THESIS

THE ALKALINE RESERVE OF DAIRY CATTLE UNDER ORDINARY FARM CONDITIONS

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[illegible] CONDITIONS.

THESIS.

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by
Russell E. [illegible]er

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THESIS

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INTRODUCTION.

The modern tendency in all lines of endeavor is greater efficiency. In an effort to secure more efficient production by the dairy cow she was taken from her natural home and placed under entirely different and artificial conditions.

The dairy cow in years gone by was required to get her feed from the grasses of the plains over which she was free to wander. Very seldom, if ever, did she receive any grain. Under these conditions existing as she was, for the most part on grasses which contain a large proportion of basic mineral matter, no mineral deficiency was felt.

But what of the present day cow that is kept in the barn for the greater part of the year and fed a ration entirely different from that received by her early ancestors? She receives considerable grain in her ration. The grain carrying, as it does, an excess of acid mineral matter in the ash is thought to cause a mineral deficiency especially among the higher producing cows.

A normal animal body has a neutral or slightly alkaline reaction that is maintained by buffer minerals found in the blood stream. It is entirely possible since these buffer materials are principally composed of alkaline minerals that a diet of grains, carrying an excess of acid minerals in the ash, would cause a change in the buffer value of the blood.

If a very decided change occurs in the buffer value of the blood the physiological functions of the body are

upset and unless such changes are remidied the animal dies.

Minor changes in the alkaline reserve are thought to cause a lowered vitality and a lessened resistance to disease. It is possible that many of the present day diseases of dairy cattle on the farms might be prevented or controlled by the regulation of the alkaline reserve.

As the level of the alkaline reserve of the blood of dairy animals under ordinary farm conditions was not known a study was undertaken in an effort to determine this.

GENERAL DISCUSSION AND REVIEW OF LITERATURE

General Discussion of Alkaline Reserve

The animal body must be maintained in a neutral or slightly alkaline condition. This is accomplished by the presence of minerals which neutralize the acids produced during the normal digestion and metabolism. This neutralization is accomplished, for the most part, by certain buffer minerals in the blood stream that comprize the alkaline reserve.

These buffer minerals are believed by Von Noorden(1) to give the blood an alkaline reaction. Farkas (2), however is of the opinion that blood is a neutral fluid. Either belief is satisfactory as they show that unless some material is present for the neutralization of acids thrown into the blood stream the reaction would become acid. Such a change in reaction of the blood would be followed by death.

It is not known whether the dairy cow under ordinary farm conditions is able to maintain the mineral matter of the blood at a point which is conducive to the proper physiological functioning.

Nature does however, generally provide the blood stream with sufficient minerals to maintain the reaction at the proper level. The minerals that accomplish this according to M.Lecanu (3) whose work appeared in 1831 are as follows:

Constituent	Parts per thousand
Chloruet of potassium Alkaline sub carbonates	8.370
Albumin combines with soda	1.865
Phosphates of Ca., Mg., & Fe. Sub Carbonates of Ca. & Mg. Peroxide of iron	2.100

This analysis shows that some of the alkaline minerals of the body are foundin the blood stream.

However not all the minerals of the body are found in the blood.The total minerals of the body as shown by the analysis of Sherman (4) is about 4 per cent. The blood according to Mathews (5) contains from 1 - 2 per cent inorganic constituents. This mineral content was found by Schmidt (6) a German investigator who analyzed the inorganic content of blood and blood serum to be as follows:

Constituent	Parts per thousand Blood	Serum
Total ash	8.750	8.570
CO_2	trace	trace
SO_3	0.662	0.130
P_2O_5	0.772	0,467
Cl	2,139	3.565
K_2O	2.523	0.382
Na_2O	2.109	4.636

Constituent	Parts per thousand Blood	Serum
CaO	0.708	0.163
MgO	0.046	0.036
Fe_2O_3	0.714	0.000

It is apparent that the blood contains a certain amount of mineral matter a majority of which is of a basic nature, although some of it is acid.

The excess of base left, after all the involatile acids have been counteracted, to neutralize other acids that might be thrown into the blood stream is termed by Van Slyke (7) as the alkaline reserve. This reserve is necessary to give the body fluids the proper reaction. The reaction of the blood was found by Lugsgvard (8) to be very constant due to the presence of the excess of basic material called the alkaline reserve.

