STUDIES OF THE COMPOSITION OF PORK MEAT

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The investigation described in the paper submitted at the 5th Meeting of the European Meat Research Institutes in which the Nitrogen content of average carcass meat, and also of three joints of meat - the shoulder, middle and leg-were investigated, has now been extended. In the previous investigation the pigs concerned had been drawn from a relatively limited population; now a further 37 carcasses taken at random from deliveries to the factory have been analysed. These carcasses were obtained from pigs, the live weights of which ranged as evenly as possible from 140 lbs. to 330 lbs. The pigs consisted of 20 hogs and 17 gilts; sows were excluded.

The carcasses were dissected as equally as possible along the chine bone thereby dividing the carcass into a 'right' and 'left' side.

Gristle, fat, rinds, ears, snouts, tails, gullets, tongues and offal were excluded, so that only the carcass meat - the so called 'useable meat' was employed for the analytical work. The meat of the left side was dissected from the bone as such, and the entire lean meat and fatty tissue so obtained was comminuted and reduced to a paste in a bowl chopper.

The right side was dissected according to a rigid conventional procedure into three categories of material:-

1. Lean meat.
2. Semi-lean meat.
3. Fatty tissue.

Into the category designated 'semi-lean' meat fall those parts of the useable meat of the carcass which are difficult to dissect into 'lean meat' and 'fatty tissue' by means of a commercial dissection operation.

Thus, in addition to the 'average' carcass meat from the left side, three further materials were obtained from the carcass. These materials were each and separately comminuted, and reduced to a homogeneous paste. Each material was analysed for fat, nitrogen and water content. Two samples of each lot were taken and a single analysis made on each sample, each observation recorded being the arithmetical average of these two samples.

A preliminary investigation had shown that the sampling and analytical errors arising from such a procedure were small.

Analysis showed these materials to have the following composition in terms of fat (chemical) and lean averaged over all 37 pigs (Table 1).

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Table 1

Material	Lean (100-F)	Fat (Chemical)
Lean	91.1	8.9
Semi-lean	61.3	38.7
Fatty tissue	14.6	85.4
Left side	54.6	45.4

The lean meat content of each sample was assumed to be (100-F)% where F is the % of fat in the sample as determined by chemical analysis.

Table 2 shows the mean values of the Nitrogen contents and Water contents for fat-free lean meat from the four different sources.

Table 2

Source	Mean value of Nitrogen Content of Fat-Free Lean (100-F)			Mean Water Content of Fat-Free Lean (100-F)		
	All Pigs	Hog	Gilt	All Pigs	Hog	Gilt
Useable carcass meat	3.47	3.47	3.47	78.4	78.6	78.1
Dissected lean	3.42	3.42	3.42	78.0	78.0	78.0
Semi-lean	3.47	3.47	3.47	78.3	78.5	78.1
Fatty tissue	3.50	3.51	3.49	74.4	74.9	73.6

The figures for the nitrogen content of fat-free meat will be referred to as "nitrogen factors".

The results in Table 2 show that:-

The mean values of the Nitrogen content of lean meat derived from 'dissected semi-lean' and 'average carcass meat' are similar (3.47). The value for dissected lean is lower (3.42) whereas that for fatty tissue is higher (3.50). The reason why carcass meat and semi-lean should give a higher value than dissected lean is almost certainly involved in the definition of lean meat (100-F). 'Lean' meat from average carcass meat and from semi-lean meat will include the contribution from the fatty tissue for which the Nitrogen content is greater, thereby increasing the apparent average Nitrogen content of the 'lean' derived from these two materials.

Thus if we define 'True Lean' as (100%- percentage Fatty Tissue), the data in Table 1 may be used to compile Table 3 in terms of True Lean, Fat and Fatty Tissue.

The estimate of fatty tissue is taken to be $\frac{F_c \times 100}{F_t}$ where F_c is the % fat in the carcass and F_t the % fat in the fatty tissue.

Table 3

Material	% Fatty Tissue	% 'True Lean' (x)	% Fat (y)	% Connective Tissue (z)
Average meat	53.4	46.6	45.4	8.0
Dissected Lean	10.4	89.6	8.9	1.5
Dissected Semi-Lean	45.3	54.7	38.7	6.6

Let 100 gms. carcass meat contain:-

x gms. True Lean.
y gms. Fat (chemical).
z gms. Connective Tissue ex Fatty Tissue,

and let N_L be the Nitrogen content of True Lean.

$$\frac{\frac{N_L x}{100} + \frac{3.50z}{100}}{100-y} = Ns$$

(where Ns is the Nitrogen content of fat-free dissected lean, semi-lean, or average meat as the case may be.

Solving this equation, values for N are obtained as in Table 4.

Table 4

Calculated Values of Nitrogen Content of 'True Lean'	
Source	Nitrogen Content
Average carcass meat	3.42
Dissected Semi-lean	3.42
Dissected Lean	3.42

The effect of correcting for the contribution of the Fatty Tissue to the Nitrogen content of the various 'leans' is to bring them to a practically common value.

Table 2 also shows that there is practically no difference in the Nitrogen contents of the different sources of lean between hogs and gilts.

The water content of fat-free dissected lean is also the same for both hogs and gilts.

There is a difference, however, in the water contents of the connective tissue from the Fatty Tissue of hogs and gilts, that of the hogs having the higher water content. This is reflected, accordingly, in the water contents of fat-free lean meat derived from average carcass meat and from semi-lean meat where again that of the hog shows the higher water content. This is probably due to the greater contribution from the Fatty Tissue.

An examination of the individual analytical results revealed correlations and relationships, which are presented in the following:-

I. DISSECTED LEAN:-

1. Nitrogen and Water Content of Fat-Free Dissected Lean.

On a fat-free basis the Nitrogen content is negatively correlated with Water content (Fig.1) approximately according to the equation

$$N = -0.155W + 15.5.$$

The results obtained are shown in Table 5 in which are given average Nitrogen contents against mean water contents arranged in frequency groups.

Table 5

Water	Nitrogen
76.8	3.62
77.3	3.50
77.8	3.41
78.3	3.39
78.8	3.32
79.3	3.29
79.8	3.17

2. Nitrogen Content of Fat-Free Dissected Lean and Live Weight.

There is a movement of the Nitrogen factor of fat-free dissected lean as the live weight of the pig varies. It is not, however, a linear correlation. The relationship is shown in Fig.2 and by the following Table.

In this, and further Tables, the 37 pigs are subdivided into 8 weight groups. The live weight range for each group is shown in the Table. The average live weight is given for each group together with the average Nitrogen factor for all pigs in the group. Column 5 gives the range of figures in order to indicate the amount of variability to be expected in the groups concerned.

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Table 6

No. Pigs	Weight Range	Average Live Weight	Nitrogen Factor Lean ex diss. Lean	Range
6	140 - 159	155	3.28	3.12 - 3.40
3	160 - 179	169	3.28	3.18 - 3.38
3	180 - 199	181	3.31	3.30 - 3.33
3	200 - 219	206	3.31	3.20 - 3.40
5	220 - 239	225	3.45	3.32 - 3.53
6	240 - 259	253	3.49	3.43 - 3.55
5	260 - 299	284	3.50	3.42 - 3.56
6	300 over	317	3.55	3.44 - 3.68

It will be seen that the Nitrogen factor is practically constant from 155 to 205 lbs. average live weight after which there is a rapid increase as live weight increases from 206 - 225 lbs. live weight. Thereafter the increase is more gradual.

3. Water Content of fat-free dissected lean and live weight.

As in the case of the Nitrogen content, the Water content also moves with live weight in a manner complementary to that of the Nitrogen (see Fig.3). From 140-170 lbs. live weight the water content remains fairly constant, but there is an appreciable fall in water content at 205 lbs. live weight. Thereafter the fall in water content is more gradual.

Accordingly, the increase of Nitrogen content with live weight must be attributed to a decrease of Water content of the flesh as live weight increases.

Data are given in Table 7.

Table 7

No. Pigs	Weight Range	Average Live Weight	Average Water Content (fat-free lean ex dissected lean)	Range
6	140 - 159	155	79.1	78.3 - 79.4
3	160 - 179	169	79.1	78.3 - 79.9
3	180 - 199	181	78.6	78.0 - 79.0
3	200 - 219	206	77.9	77.1 - 78.1
5	220 - 239	225	77.7	77.3 - 78.8
6	240 - 259	253	77.5	77.1 - 78.2
5	260 - 299	284	77.2	76.9 - 77.8
6	300 over	317	77.1	77.1 - 77.6

4. Chemical Fat Content of Dissected Lean.

Dissected Lean inevitably contains a certain amount of intramuscular fat, which is not easily dissected in a commercial operation. It was of interest to discover how this amount of fat varies on average with the live weight of the animals from which the lean is dissected.

Table 8 gives the data.

Table 8

No. Pigs	Live Weight Range	Average Live Weight	Average Fat in Dissected Lean	Range
6	140 - 159	155	9.5	8.4 - 11.3
3	160 - 179	169	9.7	8.4 - 11.6
3	180 - 199	181	7.4	5.4 - 8.9
3	200 - 219	206	(6.9)	6.2 - 7.6
5	220 - 239	225	(10.5)	6.7 - 12.4
6	240 - 259	253	8.8	7.1 - 10.7
5	260 - 299	284	8.8	7.2 - 10.4
6	300 over	317	8.4	8.5 - 9.8
			Average 8.8	

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II. AVERAGE USEABLE CARCASS MEAT:-

A. Distribution of Fat, Nitrogen, and Water in average carcass meat.

1. Proportion of (chemical) fat in carcasses.

Table 9 is compiled on the same basis as similar tables in the preceding section and shows the variation of the fat content (as chemically determined) of the carcasses from one live weight group to another.

Table 9

Proportion of Fat in Pig Carcasses at Different Live Weights

No. Pigs	Live Weight Range	Average Live Weight	Average % Fat in carcass	Range
6	140 - 159	155	42.9	36.9 - 47.8
3	160 - 179	169	43.9	37.6 - 47.3
3	180 - 199	181	41.6	34.6 - 47.0
3	200 - 219	206	44.6	39.9 - 51.4
5	220 - 239	225	45.7	37.7 - 50.5
6	240 - 259	253	46.6	41.8 - 52.6
5	260 - 299	284	46.5	37.1 - 53.1
6	300 over	317	51.1	44.0 - 57.0
Average of all pigs 45.4				

The results are also plotted in Fig.4. They show a gradually increasing trend in average fat content of the carcass as average live weight increases. The correlation is approximately linear and corresponds to the equation

$$F = .048L + 34.2 \quad \ldots\ldots\ldots(1)$$

(where F is the % fat content and L the live weight in lbs.

2. Nitrogen content and Fat content.

If we take the data obtained for all pigs and plot the Nitrogen content against the Fat content of the useable meat of the carcass, we obtain a good linear relationship. Fig.5 shows the graph, and the equation

$$N = - 0.0347\,F + 3.47 \quad \ldots\ldots\ldots(2)$$

fits the straight line obtained.

This is to be expected, and the equation confirms the results described in (I) for when F = 0, N = 3.47, whereas when F = 100, N = 0.

3. Water Content and Fat Content.

A similar examination of the Water contents of the carcasses results again in the negative linear correlation shown in Fig.6.

These points are scattered around the trend line

$$W = -0.784F + 78.4 \quad \ldots\ldots\ldots (3)$$

This again is the expected line, for when F = 0, W = 78.4, as in (I), whilst when F = 100, W = 0.

4. Nitrogen Content and Water Content.

Since the Nitrogen contents and the Water contents of the carcasses are both negatively and linearly correlated with the fat content, it is to be expected that Nitrogen and Water content will show a positive linear correlation. That this is indeed the case can be seen from Fig.7. The points are roughly scattered about the line

$$N = \frac{W}{22.6} \quad \ldots\ldots\ldots (4)$$

It is evident, however, that whilst the equations in 2, 3 and 4 describe quite well the relationship between the nitrogen, fat and water contents of the pig carcasses, Fig.7 shows some departures from the simple behaviour. In particular, a predominance of points at higher water contents are associated with values of nitrogen content which are greater than those predicted, whereas the converse is the case at lower water contents.

B. Effect of Live Weight on Water and Nitrogen Content.

The results already discussed under Section II. A, paragraphs 1-4, show the effect of the distribution of lean meat (and therefore of nitrogen and water) in all pig carcasses, irrespective of live weights, against a background of fat contents which vary to a very considerable extent. However, within lean meat itself (i.e. fat-free) there are interesting fluctuations of nitrogen content with water content which lead to important results. In the system so far considered - which is essentially the dilution of Nitrogen and Water to varying degrees with widely different amounts of fat - fluctuations of nitrogen with water content within a fat-free system are overwhelmed. This leads, as we have seen, to two possible relationships between Nitrogen and Water according to the system under consideration.

To appraise overall effects, i.e. to see whether certain factors are dependent upon the live weight of the pig, the mean values for Nitrogen, Water and Fat content have been computed for each live weight group. The trends shown by these mean values as the live weight increases have then been ascertained.

Table 10 summarises the results.

Table 10

Live Weight Range (lbs.)	No. Pigs	Mean Live Weight	Nitrogen Content	Water Content	Fat Content	100N / 100-F	100W / 100-F
140 - 159	6	155	1.859	46.6	42.9	3.25	78.1
160 - 179	3	169	1.864	44.0	43.8	3.32	78.2
180 - 199	3	181	1.967	45.3	42.1	3.39	78.3
200 - 219	3	206	1.895	43.7	44.4	3.42	78.6
220 - 239	5	225	1.879	42.6	45.7	3.46	78.4
240 - 259	6	253	1.894	41.5	46.6	3.54	77.7
260 - 299	5	284	1.920	41.3	46.5	3.59	77.2
300 over	6	317	1.765	37.9	51.1	3.60	77.5

1. Average Nitrogen Content.

The results given in Column 4 of Table 10 are plotted in Fig.8.

The graph illustrates the interesting and important result that, as the live weight increases from 140 - 300 lbs. the average nitrogen content of the useable meat of the carcass is little effected. However, there would appear to be a slight fall in nitrogen content when the live weight exceeds 300 lbs.

The point is well illustrated by the grouping of encircled points on Fig.5. On this curve, connecting Nitrogen content with Fat content are plotted the group values. The tendence for these points to group in a very restricted region of the curve illustrates

(i) the comparatively small movement of the average of fat contents when compared with the total possible variability of fat contents, and

(ii) constancy of average nitrogen content. Groups 3 and 8 are the exceptions where lower and higher average fat contents respectively influence the position of the corresponding points on the curve.

2. Average Water Content.

The water content of the 'useable meat' shows a tendency to become smaller in value as the live weight increases. The results are plotted in Fig.9.

The results indicate a slowly falling water content up to 300 lbs. live weight. As we have seen, however, the nitrogen content of the carcass remains little effected.

As in the case of the Nitrogen content, group average water contents have been plotted against group average fat contents on Fig.6. Whilst, once again the small movement of average fat content is illustrated when compared with total possible fat variability, the points are distributed along the curve showing that as the average fat content increases the average water content decreases.

3. Effect of live weight upon the 'Nitrogen Factor'.

From the figures presented in columns 4 and 6 in Table 10 it is now possible to compute average values of the 'Nitrogen Factor' for each weight group.

