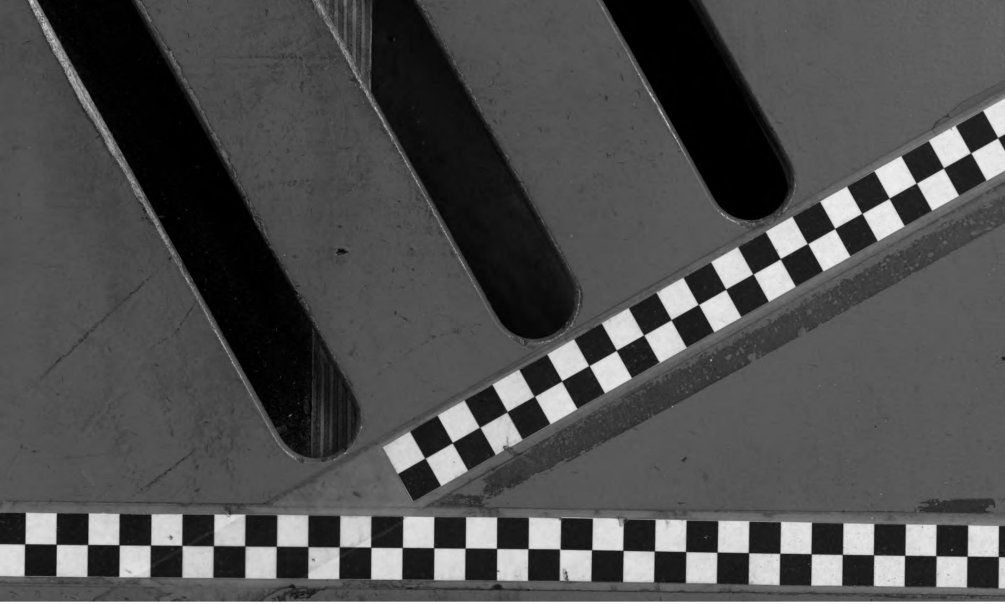

A STUDY OF THE EFFECT OF TIME AND TEMPERATURE UPON THE SWELL OBTAINED ICE CREAM

THESIS FOR THE DEGREE OF M. S.
MICHIGAN STATE UNIVERSITY

HOHEI FUNAYAMA
1921

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A Study of the Effect of Time and Temperature Upon The Swell Obtained Ice Cream.

Thesis for Degree of M. S.

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THESIS

CONTENTS

INTRODUCTION

Ice cream is a term applied to a variety of frozen products, but commonly means a frozen mixture of cream, sugar, whole milk, skim milk, condensed milk, evaporated milk or skim milk powder and flavoring substances. Ice cream is usually agitated by a dasher in the freezing process to make it smooth and of uniform consistency.

Historical: Ice cream is usually used today as a food although in the past it was considered and used only as a delicacy or dessert. In ancient times "Cream Ice" was used on the table in England and France, which cream ice preceded the use of ice cream of today. That cream ice being of relatively modern origin. "Milk ice"and "Cream ice" were introduced into Europe from Asia by Marcopolo and cream ice was served at the Court of Charles the First of England.

In 1776 English cream ice was made from milk, sugar, eggs, arrowroot or flour and flavoring extract.

In the United States Ice cream was first prepared in New York by Mr. Hall. Ice cream was served at a dinner in Washington, at which dinner President Washington partook. The first wholesale ice cream business was launched in 1851 by Jacob Frussell of Baltimore.

Ice cream made in this country is in great demand in other countries and consequently, steamers loading in New York take on this commodity for such distant countries as India, Japan, China and Australia.

At the present time in U. S. ice cream consumption is greatly increasing and is important branch of the dairy industry.

Oriental countries never had tried ice cream making except only a few home made ice creams. There was an old record that ice cream was introduced by an American. For this reason, China and Japan have retained the custom of "no use milk, no use meat to eat" because of the Buddist doctrine (religion) until about 10 years age.

Reason for making study : In Japan commercial ice cream was first made about seven years ago in Tokio by freezing by hand process. Since that time ice cream consumption has consequently increased during these few years. In 1920 the first ice cream manufacturing plant was built in Tokio by the Oriental Condensed Milk Co. At the present time in Japan ice cream making is changing from the hand process to the factory method used in the dairy industry. There have been very few investigators who have studied the technique and science of ice cream making in China and Japan. This is very regretable for dairying in the Eastern Countries. For this reason the writer has taken up the study of modern ice cream making at the Michigan Agricultural College in United States, America. He expects to introduce American ice cream making into China and Japan and carry on further studies of ice cream making under conditions prevailing in Eastern Countries.

Discussion of Swell in Ice Cream: The swell is an important item in commercial ice cream making. The swell of ice cream is due chiefly to the air which is incorporated

during the freezing process by the violent agitation, so that the finished product occupies a larger space than the original mixture. The larger the swell obtained the more air there is incorporated in the ice cream and the more open will be the texture of the product. A certain amount of swell is necessary in a high grade ice cream to give desirable texture and smoothness. If too little swell were obtained the ice cream would be icy, soggy and heavy and more solid, that is more wright per volume. It would have to be sold at a preportionately higher price and the consumers would either be paying more for their dishes or receive a smaller serving for their money of a coarse and cold product and not generally relished.

The swell should be properly done. If the swelling is not properly done the results is a loss in both quality and quantity of ice cream. Usually best results are obtained with 90 to 100 or 110 percent,swell depending upon the composition of the mix.

The temperature while freezing in the machine is a most important factor influencing the swell. Other principal causes of variation in swell are total time to freeze which has a noticeable effect on the amount swell and the quality, kind of material used, pasteurized of cream, homegenization of cream, amount of sugar and total solid, spped of dasher and type of machine.

In pasteurized cream, the pasteurization temporarily destroys the viscosity of the cream and milk and as a result pasteurized cream must be aged longer to restore the

viscosity.

Homogenizing cream breaks the solid of cream and milk into smaller particles. The whole mix is homogenized before going to the freezer. This increases the viscosity and because of this and of the smaller particles more swell is possible without sacrificing quality. The amount of sugar is important only because of its bulk, and the rate of freezing is also affected by amount of sugar and solid in ice cream. The more sugar added the more solids in ice cream, that is obtained more swell. The total solid in the mix have a decided influp ence on the amount of swell that can be obtained without injury to the quality of the ice cream.

REVIEW OF LITERATURE.

There is some published literature relative to the influence of various factors to the swell in ice cream making.

In 1910 a study of the swell in ice cream making was published by (1) Washburn. Washburn states that swell commences to form at 34° F., and ceases to form at 27°F. The maximum is reached at 28.5° F., but the cream mix should not be removed from the freezer before the temperature has reached 28° F., otherwise some of the swell is lost by the loss of air. When the swell exceeds 80 percent of the mixture the body of the ice cream deteriorates.

In 1916 (2) A. C. Baer illustrated that five gallons of 18 percent cream, enough to make 10 gallons of ice cream, after the sugar, vanilla, filler, ects. have been added amounts to 5.7 gallons of mix. This made into 10 gallons of ice cream

gives an increase in volume of 4.5 gallons by swell. And also (3) Dr. Heineman in 1920 shows that two gallons ice cream with an 80 percent swell or increase in volume can be made from one gallon of mixture.

Too low a swell produced a heavy soggy ice cream; too high a swell produce a light and fluffy. These facts have been illustrated by many investigators. Time required for proper freezing. Too rapid freezing will make poor quality and quantity of ice cream. According to (4) J. H. Frandesen and Markham in 1915 the time required for the swell will be governed by several factors. Time required for freezing ice cream mixture will depend somewhat upon the composition but more upon the temperature of the mix when put into the freezer. (5) Washburn showed that "time required for swell under normal conditions will be from 10 minutes to 14 minutes". (6) A. C. Baer published that "usually the best results are obtained by freezing the mix in from 10 minutes to 15 minutes and this does not freeze it too rapidly and at the same time allows plenty of time to whip the cream into the smooth consistency which is desirable in a good ice cream. (7) E. Williams decreed that it usually required 20 minutes time to complete the swell of a 10 gallon batch of ice cream with a brine temperature 14° F. and with a constant normal speed of the freezer. According to (8) Walter W. Fisk "time required for proper freezing should be take from 12 minutes to 20 minutes".