Mathews (9) believes that the maintenance of the blood at a definite hydrogen ion concentration is dependent upon the ability of the bicarbonate and other alkali of the blood to neutralize the acids produced during digestion and metabolism that are thrown into the blood stream. Sherman(10) indicates that the carbon dioxide holding capacity of the blood can be used as an index of the bicarbonates and other alkaline materials that comprise the alkaline reserve.

All the minerals of the blood as shown by the analysis of Schmidt do not form a part of the alkaline reserve.

Hammarstein (11) states that all the alkali of the blood exists either as alkaline salts, carbonates or phosphates, or in combination with protein or haemoglobin, make up the alkaline reserve. To Van Slyke (12) the alkaline reserve is the maximum available alkali of the blood plus that portion of the other buffers that are used when the hydrogen ion concentration is reduced to a point near the minimum compatible with human life.

Most of the authorities agree with Von Noorden(13) when he states that there are three types of bodies to be considered in the studying of the reaction of the blood.

1. The mineral constituents.

2.The volatile organic acids of the blood.

3. The buffer value of bodies., as albumins.

Mc Marriott (14) says that the alkaline reserve is composed of the carbonates, alkaline proteins and small quantities of phosphates.

The alkaline proteins acts as "buffers." A buffer is the name applied, according to Hawk (15), to the sodium phosphate and the sodium bicarbonate of the blood in view of their protective role in preventing pronounced changes in the reaction of the blood following the introduction of an acid or alkali into the blood stream.

Levy and Fountree (16) give a similiar definition of a buffer, saying that by buffer action is meant the ability of a substance to take up alkali or acid without an appreciable

change in hydrogen ion concentration. The buffer value of the blood is dependent upon the amount of carbonates and phosphates present and to a lesser degree the content of alkaline protein.

Although there is no appreciable change in the reaction of the blood the alkaline reserve is being continually used up to neutralize the acid material thrown into the blood stream. Unless it is replenished death is bound to occur. Mc Marriott (17) says that the alkaline reserve is replenished by three different methods:

1. The administration of alkalies.
2. Administration of foods with an alkaline ash.
3. The body itself replenishes by:
    a. Ammonia
    b. Selective excretion by the kidneys.

It is evident that the alkaline reserve is made up of two main factors:

1. Mineral salts.
2. Alkaline proteins.

The mineral salts form by far the greater portion of the reserve and are the first to be depleted. The alkaline proteins are called into use only when the mineral salts have been reduced to a level where the life of the organism is in danger. It is then that the proteins act as buffers and take up the acids without further change in reaction. Naturally if the acids continue to pour into the blood stream, the

buffer action of the protein will all be used up and the reaction of the blood will then change. Unless some relief is given, the animal will die following this change in reaction.

The mineral salts since they play the most important part in the alkaline reserve can be taken as an index of the alkaline reserve. We consider the buffer action of the alkaline proteins to be constant but not usable until the mineral reserve has been lowered to the danger point.

Therefore the alkaline reserve can be defined as the reserve mineral matter in the blood available for the neutralization of acids and to maintain body neutrality.

Method of Determining the Alkaline Reserve

The Van Slyke Method

The Van Slyke method (18) is now universally used for the estimation of the alkaline reserve of the blood. This method consists of the acidifying of a known amount of blood serum with an acid and then measuring the carbon dioxide liberated. This volume of carbon dioxide reduced to values for one cc of serum is termed the alkaline reserve.

As early as 1885 Walther (19) a German investigator determined the amount of carbon dioxide in venous blood and thought it all to be in combination with the alkaline mineral content of the blood.

The work of Walther was followed by that of Haldine and Barcroft (20) in which they measured the gas pressure

resulting from the addition of acid to blood in an enclosed chamber. Dibbelt (21) in 1909 treated 5 cc of blood with 10 cc of oxalic acid and conducted the liberated carbon dioxide through barium hydroxide producing barium carbonate The amount of barium carbonate thus formed was measured by titration. As this method was long and required very accurate technic it was not very widely used.

According to Van Slyke (22) an attempt was made to determine the alkaline reserve by extracting the carbon dioxide from a water solution but found that as soon as the pressure was allowed to come back to normal the carbon dioxide was resorbed. It became obvious that some change must be made by which they could remove the carbon dioxide under diminished pressure and collect it in a separate chamber where it could be measured. This modification was perfected by Abderhalden (23),which method required complicated apparatus and took considerable time due to the excessive foaming of the blood.

The Abderhalden method of estimating the alkaline reserve was used but very little, because of the complicated apparatus required. It was replaced by the method of Haldine and Barcroft which is more simple and does not require as complicated as apparatus.