In computing this factor it is assumed, as mentioned under (I), that the lean meat content is given by the expression (100-F) where F is the percentage of fat in the carcass as determined analytically. The consequence of so doing is that the estimate of lean meat content includes the contributions of nitrogen and water contents from the fatty tissue, and this has been discussed in (I).

Fig.10 shows the graph obtained when the Nitrogen factors, computed in the above manner, are plotted for all the pigs in the investivation.

On the same graph are shown the points obtained on a group basis from the figures in columns 4, 5 and 6 in Table 10.

It will readily be seen that both sets of points illustrate an upward trend, the average nitrogen factor increasing as the average live weight increases.

The relationship is a linear one and may be expressed by the equation

$N = 0.00184L + 3.0345$ where L is the live weight, thus showing the dependence of the nitrogen factor on live weight.

We have seen (II, B, 1, and Fig.8) that the nitrogen content of the total useable meat as such is only little effected by the live weight of the animal (up to 300 lbs. live weight). To compute the value of the nitrogen content on the fat-free meat it is necessary to multiply the average nitrogen content by a factor $\frac{100}{100-F}$. Because F slowly increases with live weight, the factor $\frac{100}{100-F}$ also increases with live weight. The above relationship therefore is a consequence of two effects:-

(i) a constant nitrogen content as live weight increases.

(ii) a slowly increasing fat content.

4. Effect of Live Weight on Water Content of fat-free Meat.

The figures in columns 5 and 6 in Table 10 may be used to compute the average values for the water content of fat-free meat in each weight group, by multiplying the water content of the useable meat by the factor $\frac{100}{100-F}$.

In section II, B, 2 it was seen that there is a tendency for the average water content to become lower as the average live weight increases (see Fig.9). The effect of calculating the average water content on a fat-free basis is thus to multiply a quantity which slowly diminishes as live weight increases by a factor which slowly increases as live weight increases.

The curve so obtained is shown in Fig.11. On this curve are plotted points for all pigs examined and also for the group averages (encircled).

The figure shows a slight maximum at group 3 (180 - 199 lbs.) and thereafter a very slight diminution of group average water content with live weight up to 300 lbs. live weight.

5. Correlation between Nitrogen and Water contents of fat-free Meat.

The foregoing sections have shown that, as a result of defining fat-free meat as (100-F) the Nitrogen content of fat-free meat increases as live weight increases, whilst the water content of fat-free meat has become almost independent of the live weight.

Good correlation between Nitrogen and Water contents of fat-free meat is not therefore to be expected.

Fig.12 in which these quantities are plotted, both for individual pigs and for group averages, bears out this expectation. Whilst the trend exists, the correlation is not a close one, and this finding contrasts with the results discussed in I (Figs.1, 2 and 3) where the Nitrogen and Water contents of fat-free dissected lean were shown to be negatively and linearly correlated.

The reason for this poorer correlation when dealing with fat-free meat from the entire carcass (like the discrepancies found between the Nitrogen factors for dissected lean, semi-lean and carcass meat (Tables 2 and 4) lies in the effect produced by the presence of fatty tissue and will be discussed in a later section.

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III. FATTY TISSUE FROM AVERAGE CARCASS MEAT.

1. Distribution in Carcass.

As previously mentioned all dissectable fatty tissue was removed from the carcass, comminuted, mixed and analysed for nitrogen, water and fat content.

The estimation of the fatty tissue content of the carcass is thereafter an indirect one.

If it be assumed that F_1 is the fat content of the fatty tissue as determined by analysis and F_2 the fat content of the useable meat similarly determined, then the fatty tissue content of the useable meat is taken to be:-

$$F_2 \times \frac{100}{F_1}$$

On this basis the fatty tissue content has been calculated for all the pigs examined, and also the average fatty tissue content for the pigs classified, as before, into live weight groups.

Table 11 gives the values of average fatty tissue content in the carcass, together with the average percentages of fat, water and nitrogen content in the fatty tissue, for each live weight group.

Table 11

Fatty Tissue

Range of Live Weights	No. Pigs	Mean Live Weight	% Fatty Tissue in Carcass	% Fat in Fatty Tissue	% Water in Fatty Tissue	% Nitrogen in Fatty Tissue	W / 100-F	N / 100-F
140 - 159	6	155	52.25	82.0	12.8	0.600	71.2	3.33
160 - 179	3	169	52.9	82.8	12.3	0.611	71.5	3.55
180 - 199	3	181	49.2	85.5	10.5	0.535	72.7	3.68
200 - 219	3	206	52.3	85.0	11.1	0.521	74.0	3.48
220 - 239	5	225	53.0	86.2	10.8	0.513	78.2	3.72
240 - 259	6	253	53.5	86.7	9.7	0.460	73.0	3.50
260 - 299	5	284	53.6	86.7	9.8	0.470	73.6	3.52
300 over	6	317	57.5	87.3	9.3	0.445	72.5	3.50
Mean Value (all pigs)			53.4	85.4	10.8	0.509	74.0	3.50
			σ 5.0	σ 1.8	σ 1.2	σ 0.08	σ 3.0	σ .2

The connection between the group average fatty tissue content and live weight is shown in Fig.13. Values for all pigs as well as for group averages are shown so that the possible spread may be seen. The graph shows that the average fatty tissue content is practically constant up to a live weight of 300 lbs. approximately, and that above 300 lbs. live weight there is an increase in the fatty tissue content.

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2. Fat in Fatty Tissue.

The quantity of fat in the fatty tissue tends to increase very gradually as the live weight increases. The values for all individual pigs and for group averages are shown graphically in Fig.14. The mean value for all pigs is 85.4%

3. Connective Tissue in Fatty Tissue.

If we assume that the non-fatty matter in the fatty tissue represents connective tissue, the percentage connective tissue is given by 100-F where F is the fat content of the tissue. Fig.15 shows the proportions of connective tissue in the fatty tissue at different live weights.

From Fig.15 it may be seen that, as the live weight of the pig increases, although the fatty tissue remains constant, it contributes, on average, decreasing quantities of connective tissue to the non-fatty matter in the system. The mean value for all pigs is 14.6%.

4. Nitrogen Content of Fatty Tissue.

The nitrogen content of the fatty tissue decreases as the live weight of the animal increases. Values obtained for all individual pigs and for group averages are shown graphically in Fig.16. Column 7, Table 11 gives the actual values of group averages and illustrates the principle that as the live weight of the animal increases, so the quantity of nitrogen contributed by the Fatty Tissue decreases. Mean Value for all pigs 0.509.

5. Water Content of Fatty Tissue.

As in the case of the Nitrogen content of the fatty tissue, the water content of the fatty tissue decreases as the live weight increases. The results are shown graphically in Fig.17 and the actual values of group averages appear in Column 6, Table 11.

Just as the quantity of nitrogen contributed by the Fatty Tissue to the system decreases as the live weight increases, so the quantity of water contributed also decreases with increasing live weight. Mean value for all pigs 10.8.

6. Nitrogen and Fat content of Fatty Tissue.

Fig.18 indicates the relationship between nitrogen and fat content in fatty tissue. These quantities are distributed, as the curve shows, in accordance with the relationship

$$N = -0.035F + 3.50$$

thus confirming the previously found average nitrogen factor for connective tissue (3.50).

Group averages are also shown by means of encircled points on Fig.18 and fit the above relationship. The position of these points indicates the smaller spread of average values when compared with the total possible spread of individuals.

7. Water and Fat Content of Fatty Tissue.

Like the nitrogen content, the water content is also negatively and linearly correlated with the fat content of the fatty tissue. Fig.19 illustrates the relationship graphically - a relationship given by the equation

$$W = -0.74F + 74$$

The equation confirms that when F = 0, W = 74. Group averages are again shown by means of encircled points.

8. Nitrogen and Water Content of Fatty Tissue.

It has been shown that there is a negative linear correlation between nitrogen content of fatty tissue and live weight and between water content of fatty tissue and live weight. Furthermore, there are negative linear correlations between Nitrogen content and fat content and between Water content and fat content.

In accordance with these findings, there is a positive linear correlation between Nitrogen and Water content of fatty tissue.

The relationship is shown in Fig.20, the points being distributed about the line

$$N = \frac{W}{21.2}$$

Group averages are plotted on the same curve and obey the same relationship.

IV. PROPERTIES OF TRUE LEAN.

It was seen earlier that when using a concept of 'True Lean' defined as 100% - Fatty Tissue % rather than 'lean' defined as 100% - Fat%, the average Nitrogen content became constant, irrespective of the source of the material (Table 4).

In this expression, the percentage fatty tissue content is given by the equation

$$FT\% = \frac{F_c \times 100}{F_t}$$

(where F_c is the percentage of fat in the carcass and F_t the percentage fat in the fatty tissue.

Similarly, it is possible to determine the Nitrogen and Water contents of 'True Lean' as defined above, using the expressions:-

(i) % Nitrogen content of True Lean = N_{TL}

$$N_{TL} = \frac{N - \frac{n \times F_c}{F_t}}{100 - \frac{F_c \times 100}{F_t}} \times 100$$

(ii) % Water content of True Lean = W_{TL}

$$W_{TL} = \frac{W - \frac{w \times F_c}{F_t}}{100 - \frac{F_c \times 100}{F_t}} \times 100$$

where:-

N is the percentage nitrogen in the sample.
n is the percentage nitrogen in the fatty tissue.
W is the percentage water in the sample.
w is the percentage water in the fatty tissue.

These computations have been made for all pigs investigated in order to obtain the average nitrogen and water contents of 'True Lean' from three different sources:-

Dissected lean, semi-lean and average carcass meat.

The values obtained are shown in Table 12.

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Table 12

	Source of True Lean		
	Dissected Lean	Semi-Lean	Average Carcass Meat
Nitrogen content	3.42	3.43	3.42
Water content	78.0	78.5	78.4

The results are in good agreement with those shown in Table 4.

When this method of computing the water and nitrogen contents of true lean was applied to the data obtained from the analysis of dissected lean, the following relationships between factors were found.

1. Nitrogen Content and Water Content.

Fig.21 shows the connection between Nitrogen content and Water content. The correlation is a negative linear one, the points being distributed approximately about the line

$$N = -0.155\,W + 15.5$$

2. Nitrogen Content and Water Content of True Lean and Live Weight.

Table 13 shows the group average values of the Nitrogen and Water contents of True Lean.

Table 13

Live Weight Range	No. Pigs	Average Live Weight	Nitrogen Content	Water Content
140 - 159	6	155	3.28	79.1
160 - 179	3	169	3.29	79.1
180 - 199	3	181	3.32	78.6
200 - 219	3	206	3.37	78.2
220 - 239	5	225	3.43	77.9
240 - 259	6	253	3.50	77.6
260 - 299	5	284	3.54	77.4
300 over	6	317	3.57	77.2

The results are shown graphically in Figs. 22 & 23.

The Nitrogen content which is practically constant up to 180 lbs. live weight thereafter rises gradually with increasing live weight (280 lbs.).

The Water content moves in a complementary manner and the group averages show a gradual fall with increasing live weight.

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V. RECONSTRUCTION OF CARCASS MEAT FROM TRUE LEAN AND FATTY TISSUE.

The results presented show that the adoption of the definition 100% - F.T. % for lean meat leads to consistent Nitrogen contents for lean meat. This is not the case when the conventional definition 100% - F% is used. The discrepancies in Nitrogen content obtained when using the latter definition have been shown to be due to the contribution which the Fatty Tissue makes to the nitrogen and water contents of the system.

Results of the analysis of average useable carcass meat from the whole carcass have shown that the Nitrogen factor for lean meat defined as '100-F' increases with the live weight of the pig. This is because the nitrogen content of the carcass remains practically constant in spite of the fact that the fat content F increases as the live weight increases. Consequently, the derivation of the Nitrogen factor for lean meat by multiplying nitrogen contents by the factor

$$\frac{100}{100-F}$$

leads to values which increase as the live weight increases.

The water content of the carcass meat, however, decreases with increasing live weight. When the water content of lean meat is derived, again by multiplication by the factor

$$\frac{100}{100-F}$$

the effect of an increasing F with live weight is to show a constant water content of fat-free lean meat with increasing live weight up to 280/300 lbs.

Within the 'True Lean' and fat-free 'Dissected Lean' systems there is a good negative correlation between Nitrogen and Water. In the average carcass meat, there are good negative correlations between nitrogen content and fat content, water content and fat content and a positive correlation between Nitrogen content and water content.

However, within the fat-free lean meat from this source, the negative correlation between Nitrogen and Water is poor. This result is due to the disturbing effects of the contributions of nitrogen and water from the fatty tissue.

Accordingly, it remains to explain the constancy of the nitrogen content of the carcass at different live weights, together with a diminishing water content as live weight increases, and in the following this is done by regarding carcass meat as a combination of the two components:-

(1) True Lean,

(2) Fatty Tissue,

the characteristics of which have been given above. The analysis of these two components is, of course, independent of the analysis of the average carcass meat, and by combining the Nitrogen and Water contributions of each component it should be possible to reconstruct a model of average carcass meat, at each live weight group, and to compare the values obtained with those found. Table 14, therefore,

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sets out the average proportions of Fatty Tissue and True Lean in each live weight group and computes their relative contributions to the nitrogen content of the carcass itself.

Table 14

Live Weight Range	No. Pigs	Average Live Weight	% Fatty Tissue	% Nitrogen in Fatty Tissue	% Nitrogen in carcass ex Fatty Tissue	% True Lean	% Nitrogen in True Lean	% Nitrogen in carcass ex True Lean	% Total Nitrogen
140-159	6	155	52.3	0.600	0.314	47.7	3.28	1.564	1.878
160-179	3	169	52.9	0.611	0.323	47.1	3.29	1.549	1.872
180-199	3	181	49.2	0.535	0.263	50.8	3.32	1.698	1.956
200-219	3	206	52.3	0.521	0.273	47.7	3.37	1.641	1.914
220-239	5	225	53.0	0.513	0.272	47.0	3.43	1.612	1.884
240-259	6	253	53.5	0.460	0.246	46.5	3.50	1.628	1.874
260-299	5	284	53.6	0.470	0.252	46.4	3.54	1.643	1.895
300 over	6	317	57.5	0.445	0.256	42.5	3.57	1.517	1.773

Table 15 compares the calculated Nitrogen content with that found directly by analysis. It also gives the fat content, which has been used to calculate the Nitrogen factors defining lean meat as 100-F. A comparison of these values is also given.

Table 15

Live Weight Range	No. Pigs	Average Live Weight	Nitrogen Content calculated	Nitrogen Content found	Fat Content	Nitrogen Factor calculated	Nitrogen Factor found
140-159	6	155	1.878	1.859	42.9	3.28	3.25
160-179	3	169	1.872	1.864	43.9	3.33	3.32
180-199	3	181	1.956	1.967	42.1	3.38	3.39
200-219	3	206	1.914	1.895	44.4	3.45	3.42
220-239	5	225	1.884	1.879	45.7	3.47	3.46
240-259	6	253	1.874	1.894	46.6	3.51	3.54
260-299	5	284	1.895	1.920	46.5	3.54	3.57
300 over	6	317	1.773	1.765	51.1	3.61	3.60

Table 16 assesses the contributions of True Lean and Fatty Tissue to water content in each live weight grouping.