When removing the ice cream from freezer to the

cans, (9) Washburn shows it was found that when drawn off at 29° F. the swell was 70 percent, the best temperature being 28° F. even though at this temperature product was thin. (10) W. W. Fisk shows that colder the cream mix when it enters the freezer the quicker the freezing time. For best control he advises a temperature of 40° F. He states that when ice cream is drown from freezing at temperature between 26° F./and 28° F. best results can be obtained. (11) Wisconsin Agricultural Experiment Station reported that cream should be removed from freezer at 27° F. and many other investigators published almost same results for this temperature.

The factors affecting swell by material used were discussed by some investigators (12) Walter W. Fisk illustrated that (a) age, viscosity and fat content of milk and cream (b) size of fat globules (c) pasteurized milk (d) aging milk (e) use of emulser or homogenizer (f) Method of mixing (g) use of condensed milk (h) amount of sugar (i) different kinds of flavoring (j) fillers and binder (k) total solids in mix.

(13) Washburn gives the following as the influence of material used on swell. The amount of fat in the cream has little or nothing to do with the amount of air whish may be incorporated, but it has much to do with the amount which remains incorporated. Skim milk can be made to swell 100% or even more, but the product is coarse and the results only temporary for it quickly loses its air and falls or sinks in the can.

A cream containing 35% to 40% is too soggy

to whip well and affords an poor increase . Viscosity of cream mix is of considerably more importance. Viscosity increases after having been held cold for 24 hours.

(14) According to Iowa Agricultural Experiment Station bulletin 180, the swell of ice cream is less with fresh cream than with cream which has been aged for 24 hours to 48 hours. When pasteurized cream 24 hours older was used swell was obtained than with fresh cream i. e. The aged cream produced an ice cream of a more perfect texture and swell than is produced from the fresh cream. Influence filler: (15) Walter W. Fisk, (16) Washburn states that fillers have little affect on swell. (17) A. C. Baer, (18) M. Mortensen shows that fillers do not affect swell.

The foregoing literature is all that has been published upon the swell in ice cream but is not a comprehensive study of the subject.

OUTLINE OF EXPERIMENT.

Effect of freezing temperature on swell:
Freezing is the process of cooling the mix and getting it in such condition that it is edible when frozen. The temperature in freezing and rate of freezing are important factors in this matter of increase in volume, for the reason that if the freezing be done too rapidly too little time elapses to admit of its through whipping or beating during the interval after the cream becomes cold enough to whip and before it becomes frozen and produces a course grained product in which case satisfactory swell could not be

obtained.

Too slow freezing may cause the cream to chxxx causing chunks of butter in the ice cream giving greasy and lumpy condition.

Temperature: Ordinarily mixture of cream sugar and other materials used in ice cream is not in proper condition to retain air whipped into it before it reaches about 29°F. At this temperature it begins slowly to form up and gradually increases in volume as the temperature drops from about 29°F. to 27° F or 26° F which temperature is a little below the freezing point. See experiment chart.

EFFECT OF TIME FREEZING ON SWELL:

Time required in proper swell the experiments show usually when the mix of cream entered the freezer at from 44°F. to near 40°F. the swell began in about four minutes. For such cream total time freezing required from 12 minutes to 18 minutes. Usually the first in five or six minutes of that will have been consumed in extracting specific heat in mix, so that the swell scarcely increases during this time; and in the next stage few minutes would be required to extracted part of the latent the heat and suitable whipping or beating done to incorporate air with mix so that in this time volume of mix increases quickly and last few minutes will generally be consumed increasing over 100 percent and in smooth up of ice cream.

The following experiments shows the relation between time and effectivity of bfine off and on should be not

ignored. It should be done in suitable point of time and freezing temperature. This important relation will be discussed by following experiments.

PREPARING THE MIX.

The materials in the mix were prepared in accordance with the following formula for each experiment. The mix being standardized to 14% fat and 37½ percent total solids.

Total weight of whole mix 350 lbs.

140 lbs.	35% cream
14 lbs.	skim milk powder
143 lbs.	skim milk
45 lbs.	sugar
2 lbs.	gelatine

The mechanical mixture used was of ordinary starter can type. The first materials of cream and skim milk put into the mixer and start mixing by mechanical agitator. The second, added into the mixer sugar, gelatine and skim milk powder which were prepared well mixed together. After these materials into mixer was well mixed the whole mix was pasteurized then immediately cooled down 110° F. and viscolized at a pressure of 2000 lbs. From the viscolizer the mix flowed over a surface coil cooler, the top section of which was cooled with water and the bottom section cooled with brine. The mix was then held in a refrigerator for 24 hours before freezing.

Method of Freezing. The same machine was used for each experiment. Type of freezing machine is horizon-

al with constant normal speed of the dasher(state speed).

Size of machine, ten gallons.

Freezing done by circulating brine cooled by ammonia refrigerating machine. The brine was kept between 5^{o} and 10^{o} F.

Point of freezing temperature 27.869^{o}F. in that freezing process.

Method of Taking Test:

The records of temperature were taken every minute by themometer inserted in peep hole of freezer.

Swell was tested every other two minutes by over run tester scale and over run cup. The scale used very sensitive being graduated to one hundredth of a lb. Overrun cup was adjusted to hold exactly one pound of mix.

The swell for the following experiments was calculated from the weight of mix as follows according to indicated weight by scale.

$$\text{Percent overrun} = \frac{\text{Weight of mix--Wt. of sample}}{\text{Weight of Sample}} \times 100$$

Example:

Used 1 lb. of mix for adjusting cup.

Weight of sample of same volume of ice cream 0.52 lbs.

$$\frac{1.00--0.52}{0.52} \times 100 = 92$$

92 percent overrun.

Chart Explanation: According to chart No. 1. Let the figures on the lower straight line A-B represent minutes of time during freezing process. A-C line represents

swell in percentage. B-D line represents temperature in degree F., and N. line represents temperature of ice cream in freezer. M. line represents percent swell.

EXPERIMENT 1.

Weight of mix 45 pounds

Temperature of mix when entered the machine 44°F.

Viscosity not heavy.

This experiment shows the mixture cooled down quickly during the first 3 minutes from 44 degrees to 29°F.. From 4 minutes to 10 minutes it cooled down to 26°F. while the swell increased 80 percent.

Brine was turned off at 10 minutes. At this time the mix in freezer increased air bable and beat up incorporated ing with air the swell slowly increased. The temperature after the brine turned off the temperature was going up and the mix becomes warmer. The swell increased until the temperature reached 28° F. Maximum percent of swell increased 130 percent at 27.5° F. in 18 minutes. At 28°F. the brine was turned on the temperature cooled down to 26° F. in few minutes. During this time the temperature cooled down by brine being turned on the swell decreasing rapidly. The brine was turned off again at 26°F. The temperature raised again and the swell raised in proportion.

The length of freezing time of this experiment was 40 minutes. When the ice cream was removed from the freezer the swell was 120 percent, temperature 27.3°F., at 40 minutes. The ice cream obtained was very soft.

Exp. I. Table for Time, Temp., Weight and Per Cent Swell.

Time	Temp.	Wt.	% Swell	Time	Temp.	Wt.	% Swell
9:02	40			9:24	28		
9:03	32			9:25	28	46	118
9:04	29			9:26	28		
9:05	29	67½	46	9:27	28	47½	110
9:06	28⅛			9:28	28		
9:07	28	63½	57	9:29	28	49½ brine on	102
9:08	27.5			9:30	28		
9:09	27	57	69	9:31	27.7	49¾	101
9:10	27			9:32	27.5		
9:11	26⅛	56 brine off	78	9:33	27	50¼	99
9:12	26			9:34	26⅛		
9:13	26	51	96	9:35	26	52 brine off	92
9:14	26½			9:36	26		
9:15	27	47	113	9:37	26	48	108
9:16	27			9:38	26½		
9:17	27	44½	124	9:39	26.8	46¾	115
9:18	27.2			9:40	26.8		
9:19	27½	44	127	9:41	27	45¾	119
9:20	27⅛			9:42	27.3		
9:21	28	44	127	9:43	27.3	46	118
9:22	28						
9:23	28	44⅛	124				

