' Fermentation			Total Fermentation		
Series	Loss CO_2 mgm.	Percent* ±	Series	Loss CO_2 mgm.	Percent* ±	Series	Loss CO_2 mgm.	Percent* ±	Series	Loss CO_{22} mgm.	Percent* ±
Arkady	34.36	-71	$CaSO_4$ + NH_4Cl Ca SO_4	55	-23	$CaSO_4$	54.78	-36	$NH_4H_2PO_4$	57.46	-41
$NH_4H_2PO_4$ Control $(NH_4)_2S_2O_8$ $KBrO_3$ NH_4Cl $CaSO_4$	120.84		Arkady $(NH_4)_2S_2O_5$	65	-8	$KBrO_3$ Control NH_4Cl $CaSO_4$ + NH_4Cl Arkady	86.70		$(NH_4)_2S_2O_4$ $CaSO_4$ + NH_4Cl $CaSO_4$ $KBrO_3$ Control NH_4Cl	97.68	
			NH_4Cl $KBrO_3$	68	-4						
$CaSO_4$ + NH_4Cl	281.57	+133	Control $NH_4H_2PO_4$	71		$NH_4H_2PO_4$	123.48	+42	Arkady	146.52	+50
						$(NH_4)_2S_2O_8$	168.48	+94			

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*Percent(+ or -) is in relation to control.

TABLE XV. Showing total loss carbon dioxid before breaking point in curve
(In order of increasing amount)

STRONG FLOUR WITH CORNSTARCH MIXTURE					
0' Fermentation			Total Fermentation		
Series	Loss of CO_2 mgm.	Percent $\pm$ *	Series	Loss of CO_2 mgm.	Percent $\pm$ *
Strong Control			Strong Control		
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	83.77		Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	110.66	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	209.03	+150	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)		
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	99.40		Weak Control	70.97	
Weak control			Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	113.83	+60
Strong flourwith cornstarch added to give ½ protein equivalent of weak flour (8%)	209.03	+110	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)		
CONTROLS					
Strong flour	81.79	-28	Weak flour	70.97	
Weak flour	113.04		Strong flour	101.56	-43

*Percent (+ or -)is in relation to control.

TABLE XVI. Showing volume increase per minute to breaking point
(In order of decreasing volume)

WEAK FLOURS				STRONG FLOURS			
Series	0' Fer. mgm.	Series	Total Fer. mgm.	Series	0' Fer. mgm.	Series	Total Fer. mgm.
Control	1.00	$CaSO_4$ + NH_4Cl	2.22	NH_4Cl	1.22	NH_4Cl	2.17
Arkady	1.17	$NH_4H_2PO_4$	2.03	$KBrO_3$	1.23	$NH_4H_2PO_4$	2.50
$(NH_4)_2S_2O_8$	0.97	NH_4Cl	1.92	$CaSO_4$ + NH_4Cl	1.13	Arkady	2.17
$KBrO_3$	0.93	Control	1.90	$CaSO_4$	1.12	$CaSO_4$	2.06
NH_4Cl	0.88	$KBrO_3$	1.87	Control	1.09	$CaSO_4$ + NH_4Cl	2.04
NH_4Cl + $CaSO_4$	0.73	$CaSO_4$	1.72	Arkady	1.01	$KBrO_3$	1.87
$NH_4H_2PO_4$	0.83	Arkady	1.78	$NH_4H_2PO_4$	0.99	Control	2.03
$CaSO_4$	0.79	$(NH_4)_2S_2O_8$	1.75	$(NH_4)_2S_2O_8$	0.99	$(NH_4)_2S_2O_8$	1.97

TABLE XVI. Showing volume increase per minute to breaking point
(In order of decreasing volume)

STRONG FLOUR WITH CORNSTARCH MIXTURE			
Series	O' Fer. mgm.	Series	Total Fer. mgm.
Strong control	1.09	Strong control	2.03
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.04	Weak control	1.90
Weak control	1.00	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.82
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	0.83	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.44
	CONTROLS		
Strong flour	1.09	Strong flour	2.03
Weak flour	1.00	Weak flour	1.09

TABLE XVII. Showing volume increase per minute to breaking point in curve Series grouped.
(In order of decreasing volume)