Swanson and Hulett (24) demonstrated that equilibrium could be quickly and easily obtained by using low pressure and not attempting to make the extraction complete but using a solubility table of the gas in the

liquid. By this method the determinations could be made very rapidly. However Swanson and Hulett prevented the resorption by transferring the gases to a burette without releasing the partial vacuum. The amount of carbon dioxide in the burette could be easily measured from which the alkaline reserve could be estimated.

In order to simplify the process and make the entire process possible in one apparatus Van Slyke (25) devised an apparatus that permitted the removing of the water rather that the gas from the chamber after the extraction was complete. The gas is then free to be measured in a calibrated tube over mercury. The calibrated tube was located at the top of the extraction chamber.

The Van Slyke apparatus as shown in Figure 1 was especially designed in proportions adaptable to the determination of the carbon dioxide in the blood plasma. It consists of a 50 cc pipette with three way stop cocks at top and bottom, a one cc scale on the upper stem divided into .02 cc divisions. At the bottom the apparatus is connected with a leveling bulb filled with mercury. The chamber (d) serves to draw off the solution after the carbon dioxide has been removed, the other lower connection (c) serving for the subsequent release of the vacuum by the entrance of the mercury. The capilliary (a) is used for the convenient removal of the solutions from the apparatus. Three hooks at levels 1,2, and 3 serve to hold the leveling

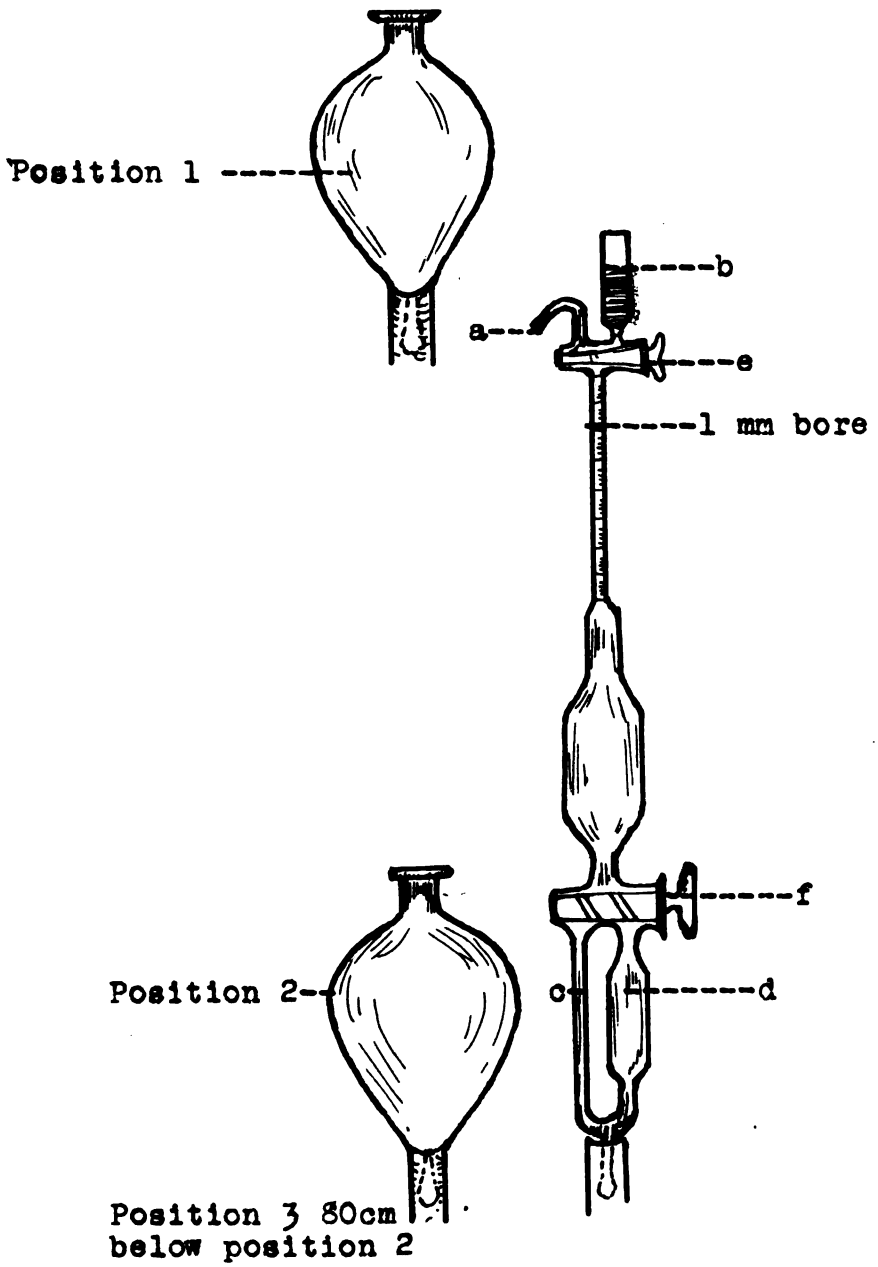

Figure 1 Van Slyke Apparatus

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bulb at the different stages of the analysis.