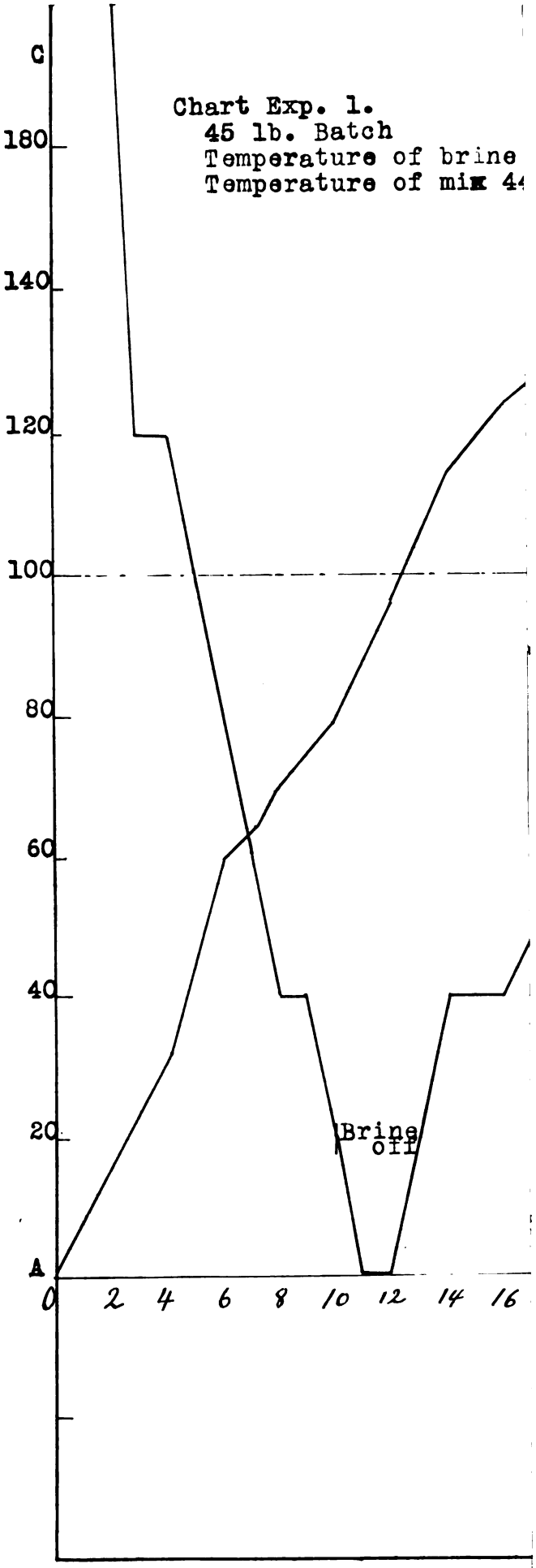


Chart Exp. 1.
45 lb. Batch
Temperature of brine
Temperature of mix 4

ly,

i

rcent

in

1.

Swell

128

on

118

100

EXPERIMENT 11.

Weight of mix 45 pounds

Temperature of mix 44.5°F.

Temperature of brine 10°F.

Freezing process at keeping 27°F , temperature only, rate of freezing normal condition.

The mix cold down quickly during first two minutes to 29°F.; cooled down to 27°F. in 6 minutes. Temperature held as near as possible at 27°F in the experiment by turning brine off and on several times.

The swell increased gradually until it reached 120 percent in 20 minutes. The maximum percent swell was 128 percent in 24 minutes at reached 27°F.

Exp. 11. Tabe for time, Temp. Weight and % Swell.
Started 3:22 P. M.

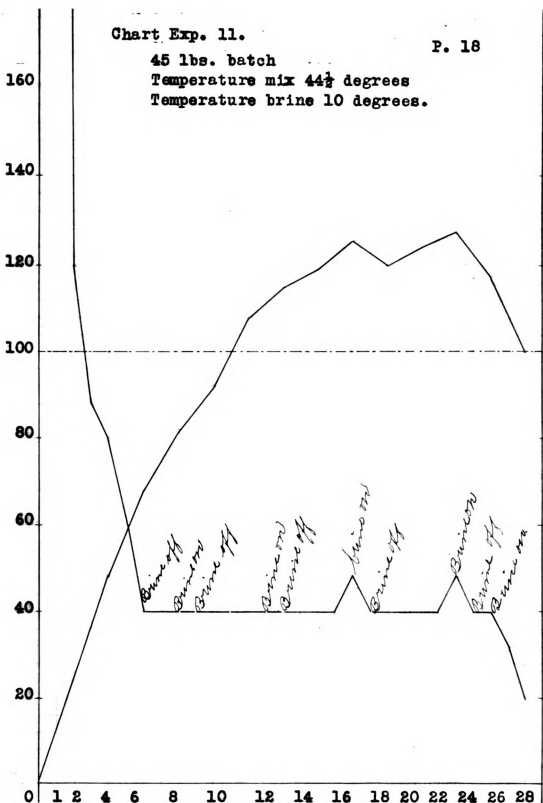
Time	Temp.	Wt.	% Swell	Time	Temp.	Wt.	% Swell
3:23	51			3:43	27		
3:24	29			3:44	27	44½	128
3:25	28.2			3:45	27		
3:26	28	67	48	3:46	27.2	44 brine on	
3:27	27½			3:47	27		
3:28	27	brine 61 on	64	3:48	27	brine 46 on	118
3:29	27			3:49	26.8		
3:30	27	brine 55 on	82	3:50	26½	50	100
3:31	27			3:51	26		
3:32	27	52	92				
3:33	26.8						
3:34	27	48	108				

Continue Table for Exp. 11.

5:55	27		
5:56	27	46-1/3	116
5:57	27		
5:58	27	45-2/3 brine on	119
5:59	27		
5:40	27.2	44 brine on	
5:41	27	brine off	
5:42	27	45½	120

Chart Exp. 11.

45 lbs. batch
Temperature mix 44½ degrees
Temperature brine 10 degrees.



45 # batch
Temp. Mix 44½
Temp. Brine 10° F.

25 degree s

Experiment 111.

45 pounds batch of mix

Temperature of cream 44°F.

Temperature of brine 5°F.

Rate of freezing normal condition.

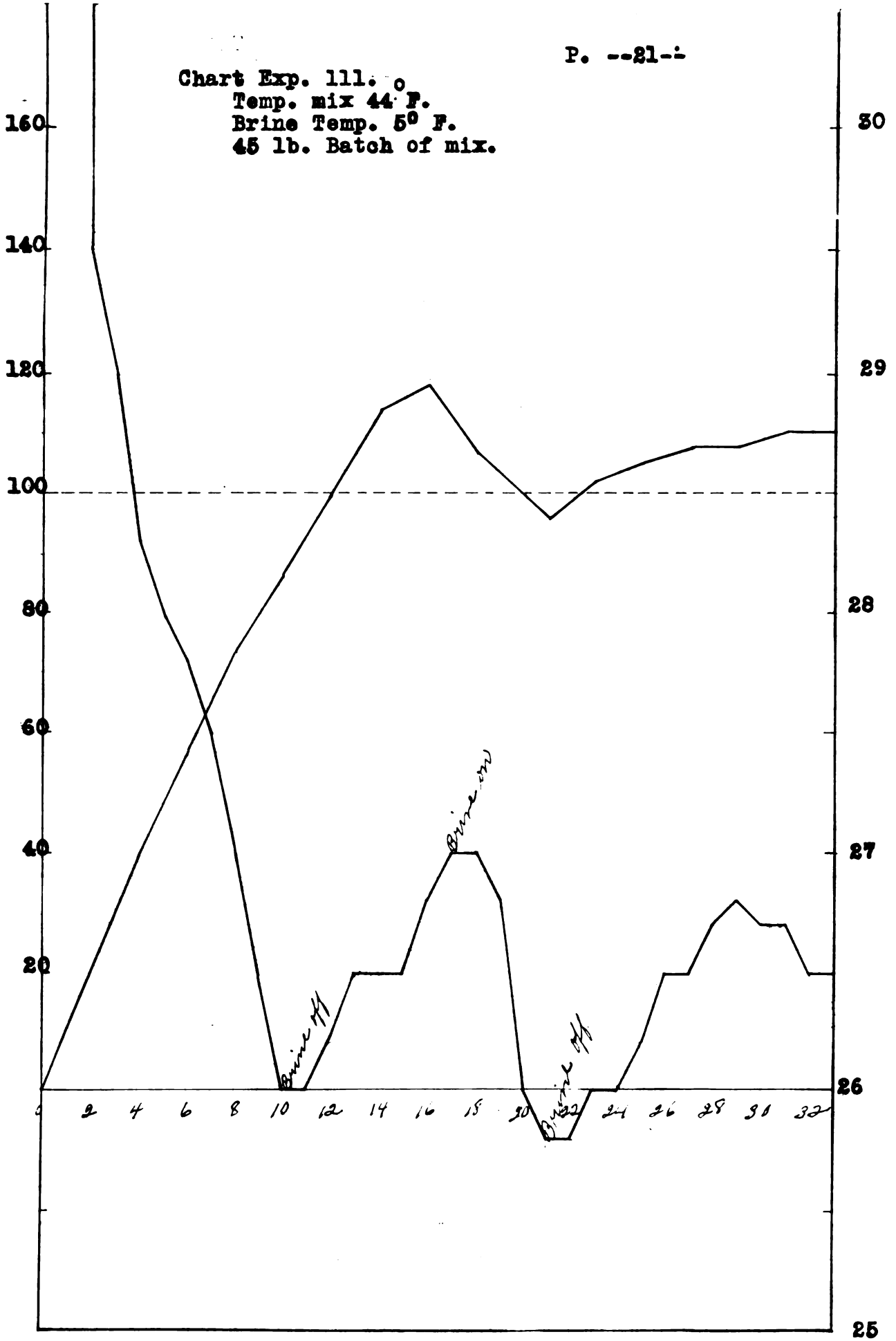
When mix was put into the freezer 44° F., then brine through the freezer and whipped the cream as experiment 1 and 11, the mixture cooled down in three minutes to 29°F. At 10 minutes the temperature was 26°F., the swell 86 percent. The brine was turned off at 10 minutes; the temperature gradually going up while the swell gradually continous raising to 120 percent at 17 minutes and this point is the maximum swell point. At this point the brine turned on the temperature cooled down and also the swell decreased. Again brine off temperature going up, the swell also increasing.