WEAK FLOUR						STRONG FLOUR					
O' Fermentation			Total Fermentation			O' Fermentation			Total Fermentation		
Series	Volume c.c.	Percent* ±	Series	Volume c.c.	Percent* ±	Series	Volume c.c.	Percent* ±	Series	Volume c.c.	Percent* ±
Arkady	1.17	+20	$CaSO_4$ + NH_4Cl	2.22	+16	$KBrO_3$ NH_4Cl	1.23	+17	$NH_4H_2PO_4$	2.50	+23
Control $(NH_4)_2S_2O_8$ $KBrO_3$	0.97		$NH_4H_2PO_4$ NH_4Cl	2.03	+6	$CaSO_4$ + NH_4Cl $CaSO_4$	1.13	+7	NH_4Cl Arkady	2.17	+7
NH_4Cl $NH_4H_2PO_4$ $CaSO_4$	0.83	-14	Control $KBrO_3$	1.90		Control Arkady	1.05		$CaSO_4$ $CaSO_4$ + NH_4Cl Control $(NH_4)_2S_2O_8$	2.03	
$CaSO_4$ + NH_4Cl	0.73	-24	Arkady $(NH_4)_2S_2O_8$ $CaSO_4$	1.75	-7	$NH_4H_2PO_4$ $(NH_4)_2S_2O_8$	0.99	-5	$KBrO_3$	1.87	-8

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*Percent (+ or -) is in relation to control.

TABLE XVII. Showing volume increase per minute to breaking point in curve
(In order of decreasing volume)

STRONG FLOUR WITH CORNSTARCH MIXTURE					
O' Fermentation			Total Fermentation		
Series	Volume c.c.	Percent ±*	Series	Volume c.c.	Percent ±*
Strong Control			Strong Control	2.03	
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.06		Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.82	-10
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	0.83	-22	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.44	-28
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.02		Weak Control		
Weak Control			Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.86	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour(8%)	0.83	-19	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.44	-23
CONTROLS					
Strong flour	1.09	+9	Strong flour	2.03	+86
Weak flour	1.00		Weak flour	1.09	

*Percent (+ or -) is in relation to control.

TABLE XVIII. Showing loss of carbon dioxid per minute to breaking point
(In order of increasing loss)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. mgm.	Series	Total Fer. mgm.	Series	O' Fer. mgm.	Series	Total Fer. mgm.
Arkady	0.39	$CaSO_4$ + NH_4Cl	0.82	$CaSO_4$	0.46	$(NH_4)_2S_2O_8$	0.93
NH_4 Cl	0.86	$CaSO_4$	1.01	Control	0.55	$NH_4H_2PO_4$	0.96
$NH_4H_2PO_4$	0.89	Arkady	1.09	$KBrO_3$	0.59	$CaSO_4$ + NH_4Cl	1.01
$CaSO_4$	0.91	NH_4Cl	1.13	Arkady	0.59	$CaSO_4$	1.01
$KBrO_3$	0.91	$KBrO_3$	1.16	$CaSO_4$ + NH_4Cl	0.60	$KBrO_3$	1.07
Control	0.94	Control	1.18	$NH_4H_2PO_4$	0.82	Control	1:13
$(NH_4)_2S_2O_8$	0.94	$(NH_4)_2S_2O_8$	1.21	NH_4Cl	0.89	NH_4Cl	1.35
$CaSO_4$ + NH_4Cl	1.56	$NH_4H_2PO_4$	1.21	$(NH_4)_2S_2O_8$	0.94	Arkady	1.63

TABLE XVIII. Showing loss of carbon dioxid per minute to breaking point
(In order of increasing loss)

STRONG FLOUR WITH CORNSTARCH MIXTURE			
Series	O'Fer. mgm.	Series	Total Fer. mgm.
Strong Control	0.55	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.05
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.71	Strong Control	1.13
Weak Control	0.94	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.16
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.16	Weak Control	1.18
	CONTROLS		
Strong flour	0.55	Strong flour	1.16
Weak flour	0.94	Weak flour	1.18

TABLE XIX. Showing Loss Carbon dioxid per minute to breaking point in curve Series grouped.
(In order of increasing amount)