The apparatus is constructed of heavy glass. At the present time it is fastened to a back ground which gives it more rigidity and tends to reduce breakage.

The stop cocks (f) and (e) should be well greased and held in place by rubber bands or fine wire springs.The function of the rubber bands or wire springs is to prevent the mercury from forcing the stop cocks out.

Wm. Slyke outlines the use of the apparatus as follows:

Outline:

Briefly stated, the 50 cc pipette of the apparatus being full of mercury,the solution to be analyzed is acidified within the pipette,the total volume being admitted is preferably 2.5 cc.. A Torricellian vacuum is then obtained in the pipette by the lowering of the leveling bulb. The carbon dioxide is extracted from the plasma by a half minutes shaking in the evacuated chamber and the water is drawn out of the 50 cc chamber into (d). Mercury is then readmitted through (c) and the volume of gas is read at atmospheric pressure in the finely divided upper stem of the pipette.

Testing the Apparatus:

Before the determination is made, the entire apparatus, including the capillaries are filled with mercury. To test the apparatus for tightness and freedom from gases the mercury bulb is lowered to position (3) so that a Torricellian

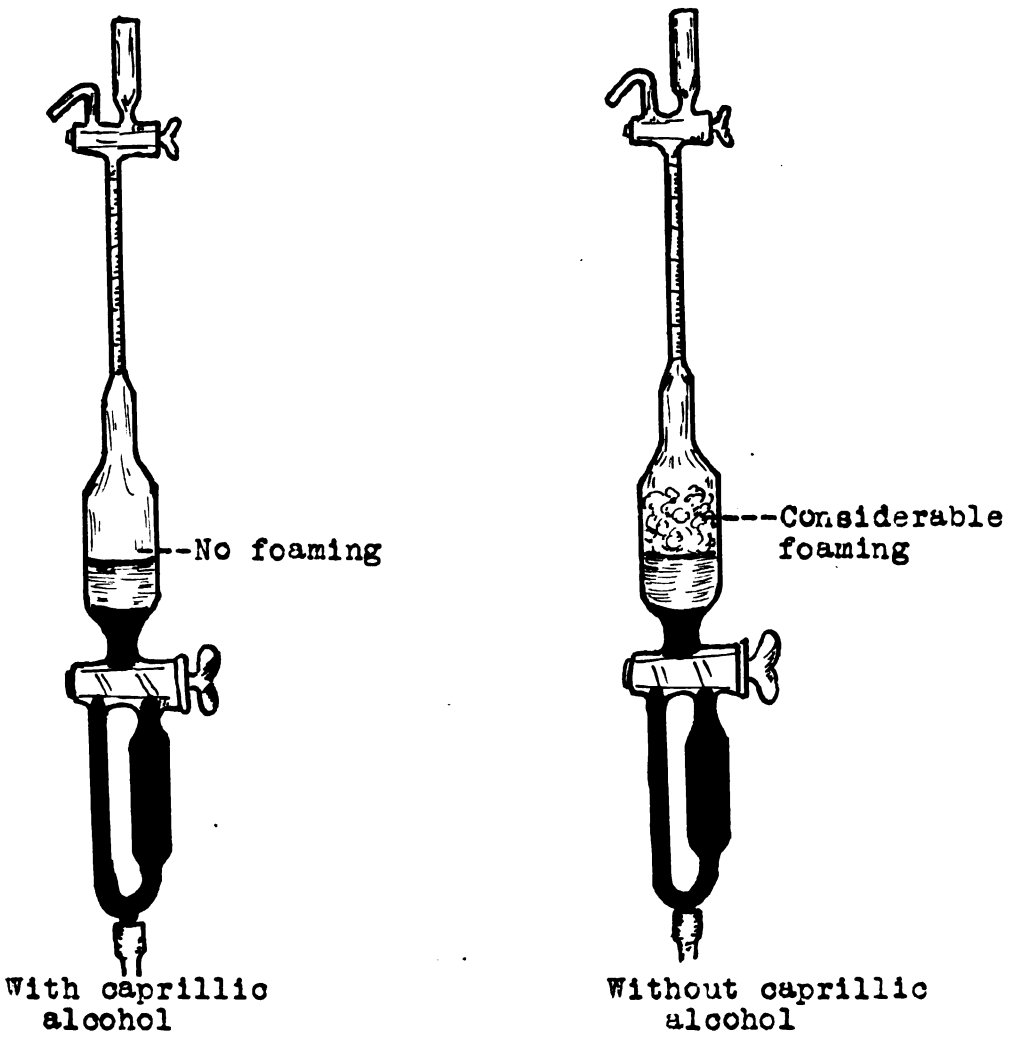

Figure 1A Drawing showing the effect of caprillic alcohol.

vacuum is obtained, the mercury falling to about the middle of (d). The leveling bulb is again raised. If the apparatus is tight and gas-free the mercury will refill it completely and strike the upper cock with a sharp click. In case there is any gas in the apparatus it serves as a cushion; the click is not heard; and a bubble remains above the mercury. If this is the case, the apparatus must be repeatedly evacuated until all the gas has been removed. Before the apparatus has been used, the rubber tubing, and even the glass walls, hold measureable amounts of gases, which are given off when the apparatus is evacuated. After it has once been freed from these gases, however, it can be used indefinitely without further trouble from this source if no air is admitted again. It is desirable, nevertheless before making the first determination, to test the apparatus as above described.