This experiment gives as following results:

Exp. 111. Table for Time, Temp. Weight and Percent Swell.

Time	Temp.	Wt.	% Swell	Time	Temp.	Wt.	% Swell.
2:44	35			3:04	25.8	51 brine off	96
2:45	29½			3:05	25.8		
2:46	29	72	39	3:06	26	49½	102
2:47	28.3			3:07	26		
2:48	28	64	57	3:08	26.2	48½	105
2:49	27.8			3:09	26.5		
2:50	27.5	57½	74	3:10	26.5	48	108
2:51	27			3:11	26.7		
2:52	26	53½ brine off	85	3:12n	26.8	48	108
2:53	26			3:13	27		
2:54	26	50	100	3:14	27	47½	110
2:55	26.2			3:15	27½		
2:56	26½	47	113	3:16	27½	47½	110
2:57	26½						
2:58	26½	46	118				
2:59	26.8						
3:00	27	45 brine on	122				
3:01	27						
3:02	26.8	48-1/3	107				
3:03	26						

Chart Exp. 111. o
Temp. mix 44 F.
Brine Temp. 5° F.
45 lb. Batch of mix.



EXPERIMENT 1V

Weight of batch 50 lbs.

Temperature of mix 45° F.

Temperature of brine 10° F.

Rate of freezing normal condition.

The mix cooled down 29°F in three minutes and at ten minutes the temperature dropped to 25.5°F. Teh swell being 80 percent.

The brine was turned off at ten minutes, the temperature going up and at 18 minutes the swell reached its maximum of 124 percent.

This experiment results show almost the same results of Experiment No. 111.

Exp. 1V. Table for Time, Weight and swell percent.

Time	Temp.	Weight	Swell
P.M. 3:56	30		
3:57	29		
3:58	28½		
3:59	27½		
4:00	27½	69	44
4:01	27		
4:02	26.8	61	64
4:03	26		
4:04	26	55½	80
4:05	25.5	Brine off	
4:06	25.8	52	92
4:07			
4:08	26	47½	110
4:09	26		
4:10	26	45	122
4:11			
4:12	26½	46½ brine on	124
4:13	26.5		
4:14	26	47	113
4:15	26		
4:16	25.8	48	108
4:17	26		
4:18	25.8	50	100

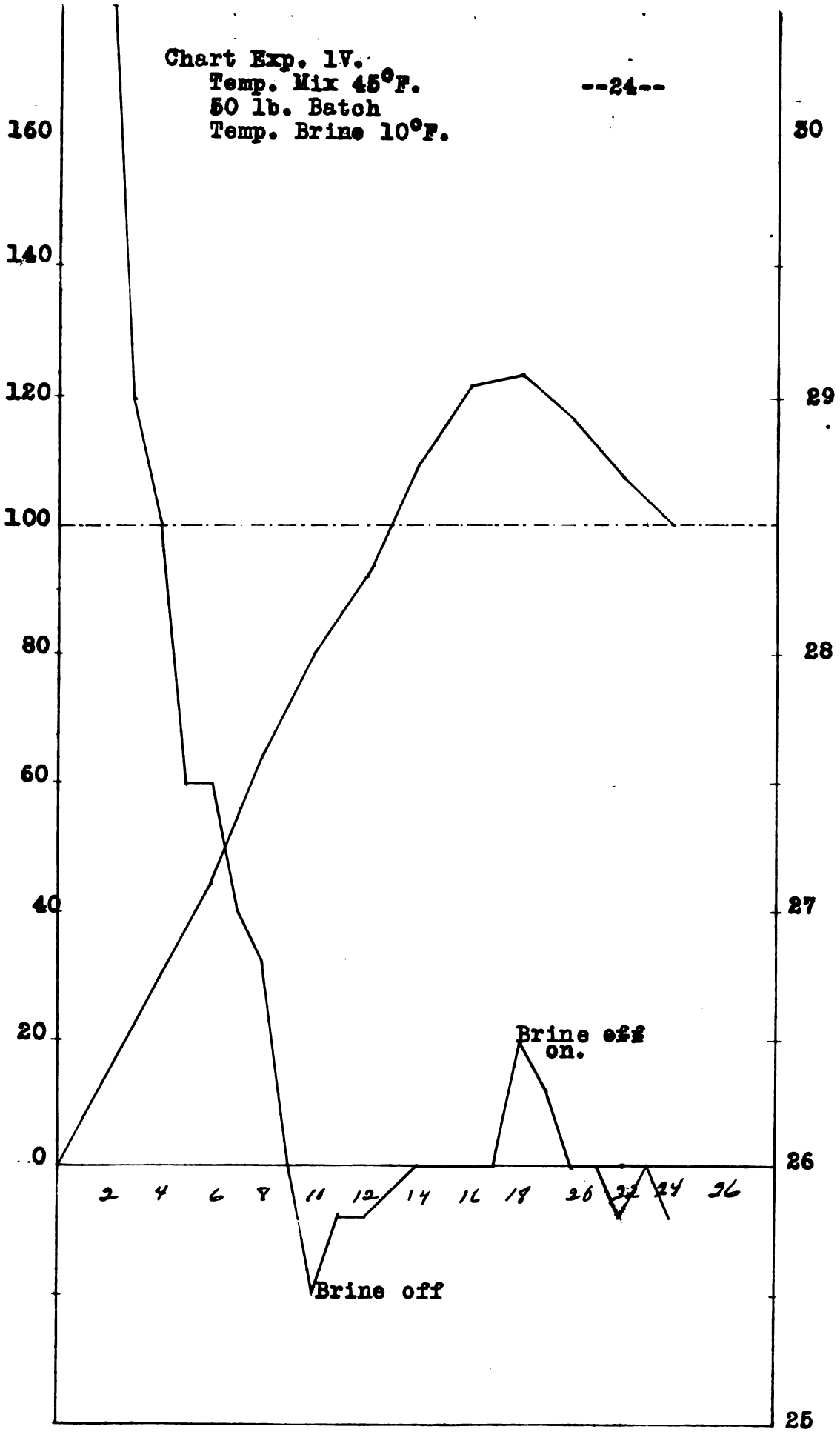


Chart Exp. 1V.
Temp. Mix 45°F.
50 lb. Batch
Temp. Brine 10°F.
--24--
160
140
120
100
80
60
40
20
0
30
29
28
27
26
25
2
4
6
8
10
12
14
16
18
20
22
24
26
Brine off
on.
Brine off

Experiment V.

Temperature of mix 47° F.

Temperature of Brine 10°F.

Weight of batch 45 lbs.

Freezing temperature, hold low temperature.

The mix cooled down to 29° F. in two minutes, the temperature reached 26° F. in nine minutes, the swell being 80 percent and rapidly cooled down to 25° F. Then temperature hold between from 26° F. to 25°F. from ten minutes to 24 minutes.

The swell because of two low temperature increased a little. At 15 minutes the swell obtained was 88 percent. At 24 minutes the swell was still 88 percent. After 24 minutes temperature was allowed to increase about 26° F., swell going up to 103 percent. It will be noted that too low temperature could not obtained proper swell however cream beat down and the ice cream frozen poorly. Air could not be incerporated into interval in mix cream.

(1) Should never do freezing at too low temperature.

(2) At 25° F. a swell over 90 percent could not be obtained.