Table 16

Live Weight Range	No. Pigs	Average Live Weight	% Fatty Tissue	% Water in Fatty Tissue	% Water in carcass ex Fatty Tissue	% True Lean	% Water in True Lean	% Water in carcass ex True Lean	% Total Water
140-159	6	155	52.3	12.8	6.7	47.7	79.1	37.8	44.5
160-179	3	169	52.9	12.3	6.6	47.1	79.1	37.4	44.0
180-199	3	181	49.2	10.5	5.2	50.8	78.6	40.1	45.3
200-219	3	206	52.3	11.1	5.8	47.7	78.2	37.5	43.3
220-239	5	225	53.0	10.8	5.7	47.0	77.9	36.7	42.4
240-259	6	253	53.5	9.7	5.2	46.5	77.6	36.1	41.3
260-299	5	384	53.6	9.8	5.3	46.4	77.4	36.0	41.3
300 over	6	317	57.5	9.2	5.1	42.5	77.2	32.8	37.9

Table 17 compares the calculated water content with the values found directly by analysis and also shows the calculated and found values for the water content of fat-free lean.

Table 17

Live Weight Range	No. Pigs	Average Live Weight	Water Content calculated	Water Content found	Fat Content	Water on fat-free calculated	Water on fat-free found
140-159	6	155	44.5	44.6	42.9	77.8	78.1
160-179	3	169	44.0	44.0	43.9	78.2	78.2
180-199	3	181	45.3	45.3	42.1	78.6	78.3
200-219	3	206	43.3	43.7	44.4	78.0	78.6
220-239	5	225	42.4	42.6	45.7	78.0	78.4
240-259	6	253	41.3	41.5	46.6	77.3	77.7
260-299	5	284	41.3	41.3	46.5	77.4	77.2
300 over	6	317	37.9	37.9	51.1	77.5	77.5

The results presented in Tables 14 - 17 show excellent agreement and may be interpreted as follows:-

1. Carcass meat may be regarded as a system comprising 2 components - True Lean and Fatty Tissue. This concept provides a consistent explanation of the analytical findings.

2. The ratio of True Lean to Fatty Tissue is practically constant, being independent of the live weight of the animal over a wide range of live weights.

3. The fat content of the fatty tissue (and, therefore, of the carcass) increases as the live weight increases and, consequently, the proportion of non-fatty matter (connective tissue) and, therefore, nitrogen and water decreases as live weight increases.
The contribution of the fatty tissue, therefore, to the overall nitrogen and water content of the carcass decreases with increasing live weight.

4. The nitrogen and water content of True Lean are constant up to about 180 lbs. live weight, after which the nitrogen content increases and the water content decreases, i.e. the flesh becomes drier.

5. The falling contribution of the Fatty Tissue to overall Nitrogen content is almost exactly counterbalanced by the increasing Nitrogen content of the True Lean with live weight.

6. The falling contribution of the Fatty Tissue to overall Water content goes hand-in-hand with a falling water content in the True Lean. Accordingly, the net result is a decrease in water content of the carcass as the live weight increases.

7. An increasing fat content with increasing live weight results in the observation that when the factor

$$\frac{100}{100-F}$$

is used as a multiplier to convert Nitrogen and Water contents to a fat-free basis a positive linear correlation between Nitrogen and Live Weight is obtained, whilst the Water content of fat-free meat appears to become independent of the live weight.