Determination:

The apparatus, including both the capillaries are filled with mercury, and the cup at the top is washed free of acid with carbonate free ammonia. The solution, plasma, is then run from the pipette into the cup. The plasma may contain some free carbonic acid as well as the carbonate and in this case it is necessary to dip the point of the needle below the surface of the solution in the cup during the transfer. If the liquid was allowed to run through the air in a free stream the free carbon dioxide would escape from it. The

apparatus is designed to take most conveniently 1 cc of solution, however, satisfactory results may be obtained by using larger or smaller amounts. With the mercury bulb at position (2) and the cock (f) in the position shown in the figure, the solution is admitted from the cup into the 50 cc chamber, leaving just enough above the cock to fill the capillary (b). The cup is washed twice into the pipette with about .5 cc water each time and finally .5 cc of 5% sulphuric acid is added. In plasma analysis a small drop of caprillic alcohol to prevent foaming should precede the acid.

It is not necessary that exactly 1 cc of each water be used or that .5 cc of acid. After each portion of water or acid is added enough is left in the capillary tube to prevent the entry of air. After the acid is added it is a good plan to place a drop of mercury in the capillary tube, this insures an air tight apparatus.

After all the solutions are in the pipette the upper cock being closed and sealed with mercury, the bulb is lowered to a position (3) and the mercury in the pipette is allowed to run down to the 50 cc mark, producing a Torricellian vacuum in the apparatus. When the mercury meniscus has fallen to a 50 cc mark, the lower cock is closed and the pipette is removed from the clamp. Equilibrium of the carbon dioxide between the 2.5 cc liquid and the 47.5 cc air is then obtained by turning the pipette upside down 25 or more times,

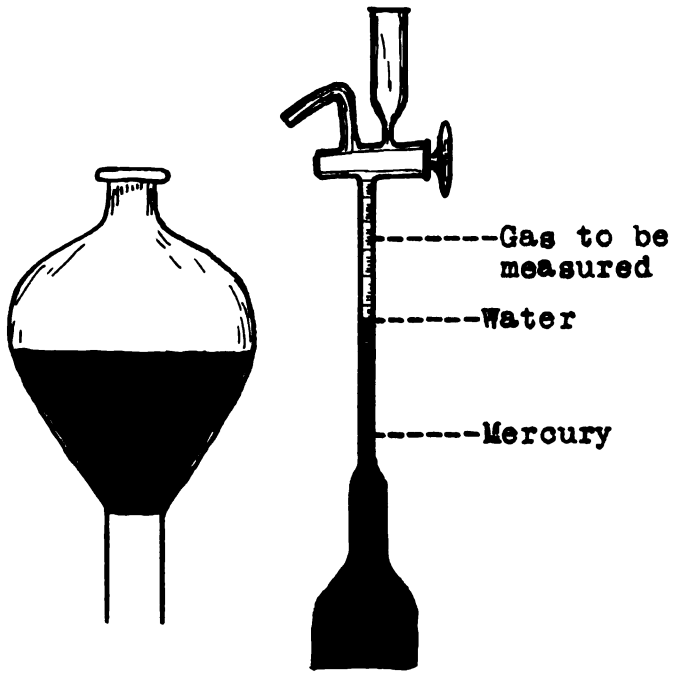

Figure 2 Showing the position of the leveling bulb when reading the volume of the gas.
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thus thoroughly agitating the contents. The pipette is then replaced in the clamp.