Exp. V. Table for Time, Temp. Weight and Percent Swell.

Time	Temp.	Wt.	% Swell	Time	Temp.	Wt.	%Swell
9:48	29			10:08	25		
9:49	28½			10:09	25	Brine 54.5 off	83
9:50	28			10:10	25.5		
9:51	28	70	43	10:11	25.8	52½	90
9:52	28			10:12	26.5		
9:53	27.5	62	61	10:13	26.5	51½	95
9:54	27			10:14	26.8		
9:55	26½	57	77	10:15	27	50	100
9:56	26			10:16	27		
9:57	26	55	82	10:17	27	50	100
9:58	25.8			10:18	27		
9:59	25.5	53½	87	10:19	27	49½	102
10:00	25			10:20	27		
10:01	25	brine 54 off	86	10:21	27	49½	101
10:02	25.5			10:22	27.2		
10:03	26	brine 52 on	92	10:23	27½	51	96
10:04	25			10:24	27.5		
10:05	25½	53	89	10:25	27.5	53	89
10:06	25						
10:07m	25	54	85				

Chart Exp. V.
Temp. Mix 47°F.
Temp. Brine 10°F.
45 lb. Batch.

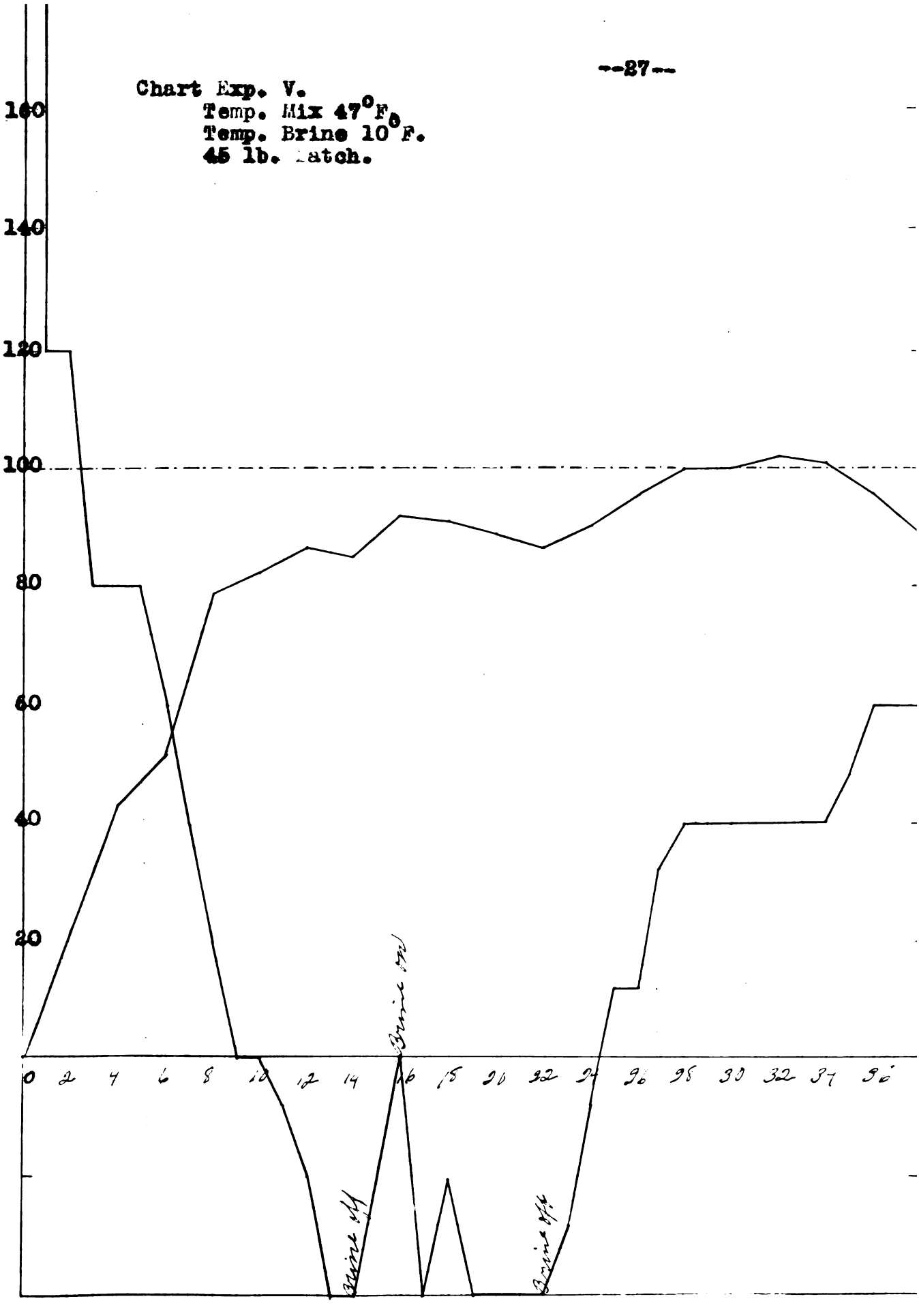
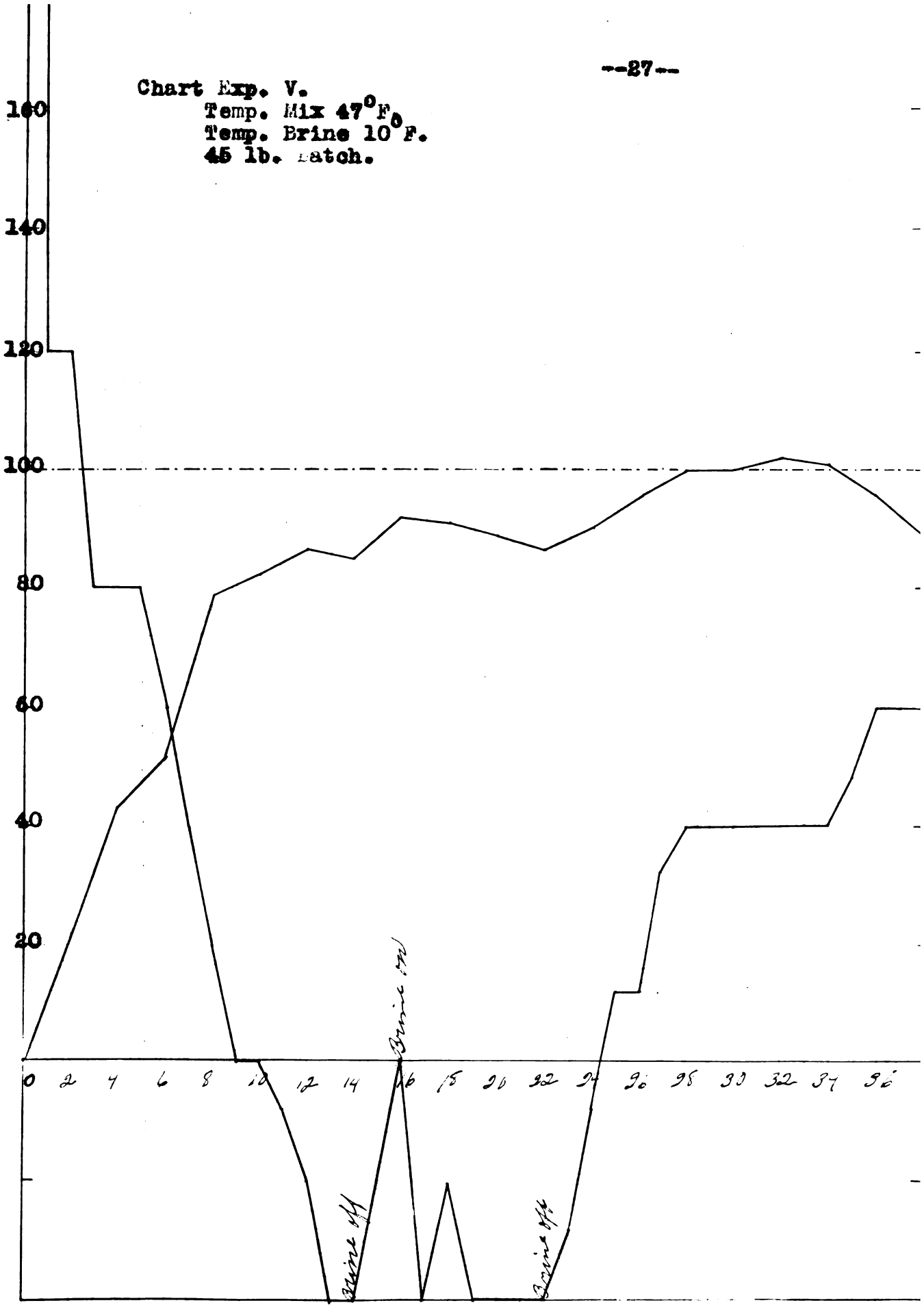


Chart Exp. V.
Temp. Mix 47°F.
Temp. Brine 10°F.
45 lb. batch.