FIG. I

NITROGEN CONTENT AND WATER CONTENT OF FAT FREE DISSECTED LEAN

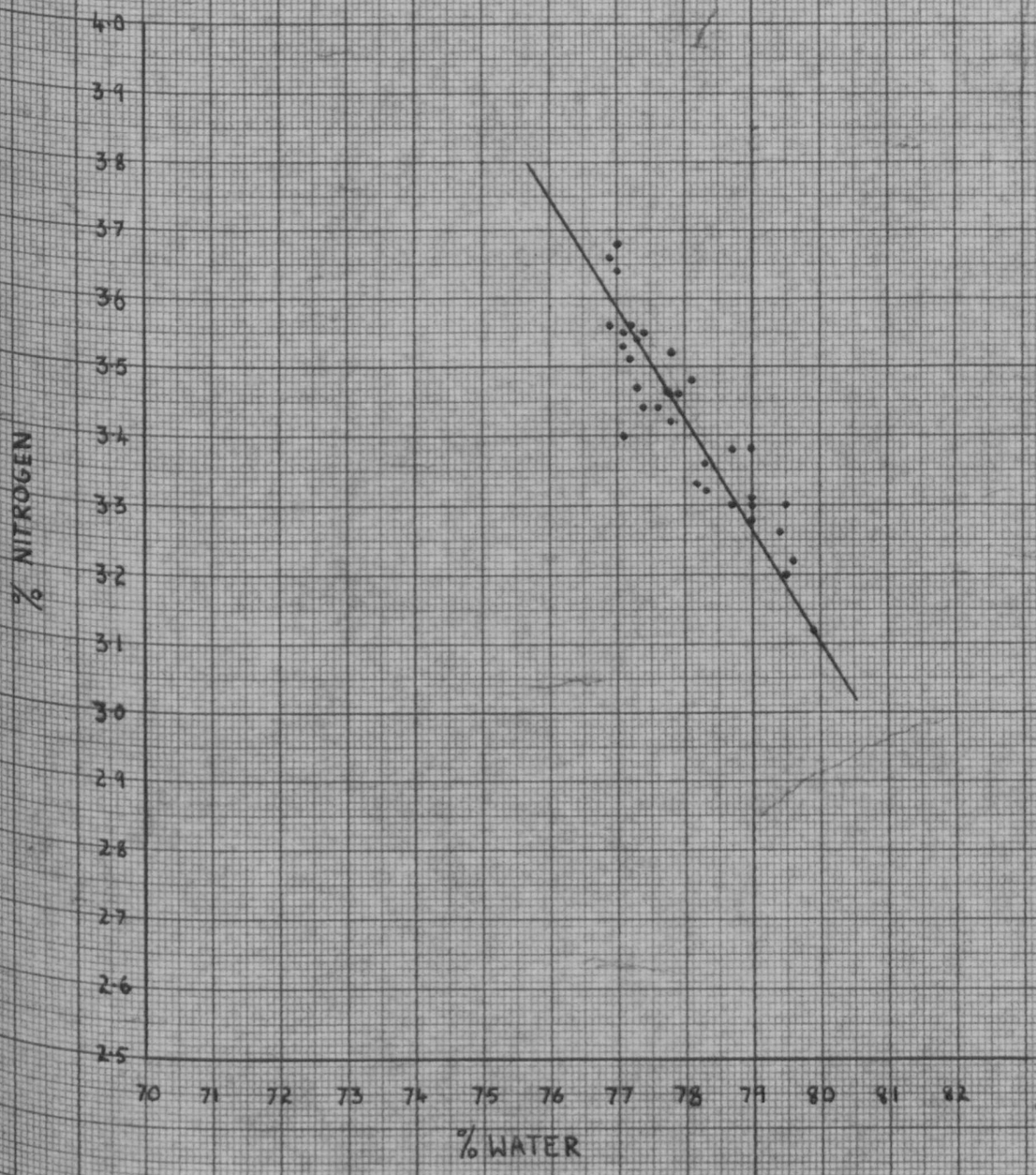

FIG. 2

NITROGEN CONTENT OF FAT FREE DISSECTED LEAN AGAINST LIVE WEIGHT

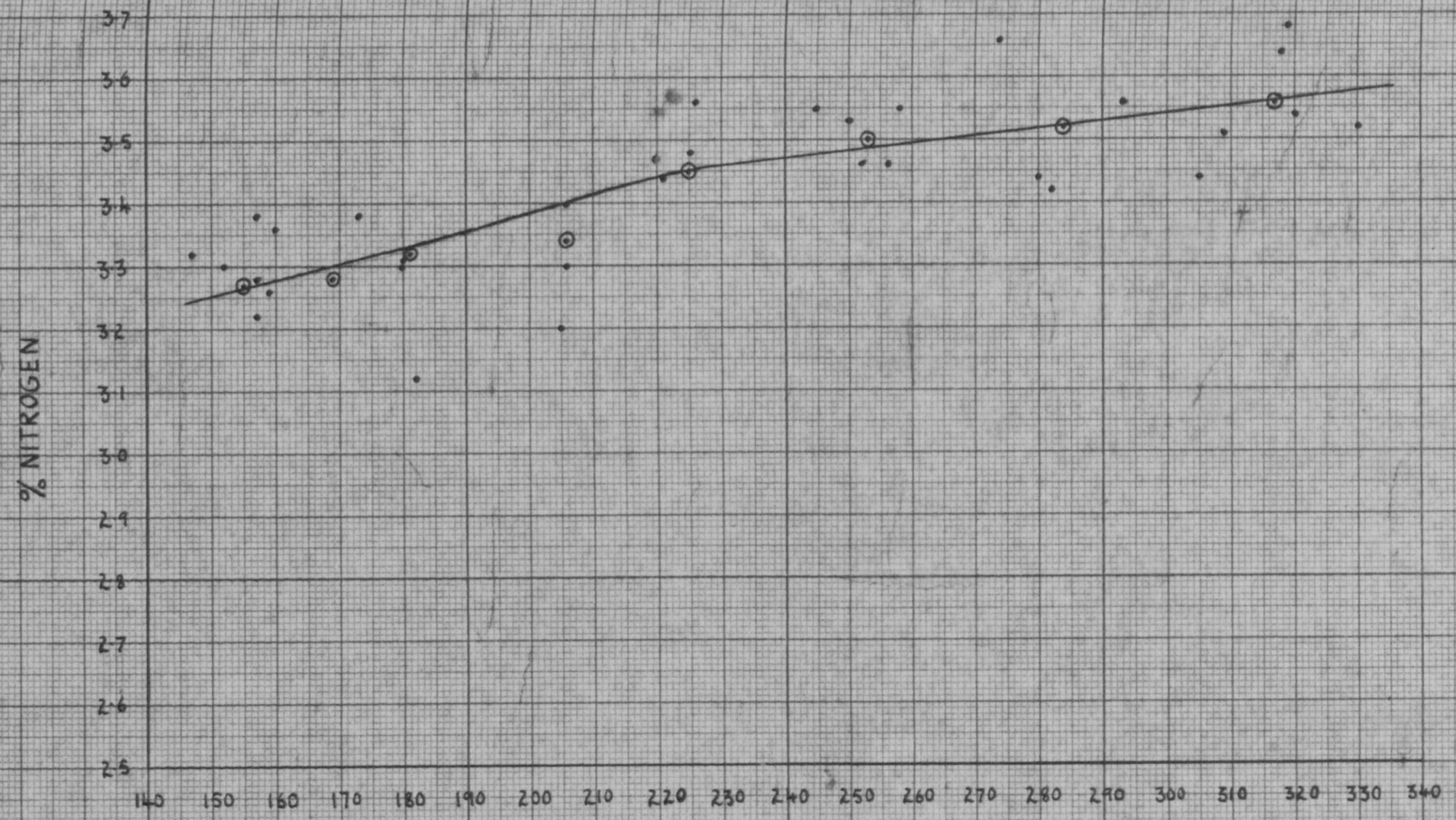

FIG. 3

WATER CONTENT OF FAT FREE DISSECTED LEAN AGAINST LIVE WEIGHT

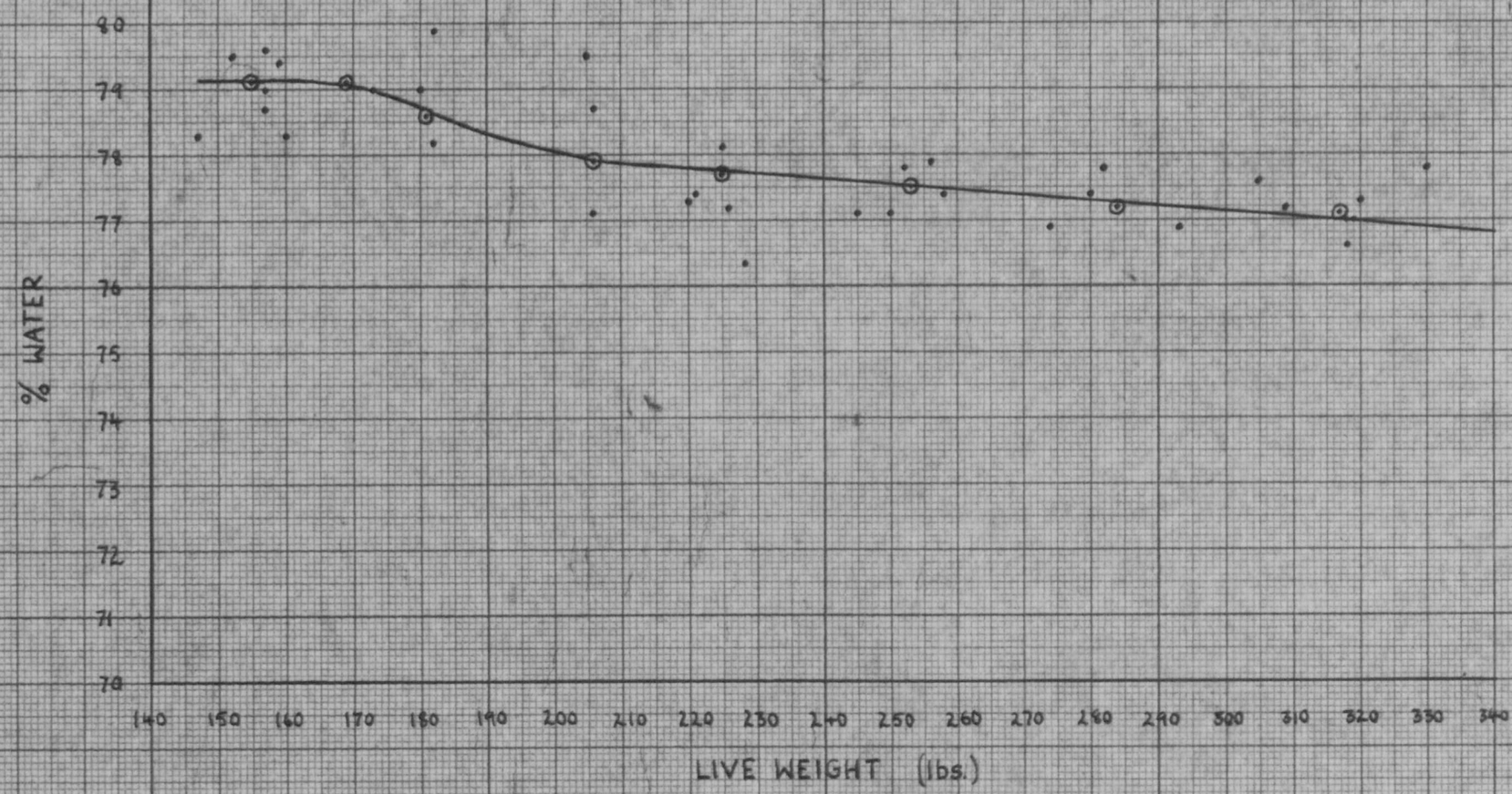

FIG. 4

FAT CONTENT OF CARCASS AGAINST LIVE WEIGHT

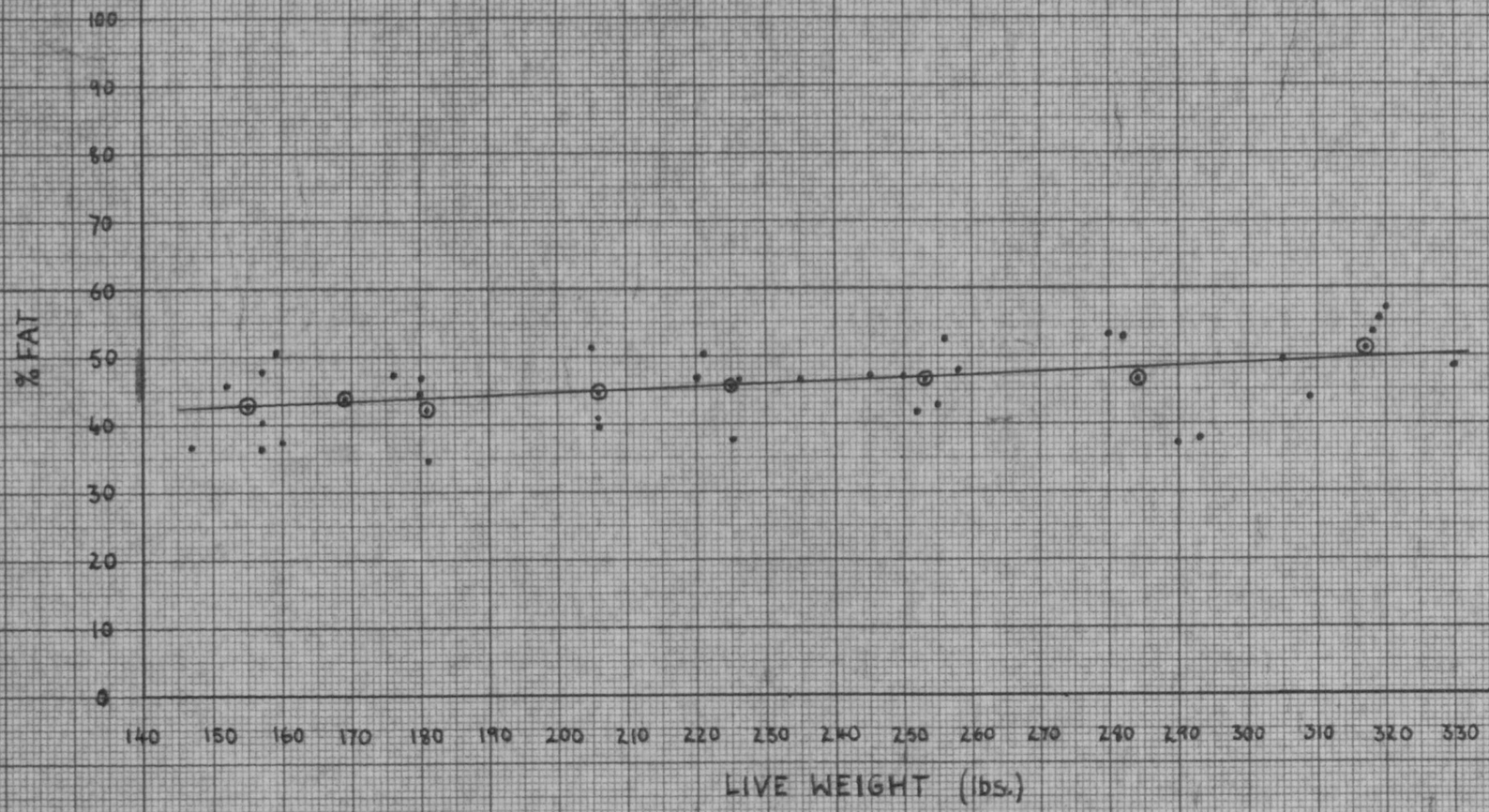

FIG. 2

NITROGEN CONTENT (COMPLETE SIDE) AGAINST FAT CONTENT

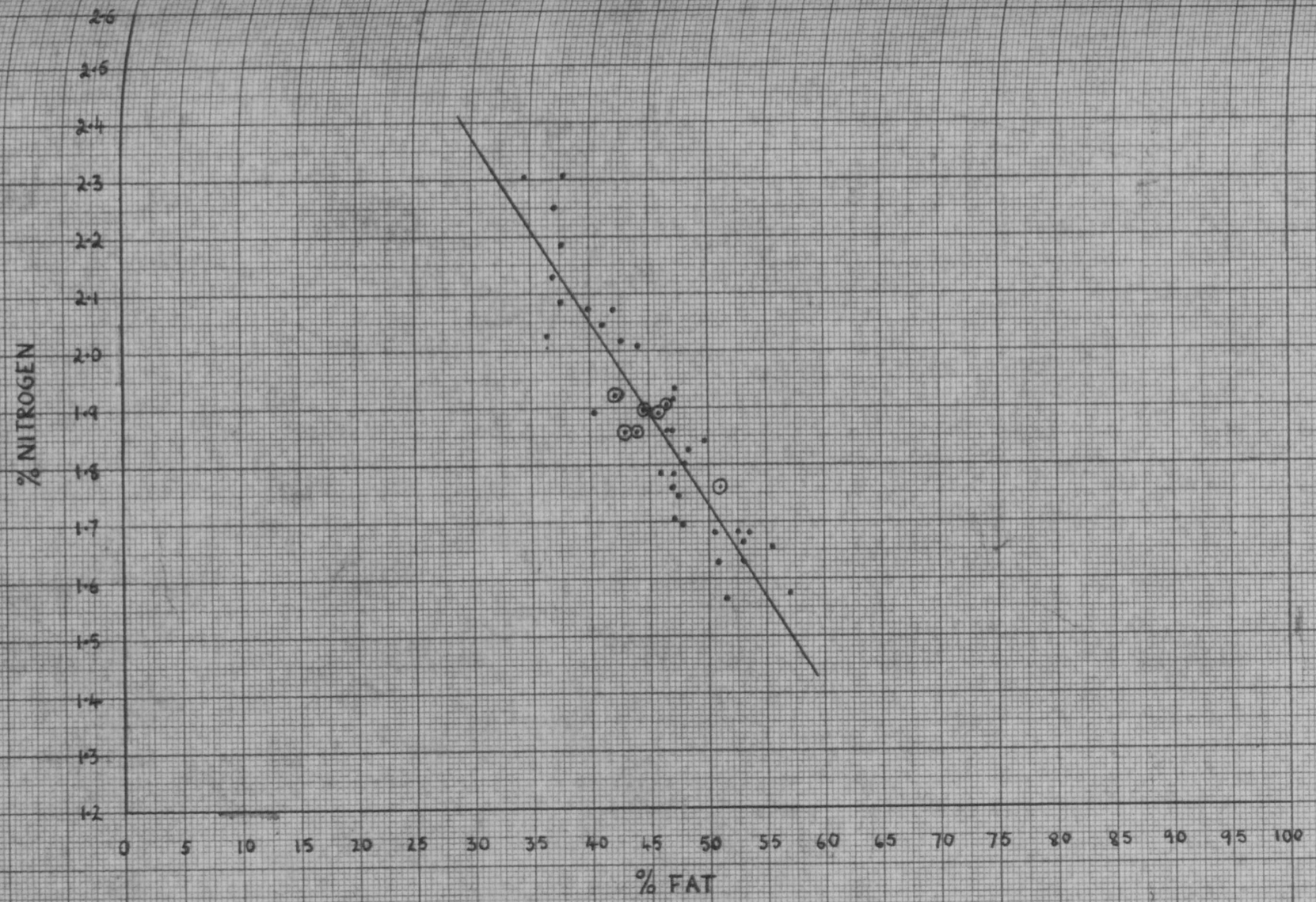

FIG. 6

WATER CONTENT (COMPLETE SIDE) AGAINST FAT CONTENT