By turning the lower cock the water solution is allowed to flow completely into (d) without allowing any of the gas to follow it. The leveling bulb is then raised in the left hand, while the cock is turned so as to connect the pipette with (c) The mercury flowing in from (c) fills the body of the pipette and as much of the calibrated stem at the top as is not occupied by the gas that has been extracted from the plasma. A few hundredths of a cc of water could not be completely drained into (d) floats on the top of the mercury in the pipette, but the error caused by the resorption of the carbon dioxide into this small amount of water is negligible if the reading is made at once. The mercury bulb is placed at such a level (Figure 2) that the gas in the pipette is under atmospheric pressure and the gas is read on the scale.. This concludes the analysis as it is ordinarily done. The results are then corrected for temperature and pressure and the amount of carbon dioxide retained in the liquid. After the determination is completed the leveling bulb is lowered without opening the upper cock and most of the mercury drawn through (c) The water solution from (d) is readmitted and the leveling bulb being raised to position (1) the water solution is forced together with a little mercury through (a).

The apparatus is now ready for another determination. It is not necessary to wash it out, since the few drops of

solution that remain attached to the walls of the apparatus do not contain an appreciable amount of carbon dioxide. One can run a series of determinations at the rate of one every three or four minutes.

When not in use the apparatus should be filled with water. Aside from keeping the cocks well greased, this is about the only special attention it requires. The mercury is occasionally cleaned by straining through a chamois skin.

The Mac Lean Needle Modification

There are two chief methods employed to obtain blood samples for analysis:

1. The Van Slyke method, by which the blood sample is collected under oil thus avoiding the loss of gas or a change of gases due to the passing through air. An apparatus for such collection is shown in Figure 3. The blood thus obtained may be brought to equilibrium with expired air reducing it to arterial basis.

2. Mac Lean needle method (26) The Mac Lean needle as shown in Figure 4 is similiar to the needle of Hallion and Bauer (27) as shown in Figure 3. This method is chiefly used to obtain samples of blood when it is desired to have them free from outside contamination. This is possible as the entire apparatus can be sterilized. In the application of this method the needle (A) is inserted into the vein and then if necessary suction can be applied at (B) facilitating