EXPERIMENT Vl. A, B.

A. Weight of Mix 50 lbs.
Temperature of mix 45° F.
Temperature of brine 10°F.

B. Weight of mix 43 lbs.
Temperature brine 10°F.
Temperature of mix 43°F.

A. Experiment result show the mix was cooled very rapidly down to 29°F. at one minute, in five minutes cooled down to 27°F.; at nine minutes temperature was 25.5°F. At this point the swell was 84 percent and maximum swell 124 percent at 14 minutes.

B. Experiment show the mix cooled down same as A. experiment point 29°F. at one minute; in five minutes cooled down 26.5°F. and cooled down to 25.5°F. at eight minutes and held at this point continuously for three minutes. Then temperature goes up to 26°F. again while the swell gradually increased to 108 percent at 11 minutes. Both A and B. Experiments seemed somewhat quickly cooled down during first few minutes but results obtained were almost near the proper swell and these experiments show almost identical graph in both swell and temperature. Total length of freezing time showed 13 minutes was best time in these A and B. Experiments.

Exp. V1--A. Table for Time, Temp. Weight and Percent Swell.

Time	Temp.	Weight	Y% Swell
4:25	29		
4:26	28.5		
4:27	28		
4:28	27½	69	44
4:29	27		
4:30	26.9	61	64
4:31	26		
4:32	26	55½	80
4:33	25.5	Brine off	
4:34	25.7	52	92
4:35	25.8		
4:36	26	49½	102
4:37	26		
4:38	26	44½	124
4:39	26.2		
4:40	26½	45	122
4:41	26.3		
4:42	26	47	113
4:43	26		
4:44	25.8	46	118

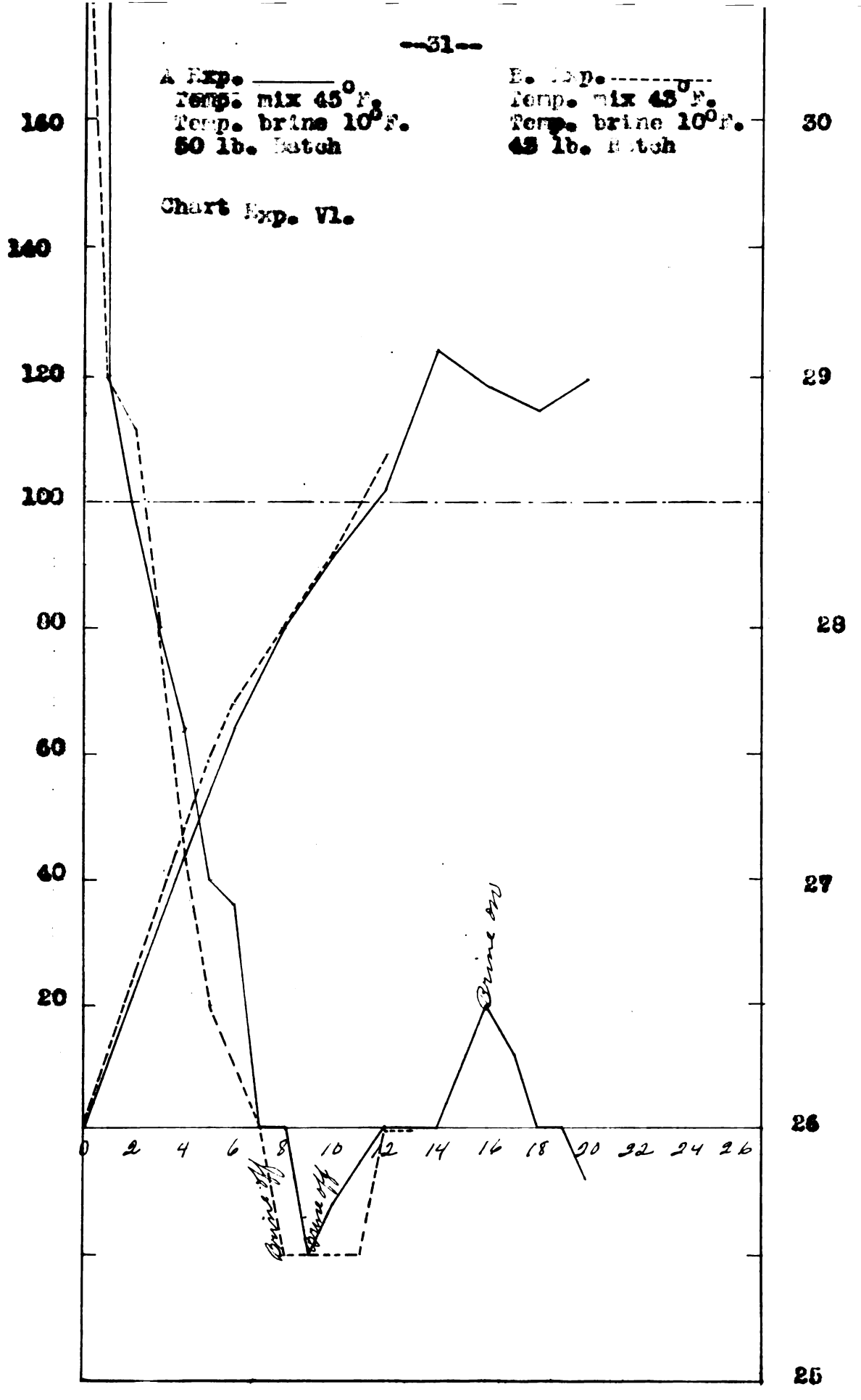
Exp. V1--B. Table for Time, Weight, Temp. and Percent Swell.

Time	Temp.	Weight	% Swell
4:43	29		
4:44	28½		
4:45	28		
4:46	27	68	49
4:47	26.7		
4:48	26.5	59	68
4:49	26		
4:50	25.5	56 brine off	118
4:51	25.5		
4:52	25.5	52	92
4:53	25.5		
4:54	26	48	108
4:55	26		

A Exp. _____°
Temp. mix 45°F.
Temp. brine 10°F.
50 lb. Batch

B. Exp. _____°
Temp. mix 45°F.
Temp. brine 10°F.
45 lb. Batch

Chart Exp. VI.



Experiment V11.

Weight of mix 50 lbs.

Temperature of mix 44° F.

Temperature of brine 10° F.