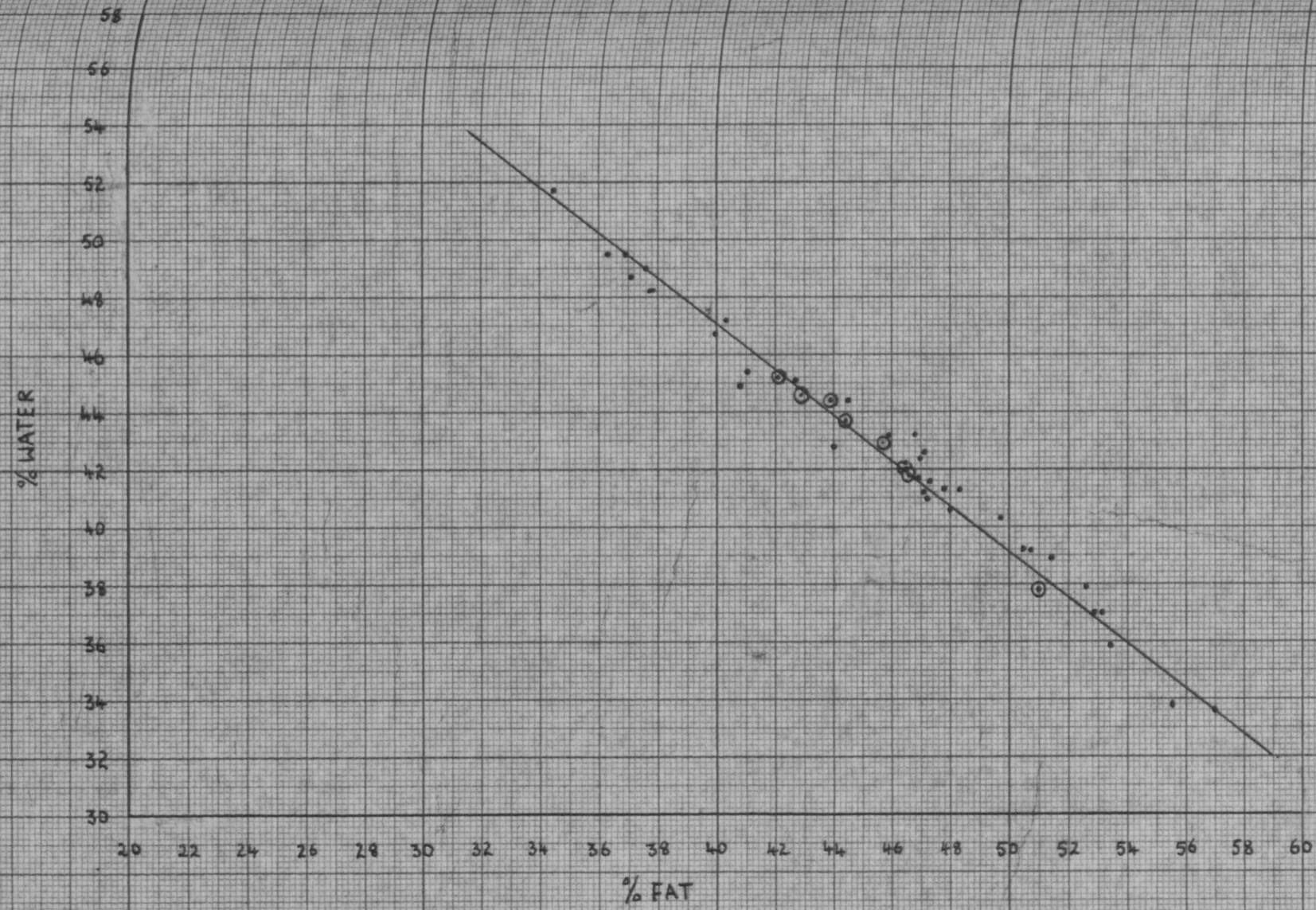

FIG. 7

NITROGEN CONTENT (COMPLETE SIDE) AGAINST WATER CONTENT

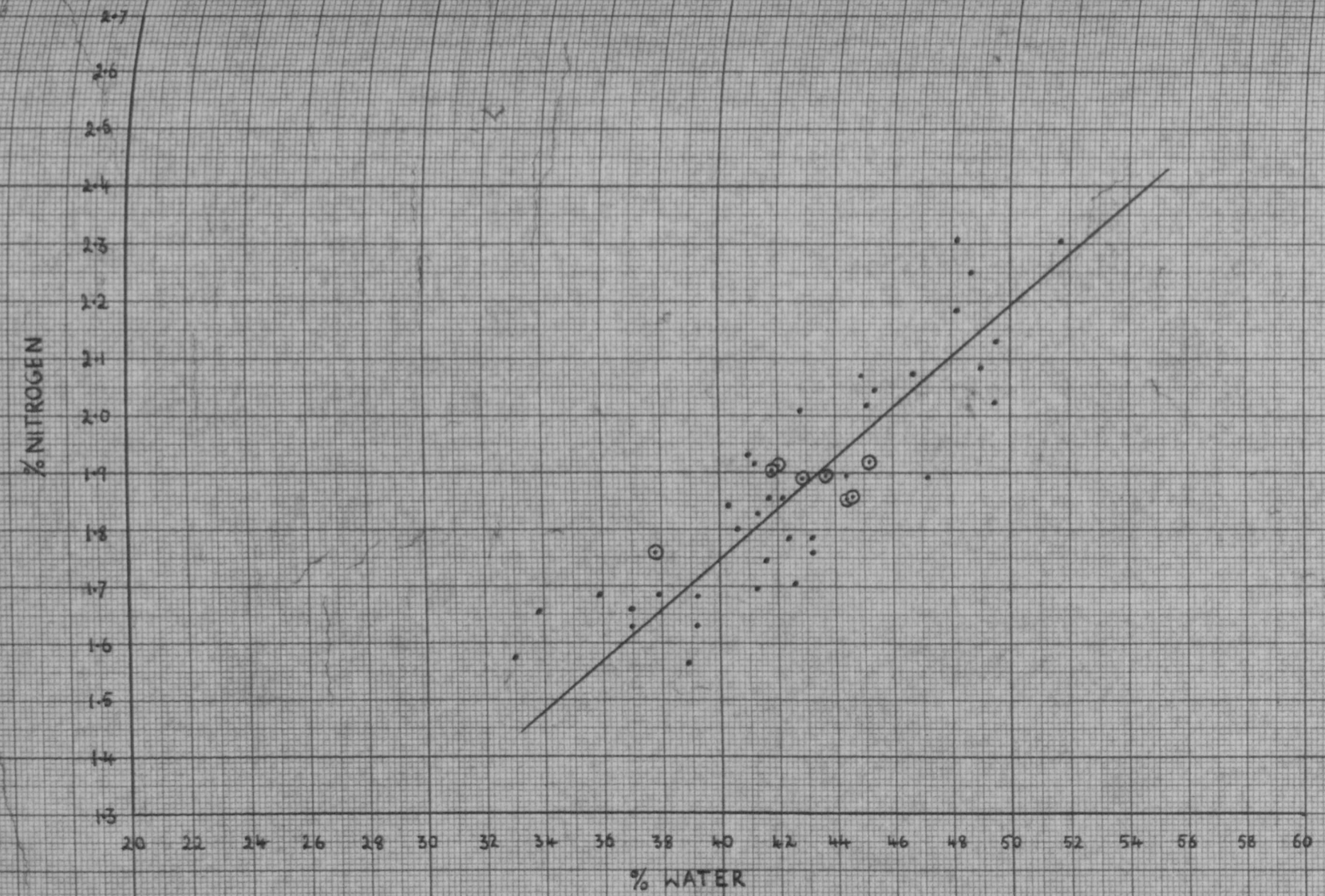

FIG. 8

AVERAGE NITROGEN CONTENT OF CARCASS AGAINST AVERAGE LIVE WEIGHT

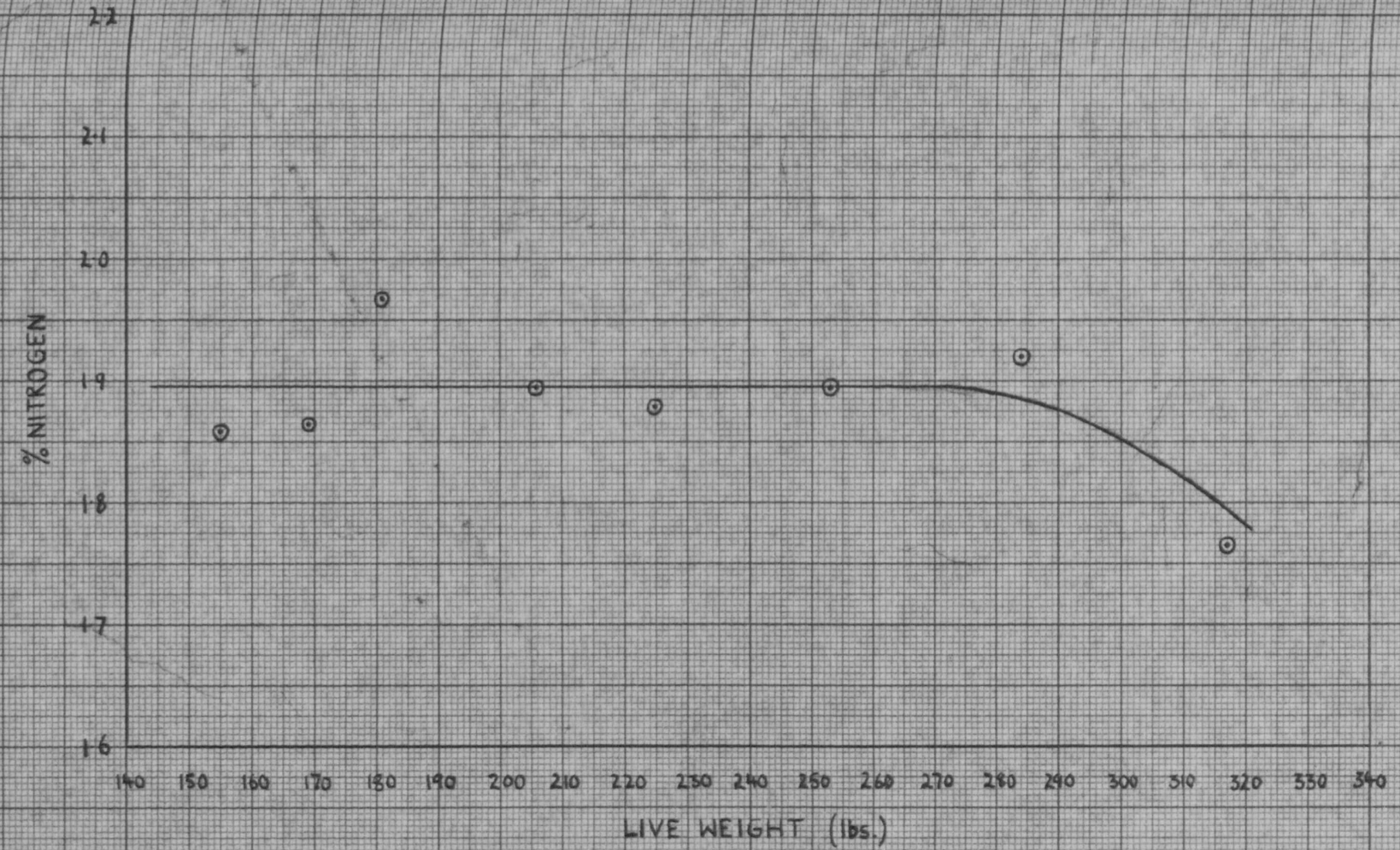

FIG. 9

WATER CONTENT OF CARCASS AGAINST LIVE WEIGHT

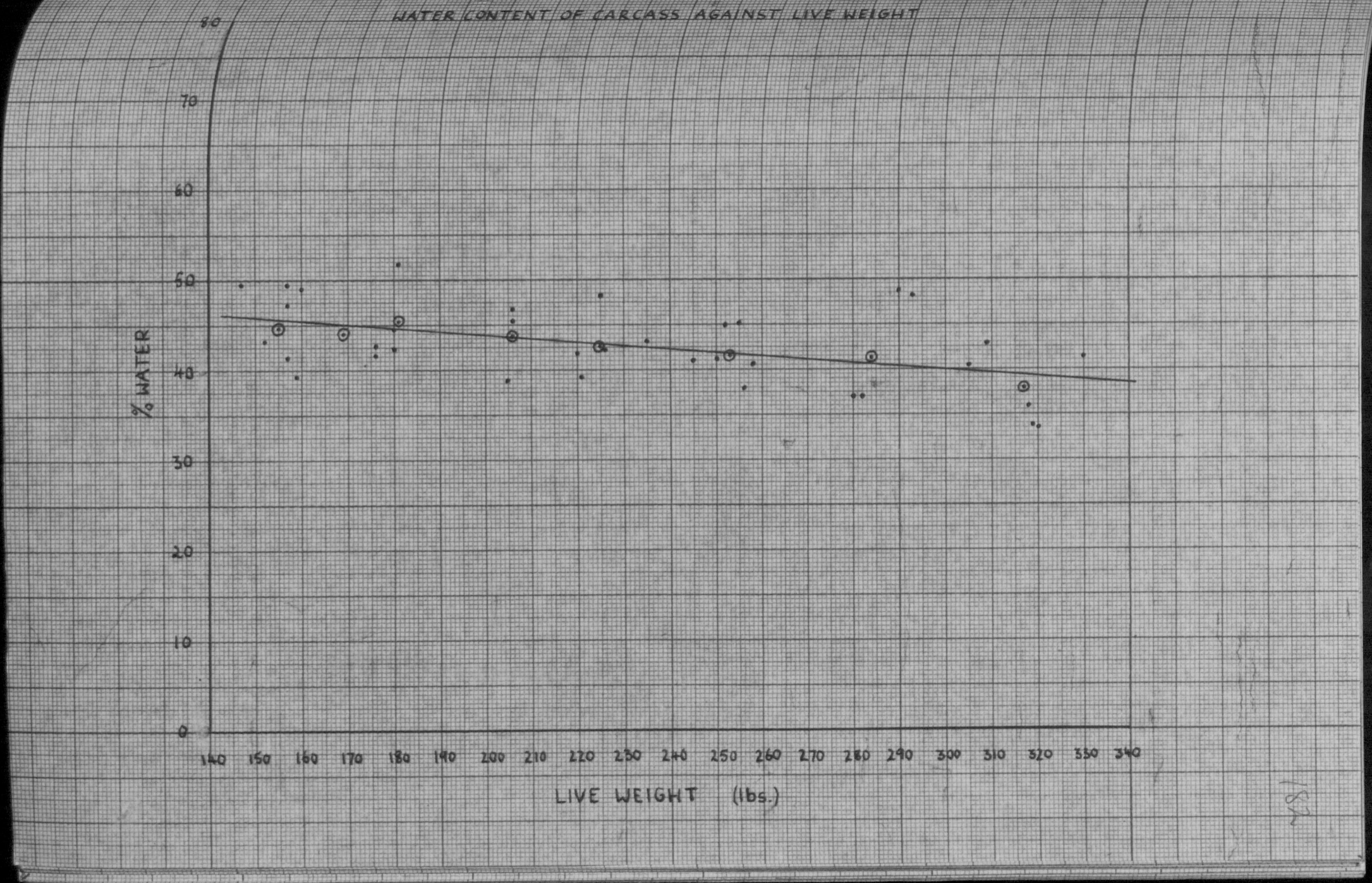

FIG. 10

NITROGEN CONTENT OF FAT FREE MEAT AND LIVE WEIGHT

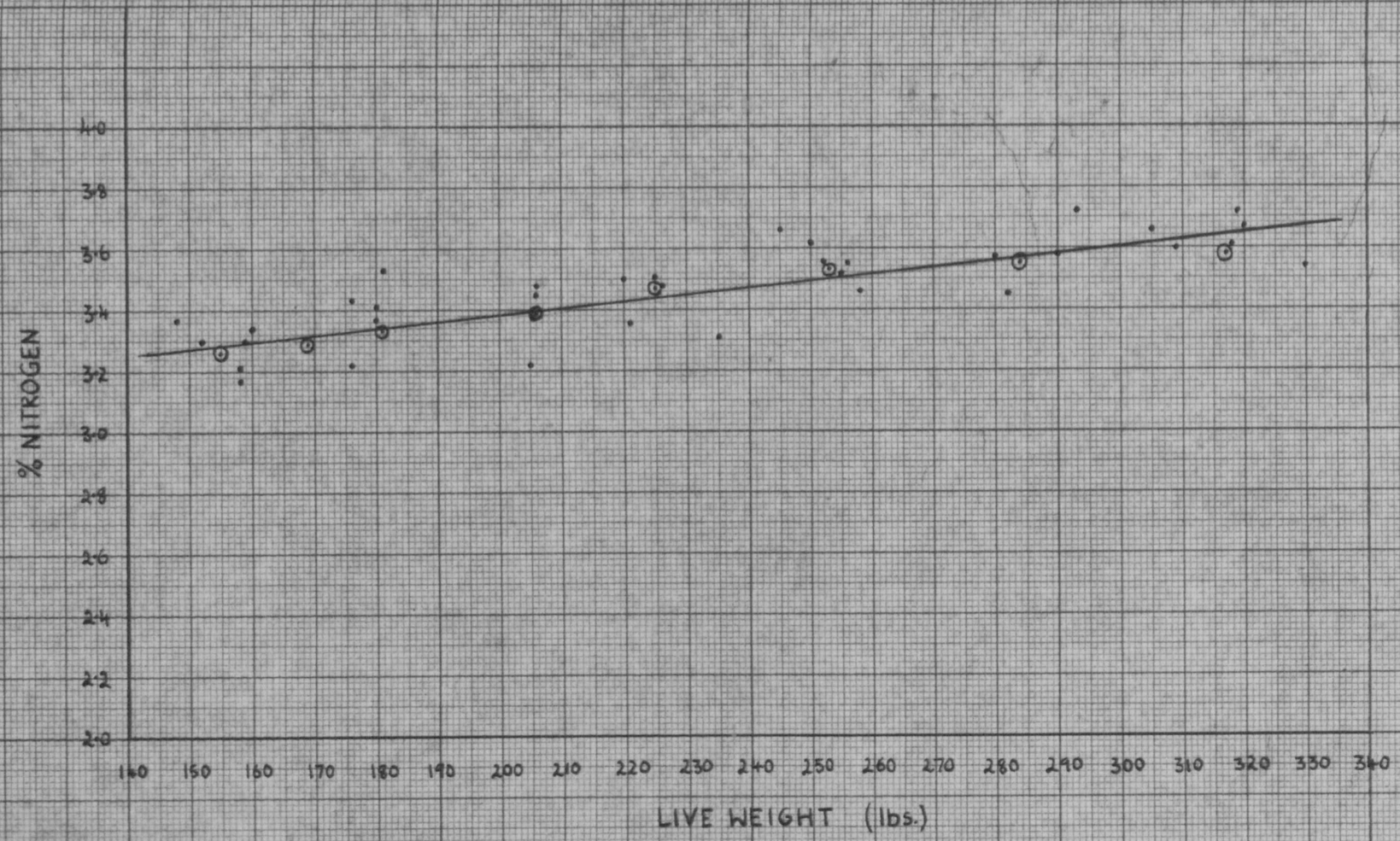

FIG. 11

WATER CONTENT OF FAT FREE MEAT AND LIVE WEIGHT

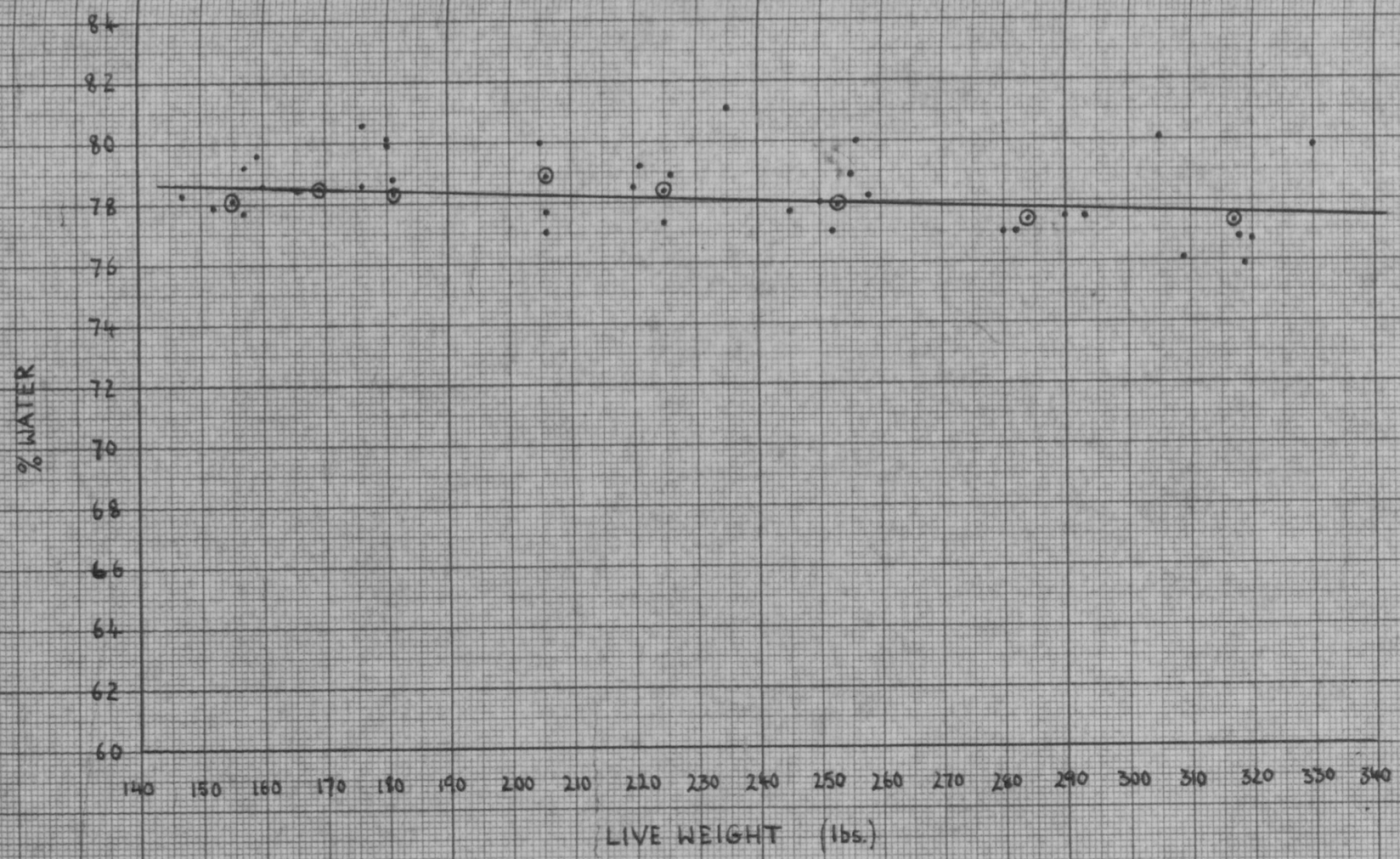

FIG. 12

NITROGEN CONTENT (FAT FREE) AND WATER CONTENT (FAT FREE)