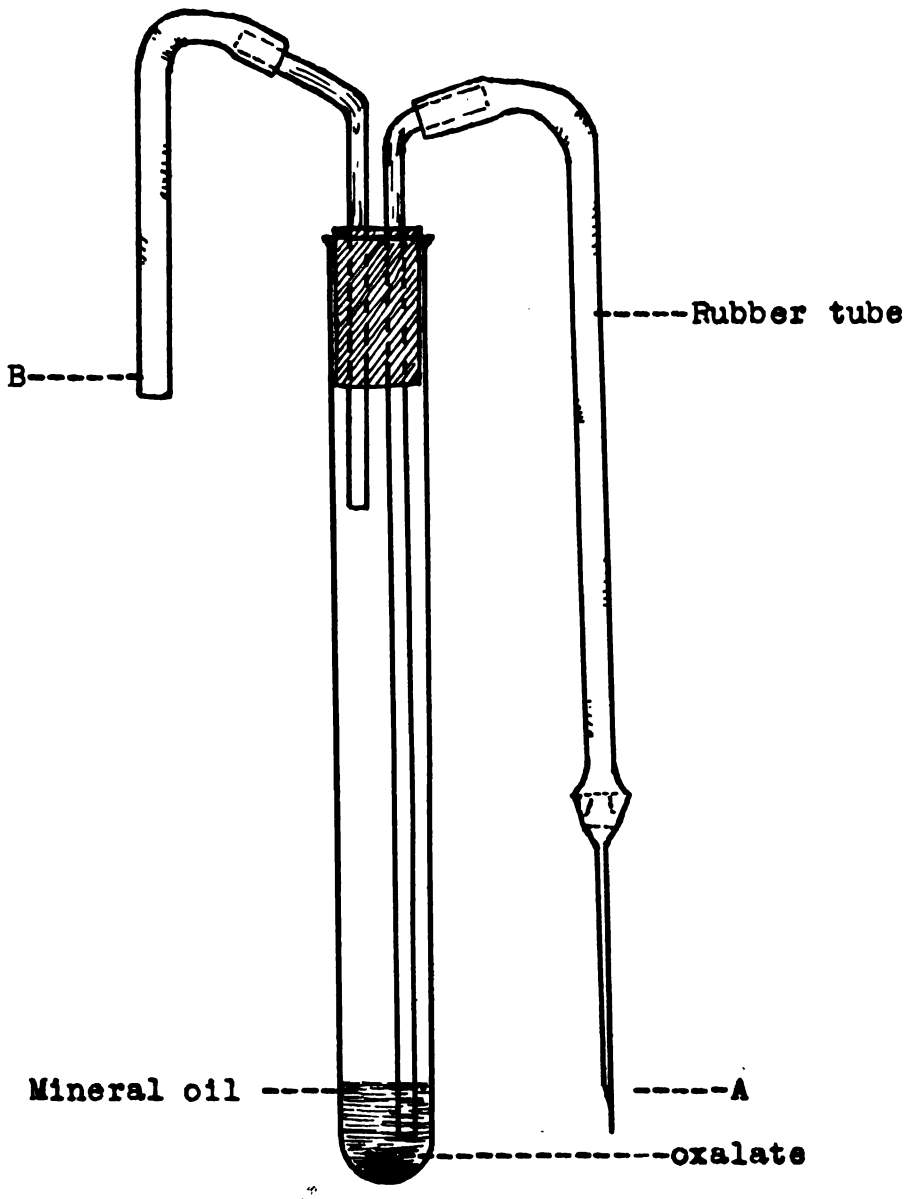

Figure 3 Van Slyke tube for collecting blood under oil.
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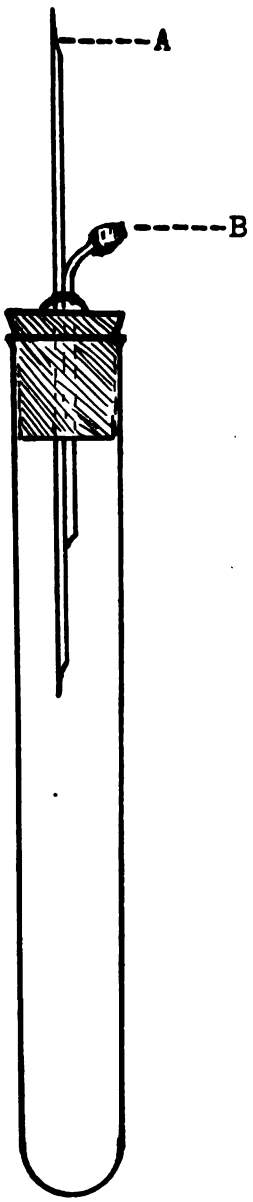

Figure 4 MacRae Needle
for venous puncture
New York Med.Jour.Dec.24,'10

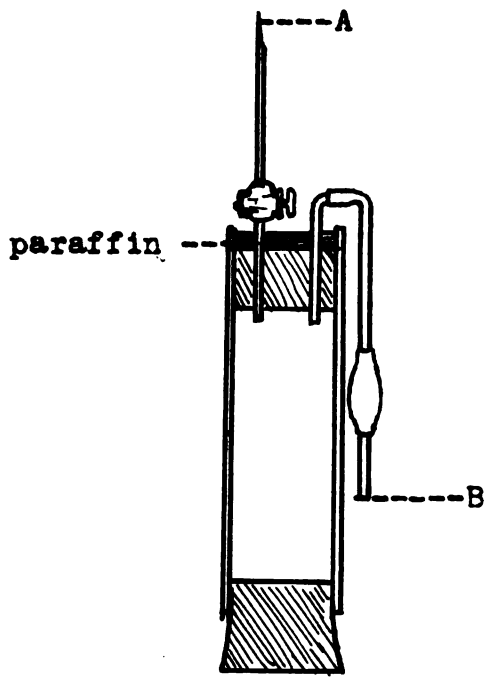

Figure 5 Hallion and Bauer
Needle for venous
puncture.
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the blood flow.