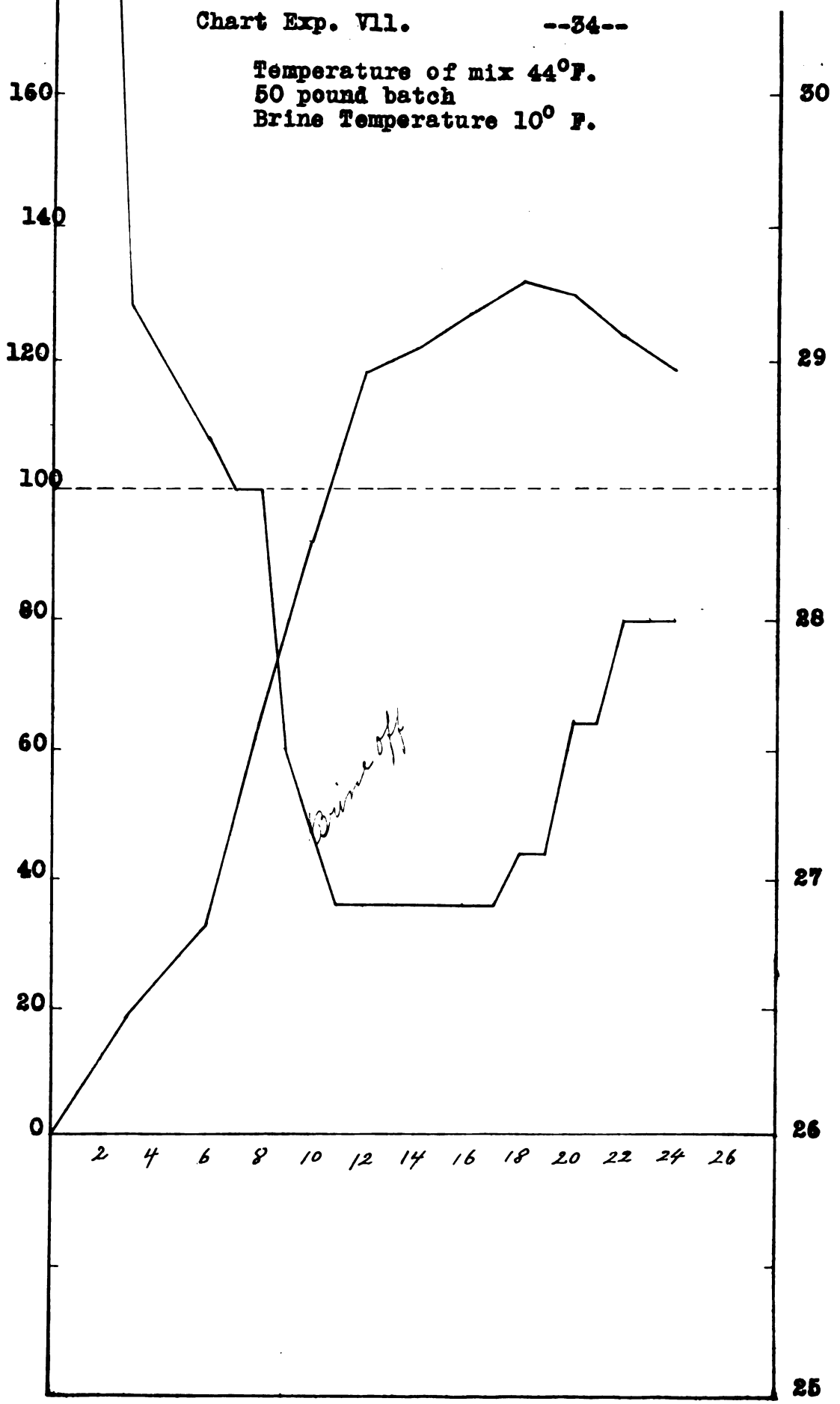
The mix entered the freezer at 44° F. and cooled down to 29.2° F. in three minutes. The mix was whipped while in this three minutes. From eight minutes to 11 minutes the Temperature dropped from 28.5° F. to 27° F. After the brine was turned off the temperature gradually went up to 28° F., the swell dropping as this point was above the freezing point 27.86° F.

The swell slightly increased during the first three minutes and from six minutes to 12 minutes the swell increased from 35 percent to 118 percent. The maximum swell 132 percent was obtained at the end of 18 minutes. After this the swell decreased due to raise in temperature at this point.

Exp. V11. Table for Time, Temp. Weight, and Percent Overrun.

Time	Temp.	Wt.	%Swell	Time	Temp.	Wt.	%Swell
3:11	44			3:31	27.6		
3:12	34			3:32	28	44.5	122
3:13	29.2	84	19	3:33	28		
3:14	29			3:34	28	46	118
3:15	28.6						
3:16	28.8	75	33				
3:17	28.6						
3:18	28.5	61	64				
3:19	27.5						
3:20	27.2	52	92				
3:21	27						
3:22	27	46	118				
3:23	27						
3:24	27	45	122				
3:25	27						
3:26	27	44	127				
3:27	27						
3:28	27.2	43m	132				
3:29	27.2						
3:30	27.6	43.5	130				

Temperature of mix 44°F.
50 pound batch
Brine Temperature 10° F.



Experiment VIII.

Temperature of mix 40°F.

Temperature of brine 10°F.

50 lbs. of batch.

The mix was cooled rapidly, from 40° F. to 28°F. in two minutes and then after a few minutes cooled down to 26° F. in eleven minutes. At this point the swell increased to 100 percent. When the brine was turned on the swell began decreasing at 15 minutes and then the swell quickly decreased . At 16 minutes the temperature cooled down to 25°F. ; at the same time the swell decreased.

This experiment shows results near the proper swell and at such freezing process. The ice cream should be removed from the freezer at 14 minutes or 15 minutes. In this point would be good results obtained for quality and quantity of ice cream.

Exp. Vlll. Table for Time, Temp. Weight and Percent Swell.

Time	Temp.	Wt.	%Swell	Time	Temp.	Wt.	%Swell
3:26	30.5			3:45	26		
3:27	28.2			3:46	25.9	55.2	80
3:28	28			3:47	25.7		
3:29	27.7	76	21				
3:30	27.5						
3:31	27.1	75	34				
3:32	26.8						
3:33	26.8	65	64				
3:34	26.8						
3:35	26.5	50	100				
3:36	26						
3:37	26.2						
3:38	26.2	47	113				
3:39	26.5						
3:40	26.5	46	118				
3:41	26.5						
3:42	26.5	49½	102				
3:43	26.5						
3:44	26.1	52½	90				

--37--

Chart Exp. V111.

Temperature of mix 40° F.
50 lb. batch
Temperature of Brine 10° F.

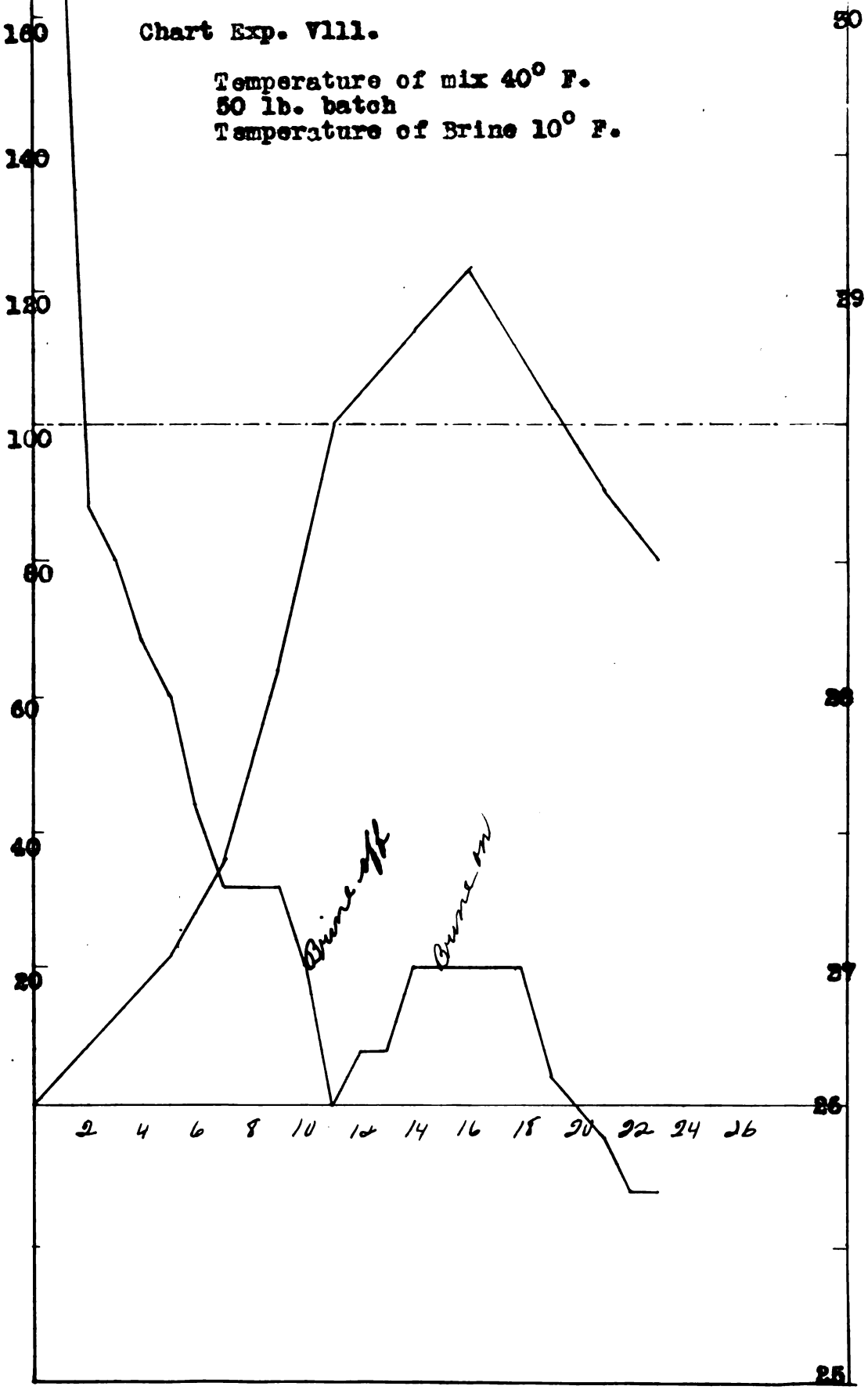


Table 1. Relation of Time, Temperature and Swell.