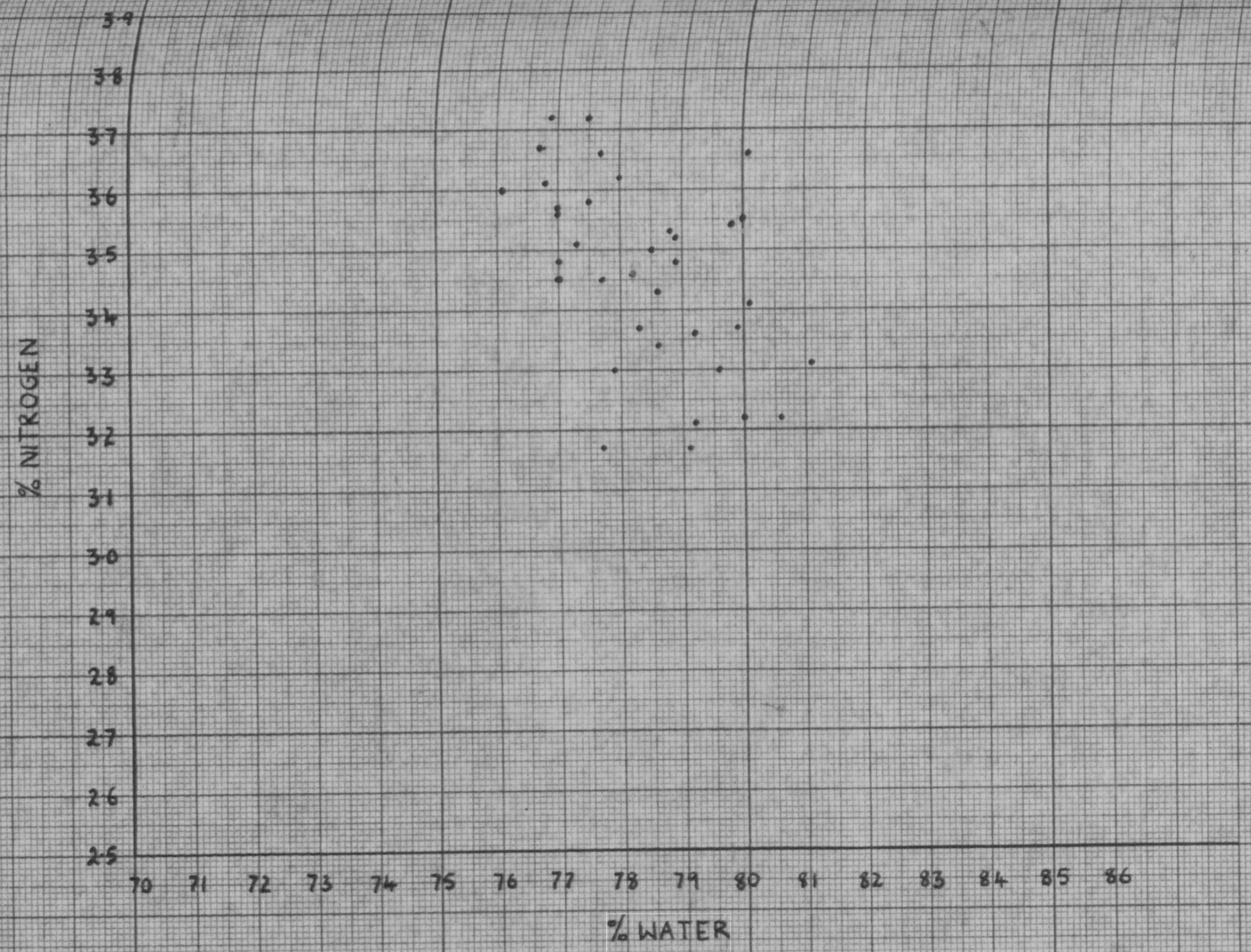

FIG. 13

FATTY TISSUE IN USEABLE MEAT

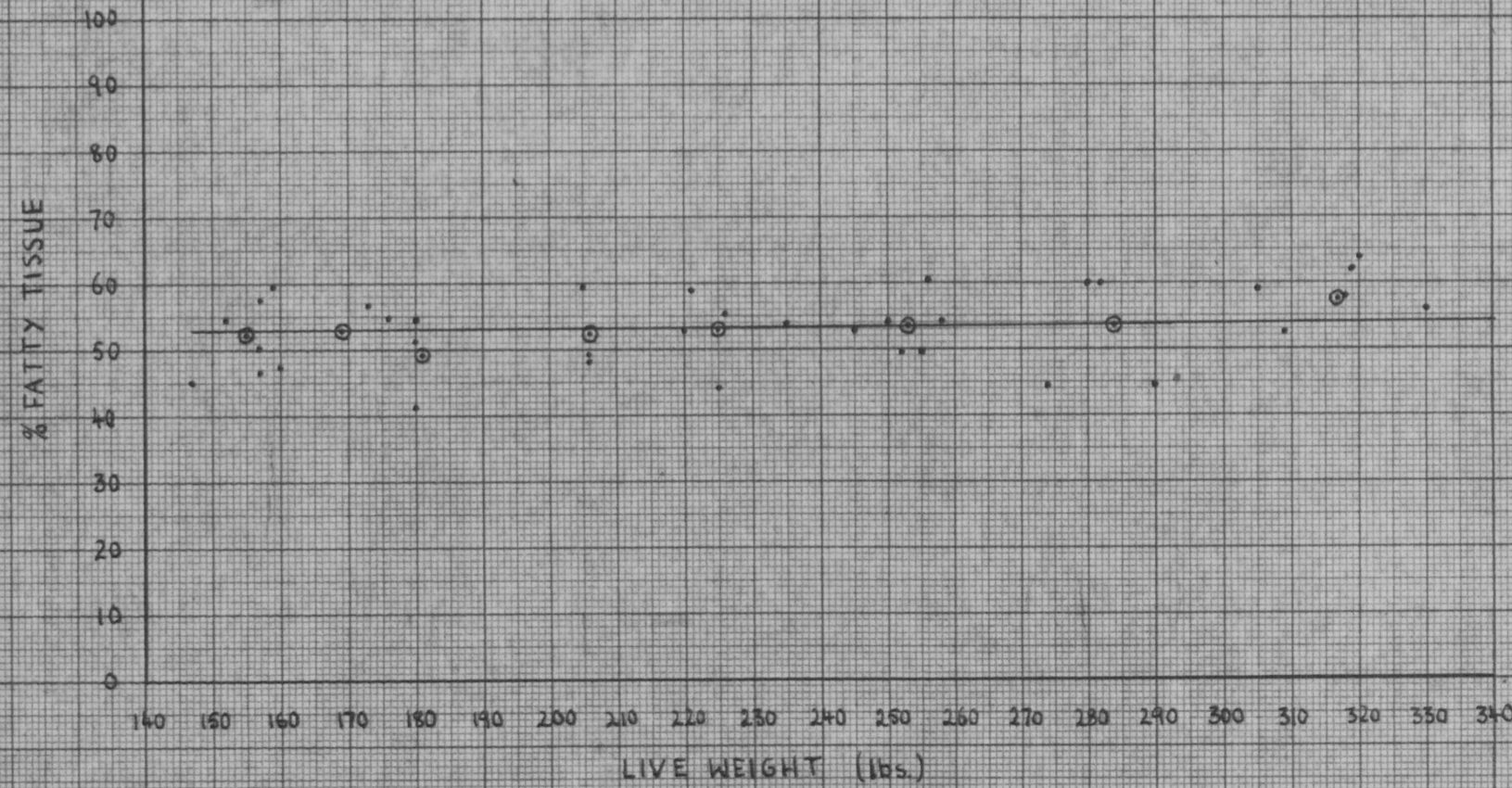

FIG. 14.