WEAK FLOURS						STRONG FLOURS					
O' Fermentation			Total Fermentation			O' Fermentation			Total Fermentation		
Series	Loss CO_2 mgm.	Percent*±	Series	Loss CO_2 mgm.	Percent*±	Series	Loss CO_2 mgm.	Percent*±	Series	Loss CO_2 mgm.	Percent*±
Arkady	0.39	-57	$CaSO_4$ + NH_4Cl	0.82	-30	$CaSO_4$	0.46	-20	$(NH_4)_2S_2O_8$	0.94	-14
NH_4Cl						Control			$NH_4H_2PO_4$	1.01	
$NH_4H_2PO_4$			$CaSO_4$	1.05	-11	$KBrO_3$					
$CaSO_4$	0.91		Arkady			Arkady	0.58		$CaSO_4$ + NH_4Cl	1.01	-8
$KBrO_3$						$CaSO_4$+ NH_4Cl			$CaSO_4$		
Control			NH_4Cl			NH_4Cl	0.71	+22	$KBrO_3$	1.10	+35
$(NH_4)_2S_2O_8$			$KBrO_3$						Control		
			Control	1.18		$NH_4H_2PO_4$	0.82	+41			
$CaSO_4$ + NH_4Cl	1.56	+71	$(NH_4)_2S_2O_8$						NH_4Cl	1.49	
			$NH_4H_2PO_4$			$(NH_4)_2S_2O_8$	0.94	+62	Arkady		

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*Percent (+ or -) is in relation to control.

TABLE XIX. Showing loss carbon dioxid per minute to breaking point in curve
(In order of increasing amount)

STRONG FLOUR WITH CORNSTARCH MIXTURE					
O' Fermentation			Total Fermentation		
Series	Loss of CO_2 mgm.	Percent ±*	Series	Loss of CO_2 mgm.	Percent ±*
Strong Control	0.55		Strong flour with cornstarch added to give protein equivalent of weak flour (4%)		
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.71	+29	Strong Control	1.11	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.16	+109	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)		
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.71	-24	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.05	-10
Weak Control	0.94		Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.17	
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.16	+23	Weak Control		
CONTROLS					
Strong flour	0.55	-41	Strong flour	1.17	
Weak flour	0.94		Weak flour		

*Percent (+ or -) is in relation to control.

TABLE XX Showing maximum increase in volume reached to falling point
(In order of decreasing volume)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. C.C.	Series	Total Fer. c.c.	Series	O' Fer. c.c.	Series	Total Fer. c.c.
Arkady	138	$CaSO_4$+ NH_4Cl	148	$CaSO_4$+ NH_4Cl	187	Arkady	233
NH_4Cl	134	$KBrO_3$	135	$(NH_4)_2S_2O_8$	184	$KBrO_3$	220
$CaSO_4$+ NH_4Cl	131	$(NH_4) H_2PO_4$	130	$KBrO_3$	177	$CaSO_4$	200
$NH_4H_2PO_4$	131	NH_4Cl	129	Arkady	177	Control	195
$KBrO_3$	131	$CaSO_4$	128	NH_4Cl	165	NH_4Cl	195
Control	129	Control	127	$NH_4H_2PO_4$	165	$CaSO_4$+ NH_4Cl	194
$CaSO_4$	120	$(NH_4)_2S_2O_8$	121	Control	163	$NH_4H_2PO_4$	184
$(NH_4)_2S_2O_8$	120	Arkady	120	$CaSO_4$	162	$(NH_4)_2S_2O_8$	177

TABLE XX. Showing maximum increase in volume reached to falling point
(In order of decreasing volume)

STRONG FLOUR AND CORNSTARCH MIXTURE			
Series	O' Fer. mgm.	Series	O' Fer. mgm.
Strong Control	163	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	202
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	161	Strong Control	195
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	155	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	173
Weak Control	129	Weak Control	127
CONTROLS			
Strong flour	163	Strong flour	195
Weak flour	129	Weak flour	127

TABLE XXI. Showing total loss of carbon dioxid before falling
(In order of increasing amounts)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. gm.	Series	Total Fer. gm.	Series	O' Fer. gm.	Series	Total Fer. gm
Arkady	104.42	Control	133.47	$NH_4H_2PO_4$	132.14	$(NH_4)_2S_2O_8$	83.51
$KBrO_3$	125.52	$NH_4H_2PO_4$	163.77	$CaSO_4$	139.91	NH_4Cl	123.24
$(NH_4)_2S_2O_8$	133.64	$(NH_4)_2S_2O_8$	210.37	Control	143.91	$CaSO_4$	128.67
NH_4Cl	150.91	NH_4Cl	224.39	$KBrO_3$	179.16	Control	131.36
Control	154.72	$CaSO_4$	229.59	$CaSO_4$ ÷ NH_4Cl	187.93	$NH_4H_2PO_4$	162.94
$CaSO_4$	185.35	$CaSO_4$ ÷ NH_4Cl	232.72	Arkady	190.35	$CaSO_4$ ÷ NH_4Cl	164.41
$NH_4H_2PO_4$	193.81	$KBrO_3$	252.62	NH_4Cl	223.93	$KBrO_3$	307.28
$CaSO_4$ ÷ NH_4Cl	281.57	Arkady	272.51	$(NH_4)_2S_2O_8$	236.92	Arkady	408.16