The following table showing relation time, temperature and swell percent in five minutes, ten minutes, 15 minutes and 18 minutes during freezing process of ice cream.

The average percent of swell obtained in five minutes was 50.5 percent, average temperature 27.7. The average percent swell obtained in ten minutes was 85 percent and average temperature in ten minutes was 26.8°F. Average swell and Temperature in fifteen minutes were 112.8 pe cent swell and 26.4°F. Average swell and temperature in eighteen minutes were 116 percent swell and 26.5° F. temperature.

Time	5 min.		10 min.		15 min.		18 min.	
Exp. No.	Swell	Temp.	Swell	Temp.	Swell	Temp.	Swell	Temp.
1	56	28.5	78	26.5	120	27	130	27
11	60	27.5	92	27	117	27	122	27
111	49	28	85	26	116	26.5	116	27
1V	40	27.5	80	25.5	106	26	125	26.5
V	44	28	82	26	92	26	92	26
V1	54	27.5	92	25.5	123	26	114	26
Average	50.5	27.7	85	26.8	112.8	26.4	116	26.5

Table 11. Correlation of time and temperature at 80% and 100% swell.

% Swell	When reached to 80% swell		When reached to 100% swell		Rate from 80 to 100% Swell		Condition freezing process.
Exp. No.	Time	Temp.	Time	Temp.	Time	Temp.	
1	10 min.	26.5°F.	12	26°F.	2 min.	-0.5	Normal.
11	8	27	11	27	3	0	"
111	10	26	12	26.2	2	+0.2	"
1V	10	25.5	13	25.8	3	+0.3	"
V A	8	26	12	26	4	0	"
V1B.	8	25.5	11	25.5	3	0	"
Average	9	26.1	11-5/6	26.1	2-5/6	0.00	

This table shows that the average temperature (26.1°F.) remained constant during the average increase in swell from 80npercent to 100 percent. The time required to increase the swell from 80 percent to 100 percent was 2-5/6 minutes. This result show the swell from 80 percent to 100 percent could obtained at same temperature about 26°F. This result corresponds with experiment 11 showing that when the ice cream within the proper range of temperature the swell can be increased without change of temperature.

Effectivity of "Brine off and on" to the swell and the temperature.

Table 111. Effect within five minutes after brine was off and was turned on.

Effect within five minutes after brine was off.

Exp. No.	Temp.		% Swell	
111	26°F-26.5°F.	=+0.5°F	85-118	=+33
1	26.5-27	=+0.5	88-124	=+36
1V	25.5-26	=+0.5	80-116	=+36
V1	25.5-26	=+0.5	87-124	=+37
Average		0.5		35

+ sign shows going up +sign shows increase

Effect within five minutes after brine was on

Exp. No.	Temp.		% Swell	
1	28°F-26.6°F	=-1.4°F.	102-96	= -6
11	26-25	=-1.0	92-88	= -4
111	26.9-25.8	= - 1.1	122-96	= -26
1V	26.5-26	= -0.5	118-84n	= -34
Average		-1.0		-17.4

- sign shows going down - sign shows decrease.

From above table the following correlation could obtained.

Effect to temperature:	Effect of swell %:
Brine off equal plus 0.5	Brine off equal plus 35
Brine on " -1.0	Brine on " - 17.4

Now if effectivity by brine off and on assumed as 10. will obtained following equation.

Effect to temperature:	Effect to swell %:
Brine off effectivity = 5	Brine off effectivity = 10
Brine on effectivity = 10	Brine on effectivity = 5

i.e. The brine on has twice effectivity of brine off for temperature in freezing process.

The brine on has $\frac{1}{2}$ effectivity of brine off for the swell in freezing process.

The brine off has $\frac{1}{2}$ effictivity of brine on for the temperature in freezing process.

The brine off has twice effectivity of brine on for the swell in freezing process.

The swell dropped when brine was turned on because the ice cream was frozen firmer causing it to become stiff and brittle and the additional whipping caused the air which had previously been incorporated to be beaten out. The brine on and off should be done in conformity with effectivity of brine on and off. This factor is one of important factors to keep. overrun under proper control of ice cream freezing process.

Usually when the brine turned off and on as soon effected to temperature, but the swell had effected few minutes later than the temperature. As satisfactory in "brine effectivity " of above discreption.

Usually brine off in freezing process should be done between 26.5° and 26° F. at 8 to 10 minutes and brine on should be turned on if the temperature is going up near the 28° F. of temperature and let the temperature cool down.

Table 1V. Relation of Maximum percent swell, time and temperature.

The following table shows that the average maximum percent swell 123 percent, temperature at about 27 degrees and time average 20 minutes takes to maximum swell.

When reached maximum percent swell				
Exp. No.	Time	Temp.	% Swell	Freezing condition
1	18	27.5	130	Normal
11	24	27.2	128	27°F. only
111	17	27	122	Normal
1V	18	26.5	124	Normal
V	31	27	102	Low Temp.
V1	14	26	124	Low Temp.
V11m	18	27.1	132	Quickly freezing
Average	20	26.9	123.1	

It is noted that with this maximum point of swell the ice cream was forzen too thorough and very porous, light and fluffy because usually total length of freezing shoul be done in less than 20 minutes and the percent swell should not beyond 110 percent swell.

SUMMARY

Proper swell could not be obtained with too high temperature or too low temperature in freezing process. Best freezing temperature from 25.5°F. to 27°F. The experiment V. shows that too low temperature 25°F. the swell does not increase. In which case the ice cream is frozen too stiff and is rather brittle so that continued beating tends to break down the air cells which have already been formed.

The experiment 1 and Vll show that at high temperature of 28° F. the swell does not increase and ice cream was soft.

Too slow and too rapidly freezing should be avoided. If taken such freezing process it would obstruct keeping overrun under proper control and lose quality and quantity of ice cream

The mixture temperature when entered the freezer should be taken as near 40°F. as possible. It is better the control of temperature of freezing ice cream in freezer.

The temperature of ice cream when drawn from the freezer to cans should be from 26°F to 27°F, as at this temperature the ice cream has the proper consistency. If

the temperature is higher the ice cream will be too soft and is liable to crystalize out in the harding room. Best result obtained at 26°.5 F. mixture in the freezer.

In Experiment 1V the mix did not cool down to 29°F until four minutes had elapsed. 100% swell was obtained at the end of 13 minutes. In Experiment V1 A the mix was cooled down to 29° F in two minutes and 100 percent swell was obtained at the end of 11 minutes. This shows that the swell is dependent upon the length of time the ice cream whips at the proper temperature. In experiment 1V the extra two minutes during which the mix was above 29°F was lost time in the freezing process so far as swell is concerned. Therefore the colder the mix before entering the freezer or the sooner it is cooled down after entering the freezer the more time is saved in the freezing process.

In Experiment No. 111 the brine was turned off at the end of 10 minutes when the temperature had reached 26°F. At the end of 17 minutes the temperature had raised to 27°F, the swell increased during this time from 85 percent to 122 percent. At this point the brine was turned on for four minutes, the temperature dropping to 25.8°F. and the swell decreasing to 96 percent. The brine was again turned off the temperature raising to 26.8°F in eight minutes. This temperature curve follows very closely the first raise in temperature after brine was turned off. However, the swell during this 8 minutes increased only 12% while during the raise in temperature after the brine was turned off the first time for seven minutes the swell had increased 37 percent.

The same result will be noticed in examining Chart No. 1. Also in chart No. V when the temperature was allowed to raise after 24 minutes of time the swell did not increase as rapidly as it ddd in the normal freezings after 10 or 12 minutes had elapsed. This leads to the conclusion that after the ice cream has whipped in the machine for a long time (20 to 30 minutes) its consistency is such that air is not incorporated as readily as it is under some conditions earlier in the freezing process.

Total length of freezing time it should be from ten to eighteen minutes.

An excessive swell should be avoided. An excessive swell in ice cream is always obtained at the expense of quality. Best percentage of swell is from 90% to 100% or 110%. This is an important item in commercial ice cream making.

Temperature has direct relation to swell"the temperature by brine off" has twice effectivity of brine on to the swell and "temperature by brine on" has ½ effectivity of brine off to the swell. The temperature should be control to the swell by brine off and on. See Experiment Table No. 11.

Should have viscous milk and cream and age the milk cream or mix. Without viscosity could not obtained desirable swell. Pasteurized cream and milk should be aged until viscous and the cream and milk or whole mix should be homogenized or emusified.

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