FAT CONTENT OF FATTY TISSUE

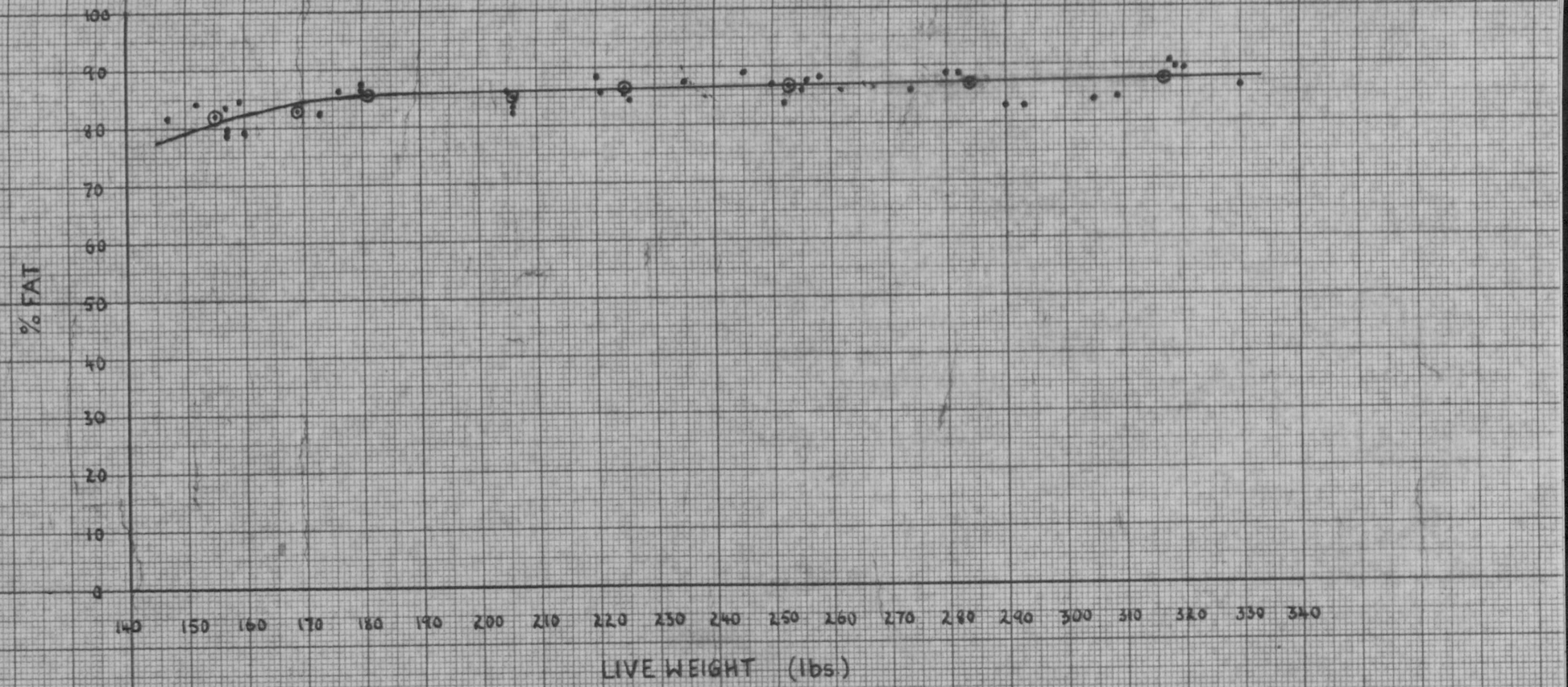

FIG. 15

CONNECTIVE TISSUE CONTENT OF FATTY TISSUE

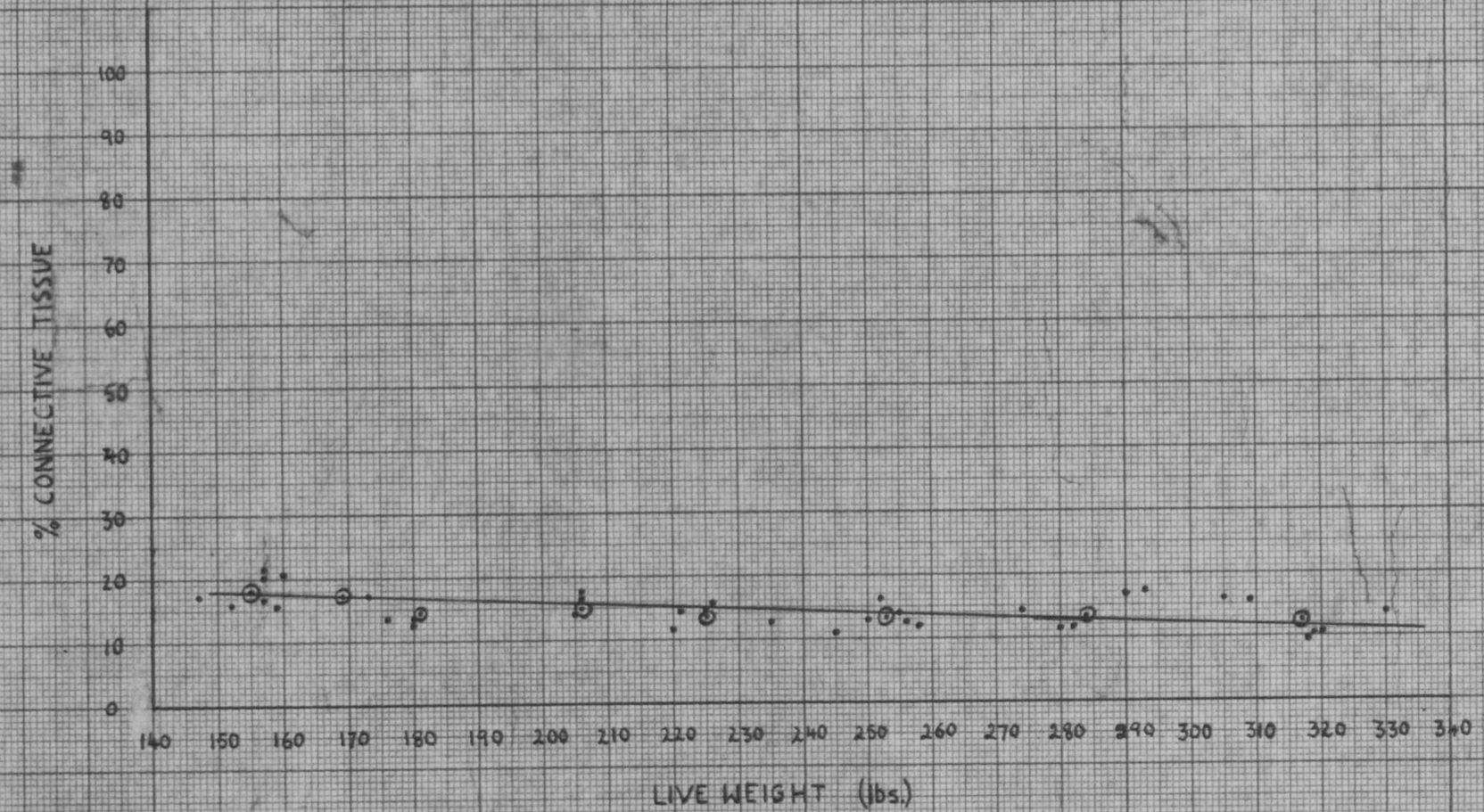

FIG. 16

NITROGEN CONTENT OF FATTY TISSUE

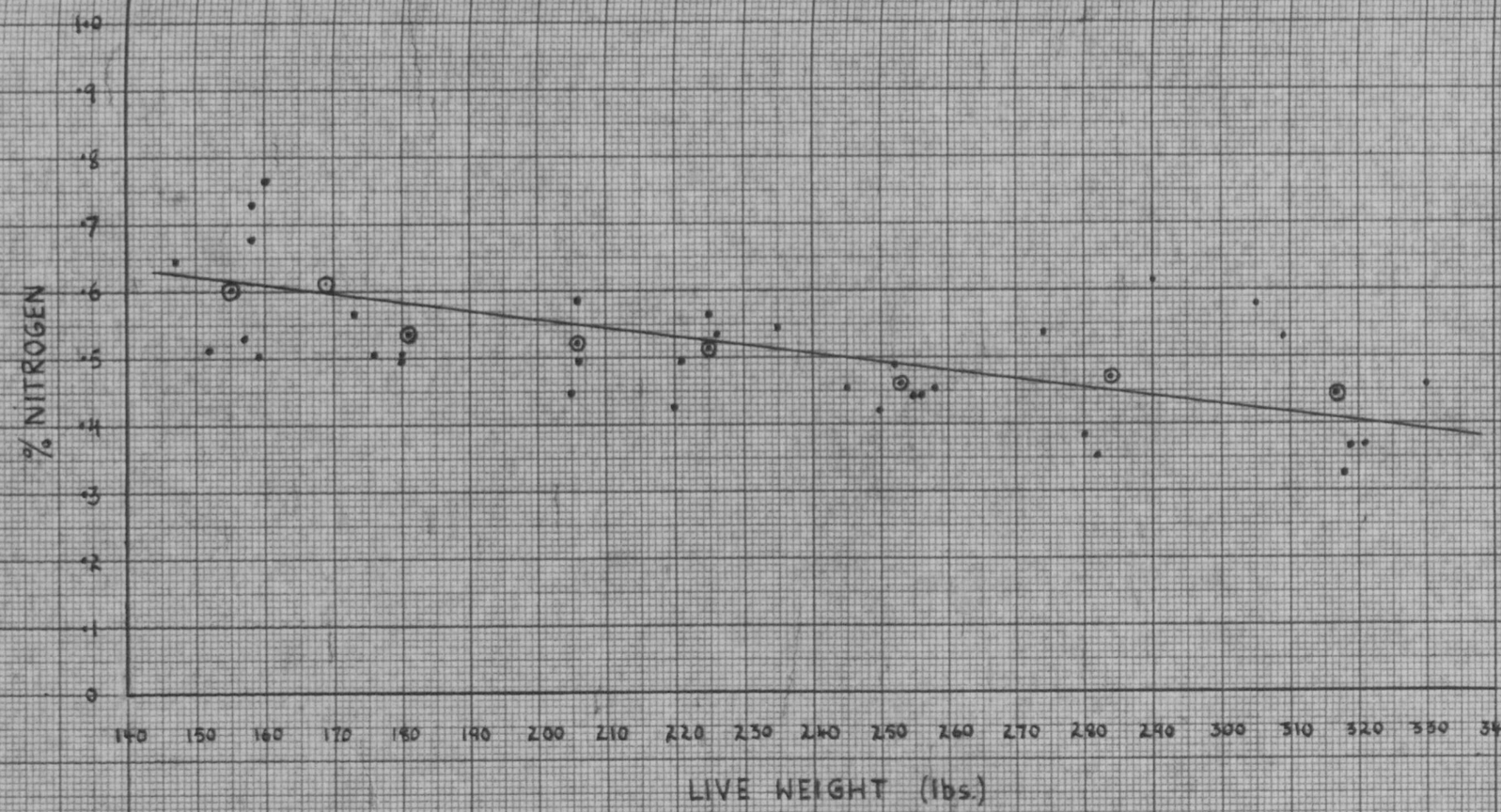

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FIG. 17

WATER CONTENT OF FATTY TISSUE

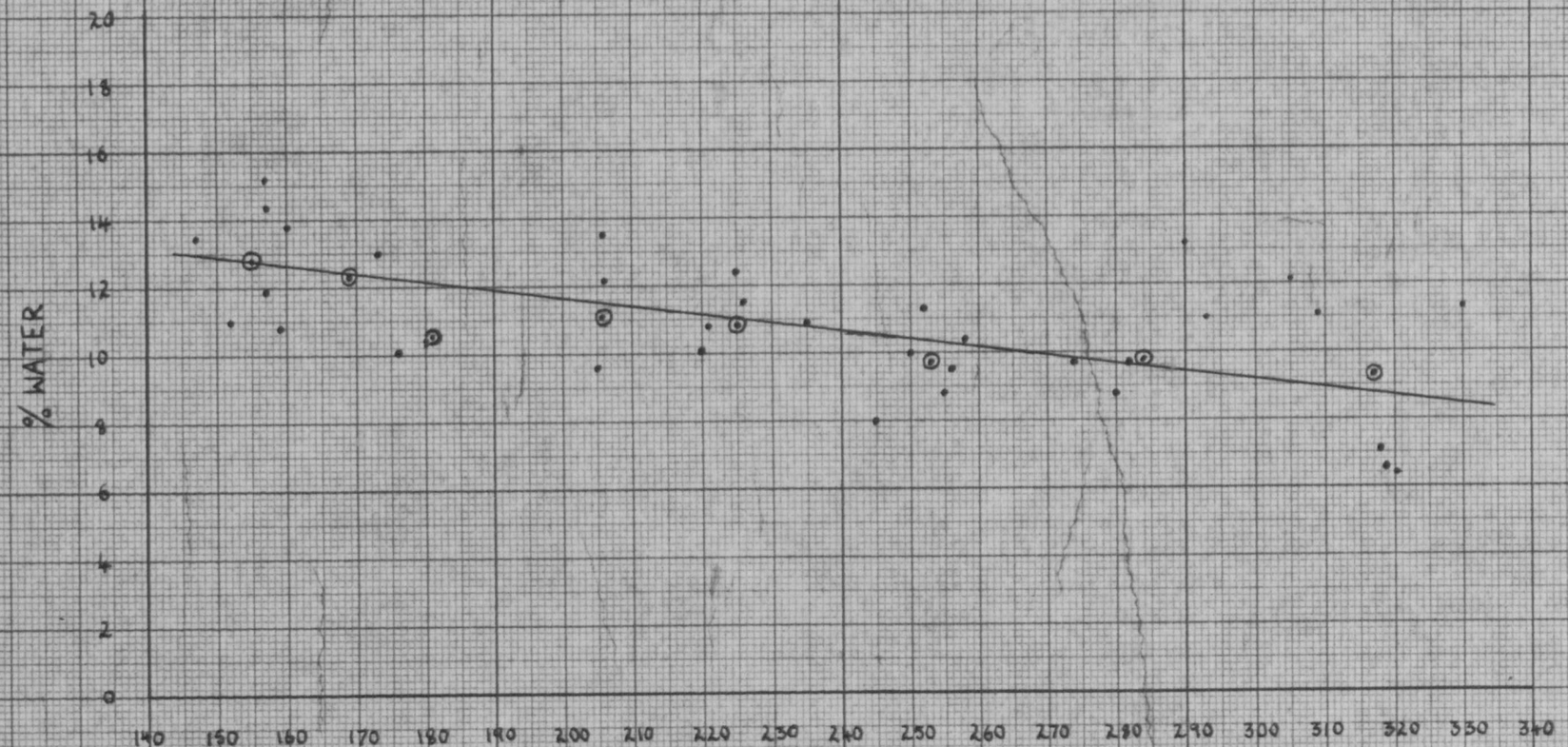
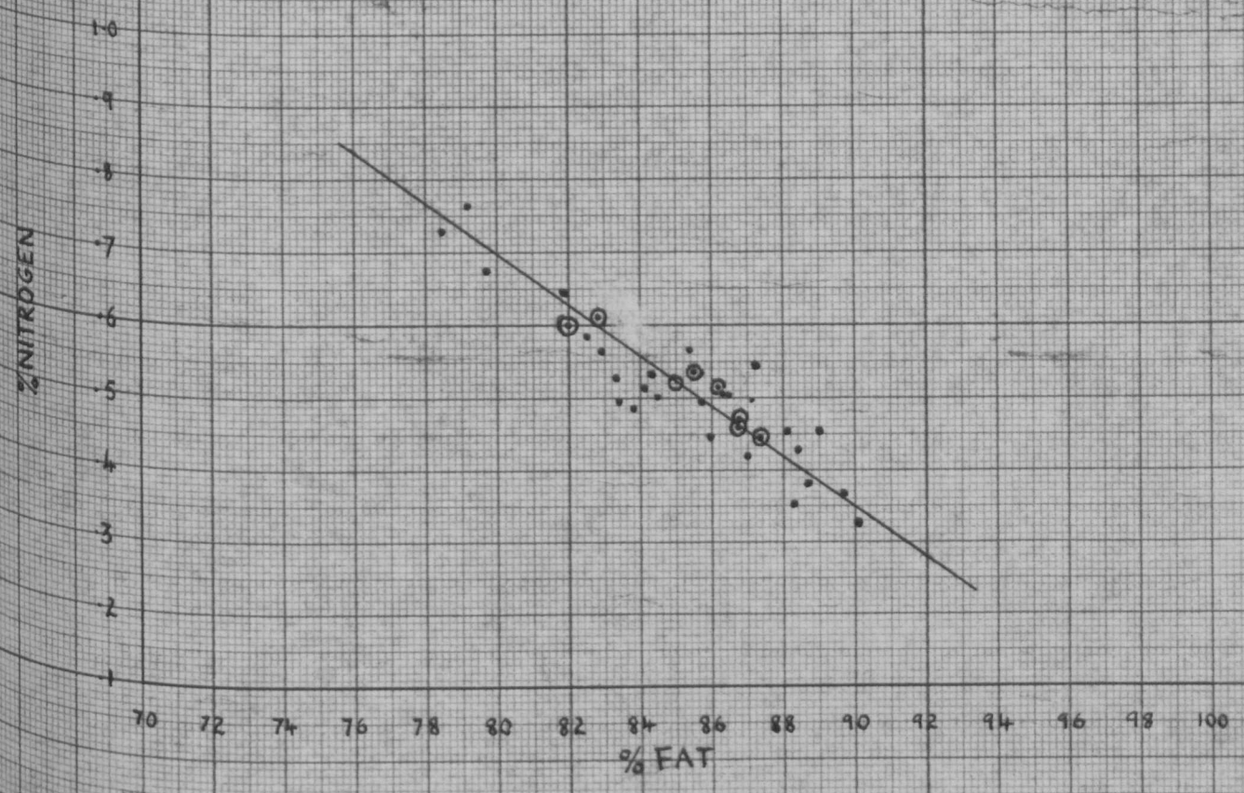


FIG. 18

RELATIONSHIP BETWEEN NITROGEN CONTENT AND FAT CONTENT IN FATTY TISSUE



RELATIONSHIP BETWEEN WATER CONTENT AND FAT CONTENT IN FATTY TISSUE

FIG. 19

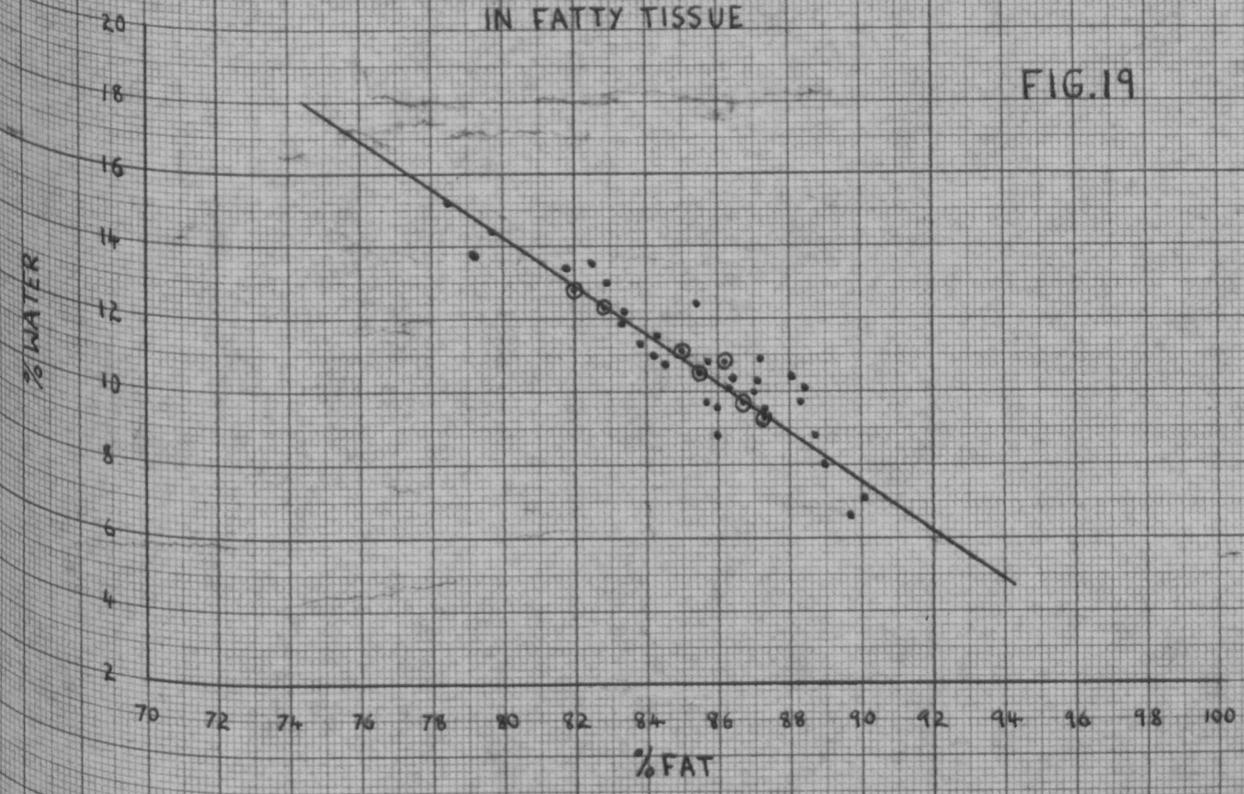
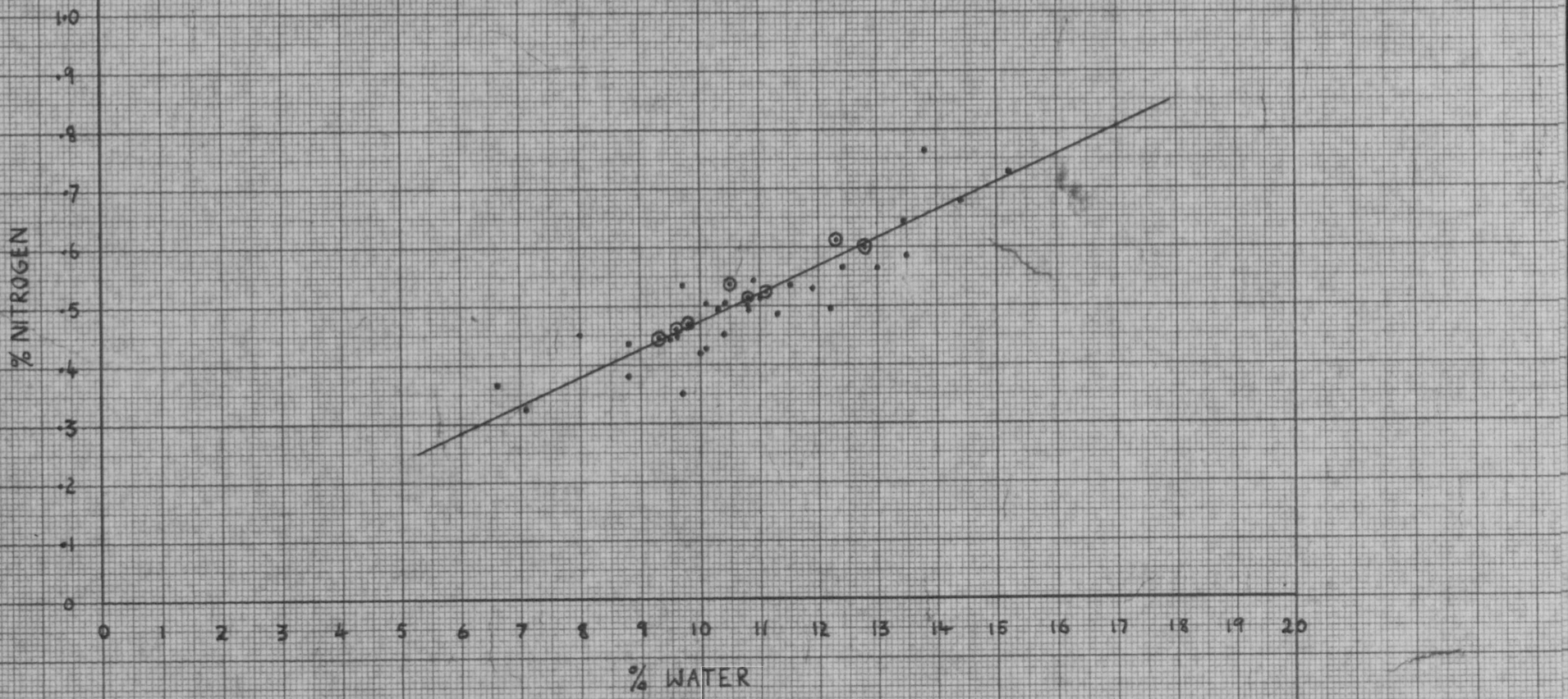