TABLE XXI. Showing total loss of carbon dioxid before falling
(In order of increasing amounts)

STRONG FLOUR AND CORNSTARCH MIXTURE			
Series	0' Fer. gm.	Series	Total Fer. gm.
Strong control	143.9	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	126.11
Weak control	154.72	Strong Control	131.36
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	379.25	Weak Control	133.47
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	636.92	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	304.30
		CONTROLS	
Strong flour	143.91	Strong flour	131.36
Weak flour	154.72	Weak flour	133.47

TABLE XXII. Showing total time before falling
(In order of decreasing time)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer.	Series	Total Fer.	Series	O' Fer.	Series	Total Fer.
Ca SO_4	(180	$NH_4H_2PO_4$	163	$(NH_4)_2S_2O_8$	204	$KBrO_3$	(180
NH_4Cl	(180	$KBrO_3$	(150	Control	(180	Arkady	(180
$CaSO_4$+ NH_4Cl	(180	Arkady	(150	$CaSO_4$	(180	Control	(120
$KBrO_3$	(180	$CaSO_4$	(120	NH_4Cl	(180	$CaSO_4$	(120
Control	(150	NH_4Cl	(120	$CaSO_4$+ NH_4Cl	(180	$CaSO_4$ + NH_4Cl	(120
$(NH_4)_2S_2O_8$	(150	$CaSO_4$+ NH_4Cl	(120	$NH_4H_2PO_4$	(180	$NH_4H_2PO_4$	(120
$(NH_4)_2S_2O_8$	(150	$(NH_4)_2S_2O_8$	(120	KBr O_3	(180	NH_4Cl	(90
$KBrO_3$	138	Control	90	Arkady	175	$(NH_4)_2S_2O_8$	(90

TABLE XXII. Showing total time before falling
(In order of decreasing time)

STRONG FLOUR AND CORNSTARCH MIXTURE			
Series	O' Fer. mgm.	Series	O' Fer. mgm.
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	270	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	180
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	240	Strong Control	120
Strong Control	180	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	120
Weak Control	150	Weak Control	90
CONTROLS			
Strong flour	180	Strong flour	120
Weak flour	150	Weak flour	90

TABLE XXIII. Showing loss of CO_2 per cc. increase in volume before falling point
(In order of increasing loss)

WEAK FLOURS				STRONG FLOURS			
Series	O'Fer. mgm.	Series	Total Fer. mgm.	Series	O'Fer. mgm.	Series	Total Fer. mgm.
Arkady	0.76	Control	1.05	$NH_4H_2PO_4$	0.80	$(NH_4)_2S_2O_8$	0.47
$KBrO_3$	0.96	$NH_4H_2PO_4$	1.26	$CaSO_4$	0.86	NH_4Cl	0.63
$NH_4S_2O_8$	1.11	$CaSO_4$ + NH_4Cl	1.57	Control	0.80	$CaSO_4$	0.64
NH_4Cl	1.13	$(NH_4)_2S_2O_8$	(1.74	$CaSO_4$ + NH_4Cl	1.00	Control	0.67
Control	1.20	NH_4Cl	(1.74	$KBrO_3$	1.01	$CaSO_4$ + NH_4Cl	0.85
$NH_4H_2PO_4$	1.48	$CaSO_4$	1.79	Arkady	1.08	$NH_4H_2PO_4$	0.89
$CaSO_4$	1.54	$KBrO_3$	1.87	$(NH_4)_2S_2O_8$	1.29	$KBrO_3$	1.40
$CaSO_4$ + NH_4Cl	2.15	Arkady	2.27	NH_4Cl	1.36	Arkady	1.75

TABLE XXIII. Showing loss of CO_2 per c.c. increase in volume before falling point
(In order of increasing loss)