FIG. 20

RELATIONSHIP BETWEEN NITROGEN AND WATER CONTENT IN FATTY TISSUE



RELATIONSHIP BETWEEN NITROGEN CONTENT AND WATER CONTENT IN TRUE LEAN

FIG. 21

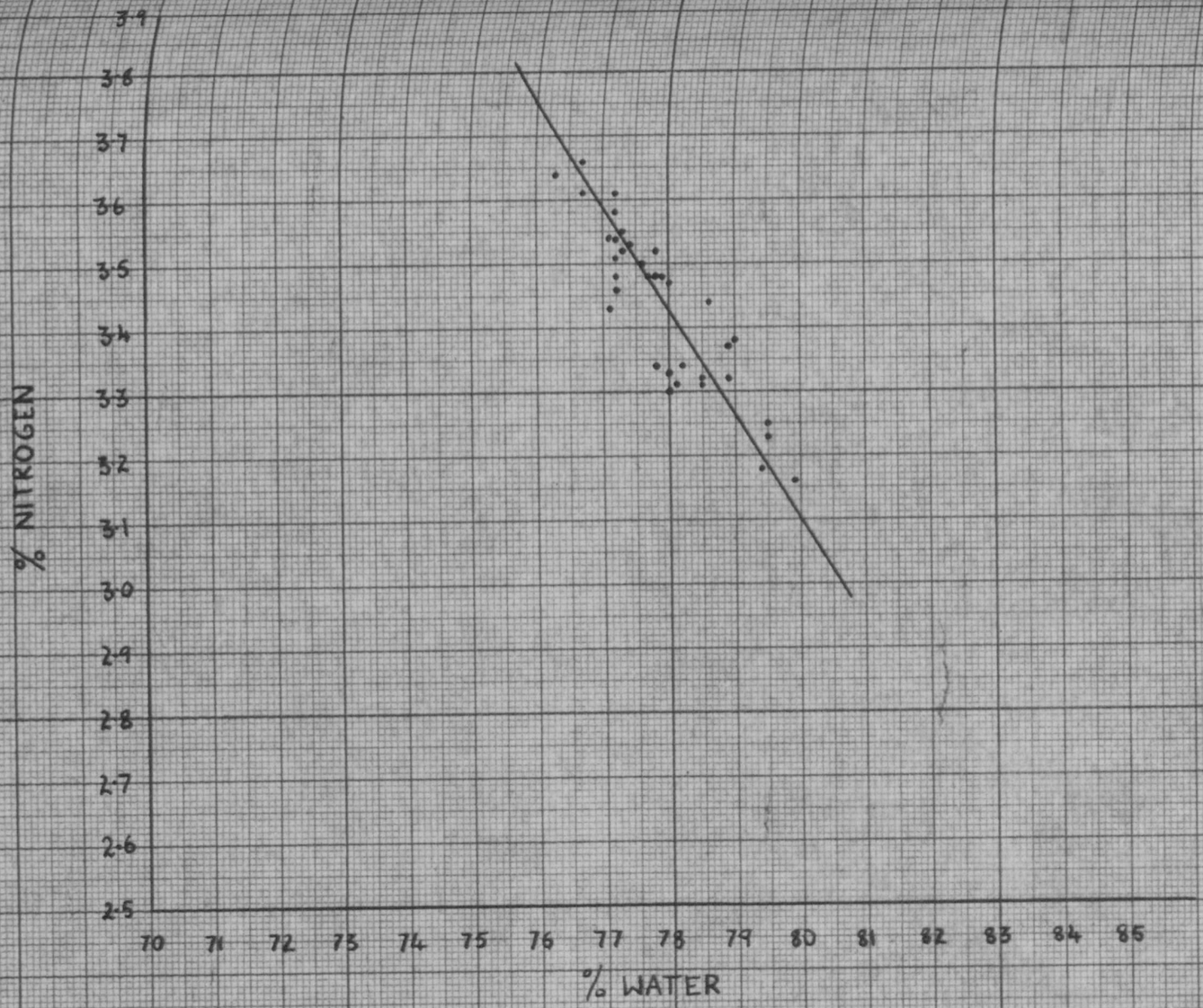


FIG. 22

NITROGEN CONTENT OF TRUE LEAN AGAINST LIVE WEIGHT

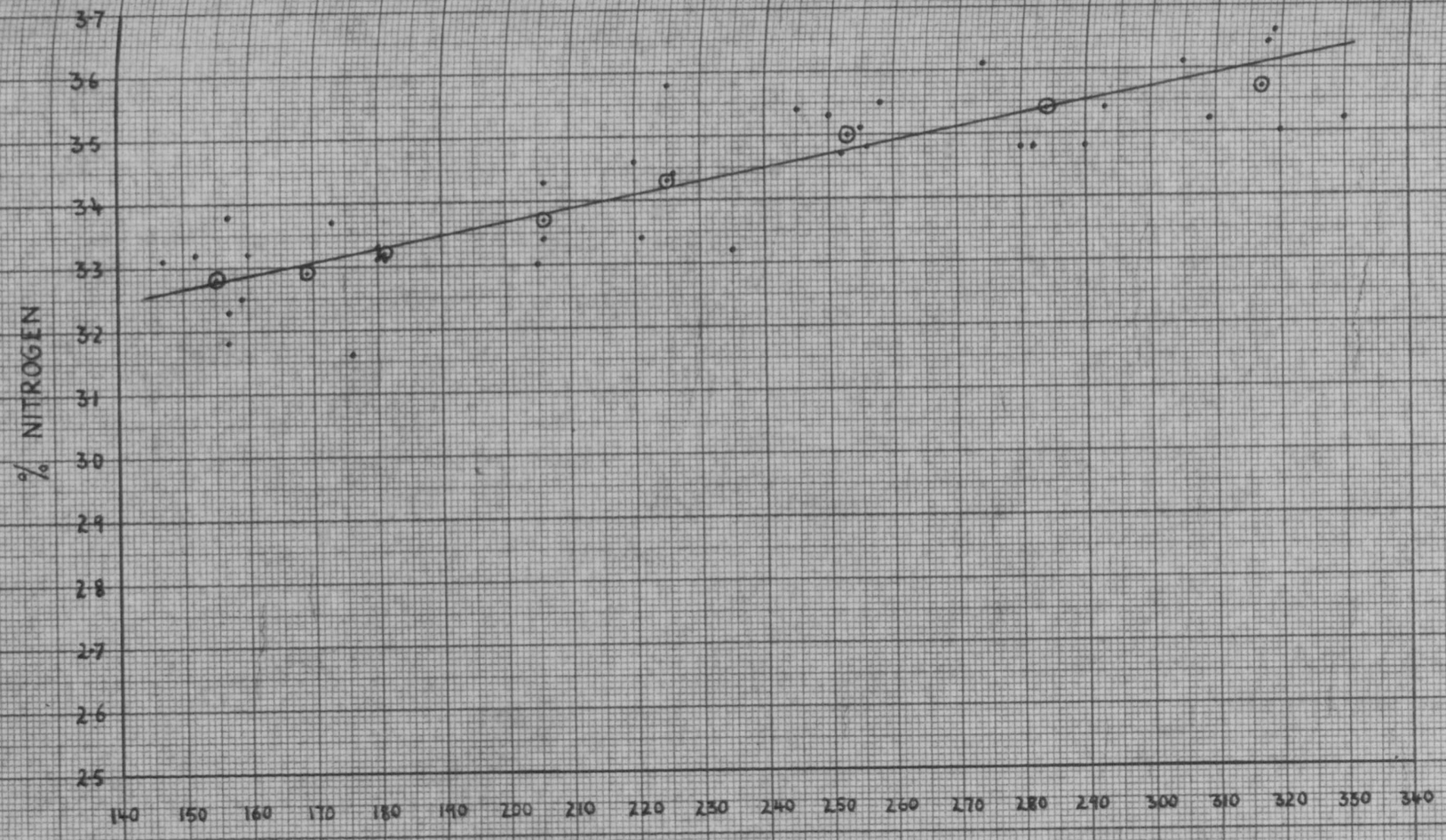
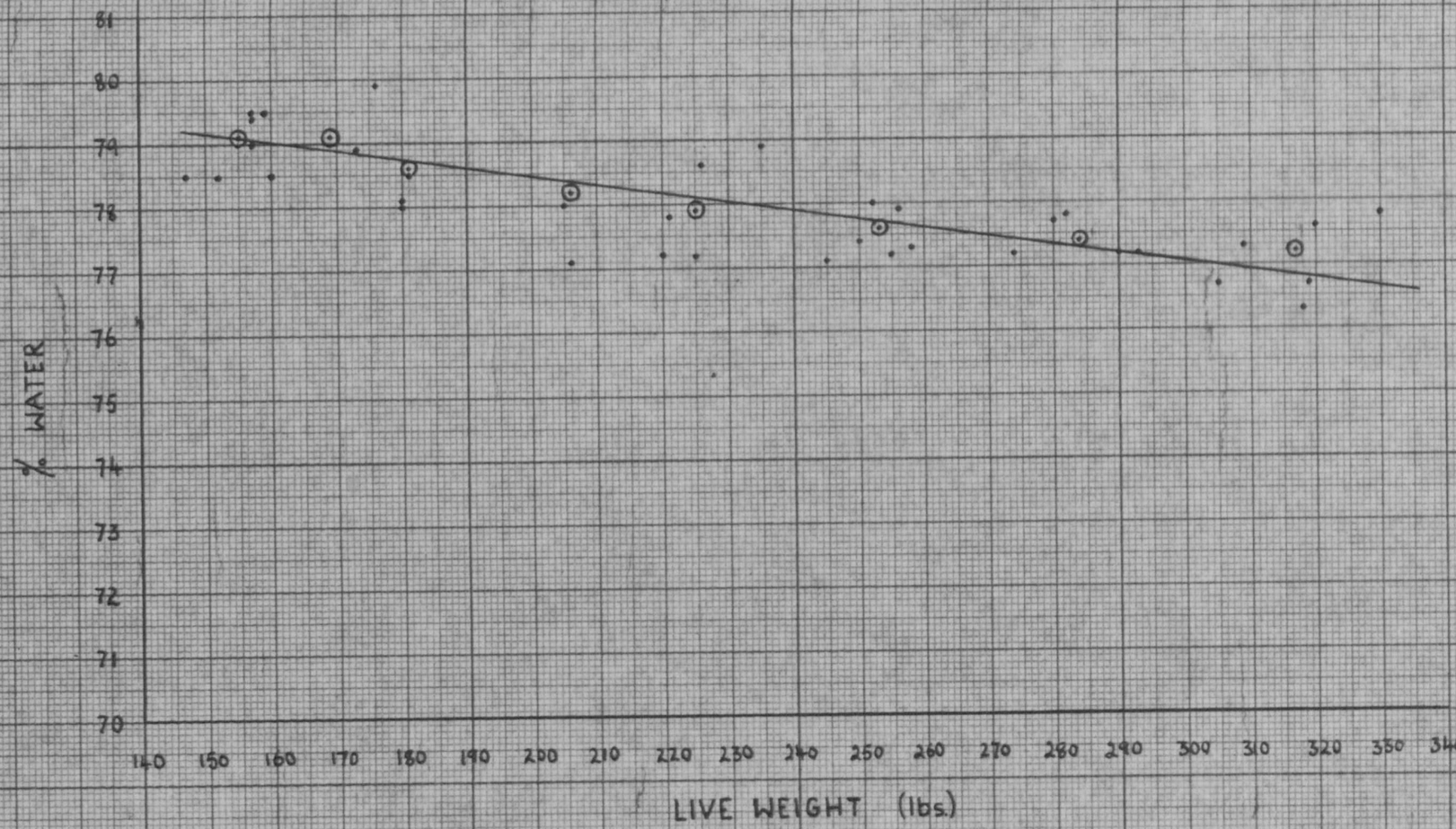


FIG. 23

WATER CONTENT OF TRUE LEAN AGAINST LIVE WEIGHT



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