STRONG FLOUR AND CORNSTARCH MIXTURE			
Series	O'Fer. gm.	Series	Total Fer. gm.
Strong Control	0.88	Strong Control	0.67
Weak Control	1.20	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.73
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	2.36	Weak Control	1.05
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	4.11	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.51
		CONTROLS	
Strong flour	0.80	Strong flour	0.67
Weak flour	1.20	Weak flour	0.80

TABLE XXIV Showing loss of CO_2 per minute to falling point
(In order of increasing loss)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. gm.	Series	Total Fer. gm.	Series	O' Fer. gm.	Series	Total Fer. gm.
Arkady	0.58	$NH_4H_2PO_4$	1.00	$NH_4H_2PO_4$	0.73	$(NH_4)_2 S_2O_8$	0.93
NH_4Cl	0.84	Control	1.48	$CaSO_4$	0.78	$CaSO_4$	1.07
$(NH_4) S_2O_8$	0.89	$KBrO_3$	1.68	Control	0.80	Control	1.09
$KBrO_3$	0.91	$(NH_4)_2S_2O_8$	1.75	$KBrO_3$	0.99	$NH_4H_2PO_4$	1.36
Control	1.03	Arkady	1.82	Arkady	1.06	NH_4Cl	1.37
$CaSO_4$	1.03	NH_4Cl	1.87	$(NH_4)_2S_2O_8$	1.16	$CaSO_4$ + NH_4Cl	1.37
$NH_4H_2PO_4$	1.29	$CaSO_4$	1.91	NH_4Cl	1.24	$KBrO_3$	1.71
$CaSO_4$ + NH_4Cl	1.56	$CaSO_4$+ NH_4Cl	1.94	$CaSO_4$ + NH_4Cl	1.57	Arkady	2.27

TABLE XXIV. Showing loss of CO per minute to falling point
(In order of increasing loss)

		STRONG FLOUR AND CORNSTARCH MIXTURE	
Series	O' Fer. gm.	Series	Total Fer. gm.
Strong control	0.83	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.05
Weak control	1.03	Strong Control	1.09
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.58	Weak Control	1.48
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	2.40	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.69
		CONTROLS	
Strong flour	0.80	Strong flour	1.09
Weak flour	1.03	Weak flour	1.48

TABLEXXV Showing volume increase per minute to falling point
(In order of decreasing volume)

WEAK FLOURS				STRONG FLOURS			
Series	O' Fer. gm.	Series	Total Fer. gm.	Series	O' Fer. gm.	Series	Total Fer. gm.
$KBrO_3$	0.95	Control	1.31	$CaSO_4$ + NH_4Cl	1.04	NH_4Cl	2.17
$NH_4H_2PO_4$	0.89	$CaSO_4$ + NH_4Cl	1.23	Arkady	(1.01	$CaSO_4$	1.67 ?
Control	0.86	$CaSO_4$	(1.07	KBr O_3	(0.98	$(NH_4)_2S_2O_8$	1.96
$(NH_4S_2O_8)$	0.80	NH_4Cl	(1.07	NH_4Cl	(0.92	Control	1.62
Arkady	0.77	$(NH_4)_2S_2O_8$	1.01	$NH_4H_2PO_4$	(0.92	$CaSO_4$ + NH_4Cl	1.62
NH_4Cl	0.74	$KBrO_3$	0.90	Control	0.91	$NH_4H_2PO_4$	1.53
$CaSO_4$ + NH_4Cl	0.73	$NH_4H_2PO_4$	0.80	$CaSO_4$	0.90	Arkady	1.29
$CaSO_4$	0.67	Arkady	0.80	$(NH_4)_2S_2O_8$	0.90	$KBrO_3$	1.22

TABLE XXV Showing volume increase per minute to falling point
(In order of decreasing volume)

		STRONG FLOUR AND CORNSTARCH MIXTURE	
Series	0' Fer. gm.	Series	Total Fer. gm.
Strong Control	0.91	Strong Control	1.62
Weak Control	0.86	Weak Control	1.44
Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	0.57	Strong flour with cornstarch added to give ½ protein equivalent of weak flour (8%)	1.31
Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	0.52	Strong flour with cornstarch added to give protein equivalent of weak flour (4%)	1.12
		CONTROLS	
Strong flour	0.91	Strong flour	1.62
Weak flour	0.86	Weak flour	1.31