The Mac Mae needle method is of chief value in clinical work (28) and is considered sufficiently accurate for this type of work. The blood drawn by this method enters the collecting tube in a fine stream and falls the length of the tube, several centimeters, before reaching the bottom. During this fall there is an opportunity for the escape of carbon dioxide and the absorption of oxygen from the air in the tube. By using this method the alkaline reserve readings are found to be somewhat lower than those obtained by collecting under oil. The tenth of a second required for the blood to fall to the bottom of the tube is thought to be about time enough to bring it to an arterial basis due to the absorption of oxygen and the loss of carbon dioxide. This bringing of the blood to an arterial basis dispenses with the necessity for treating the blood with alveolar air previous to the making of the determinations.

Literature Supporting the Mcenne Needle Method.

Blatherwick (29) working with cattle found that if the blood was taken from the jugular vein and allowed to flow rapidly through a large cannula it showed no appreciable loss of carbon dioxide. He checked his results by collecting some samples under oil and found that the slightly modified Mac Mae needle method gave accurate results.

Haggard and Henderson (30) state that the carbon dioxide tension of the body fluids approximates that of

arterial blood and this would indicate that the Mac Rae needle method inasmuch as it gives an alkaline reserve of the blood that approaches the level of arterial blood would give a satisfactory index of the alkaline reserve or the carbon dioxide tension of the body fluids.

Buell (31) found that the ability of an animal to protect itself against the encroachment of acids was proportional to the bicarbonate content of arterial blood. This being the case, then an alkaline reserve run on arterial blood would give a more accurate indication of the animals protective power against acids than would an alkaline reserve of venous blood.

When venous blood is exposed to the air, as it is in the collection by the Mac Rae needle method, it becomes arterial in appearance. Foster (30) credits this difference to a change in the carbon dioxide and oxygen content, the oxygen content being as much changed as the carbon dioxide content.

Barr and Himwich (33) state that the venous blood will have a higher carbon dioxide content that arterial blood averaging about 4 volumes per cent higher. This they state makes it impossible to draw any conclusions concerning arterial conditions from venous samples.

Van Slyke and Stadie (34) found that venous blood contained 10% the carbon dioxide of arterial. They say that venous blood might be used for determinations if it is

centrifuged without the loss of carbon dioxide. These authors in another article (35) state that the carbon dioxide capacity of venous blood parallels that of arterial and is but slightly higher.

Barr and Himwich (36) support Van Slyke and Stadie saying that changes in the carbon dioxide content of venous blood are in the same direction as the changes in arterial blood content.

Dr R.C.Huston (37) of the Chemistry Department of the Michigan Agricultural College is of the opinion that the alkaline reserve as determined on venous blood collected by the Mac Rae needle method will be close to that determined on arterial blood of the same animal.

The change that the blood undergoes in the lungs is to lose carbon dioxide and take on oxygen. Rosenau (38) calculated that the inspired air has .03% carbon dioxide and that the expired air has a carbon dioxide content of 4.38%. He also found that the free carbon dioxide content of arterial blood was the same as that of expired air and states that the level of the carbon dioxide in the arterial blood is regulated by the lung ventilation and is at the same level as that of expired air.

It is then evident that the most change that blood can undergo when drawn from a vein and exposed to air is to have the free carbon dioxide content of the blood brought into equilibrium with that of the surrounding air. This is substantiated by the fact that the level of the carbon dioxide

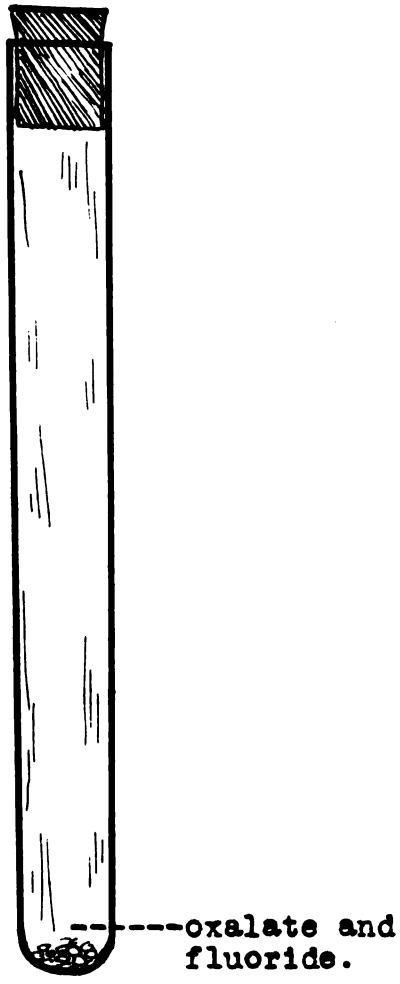


Figure 7. Tube used by Reed and Huffman for collection of samples

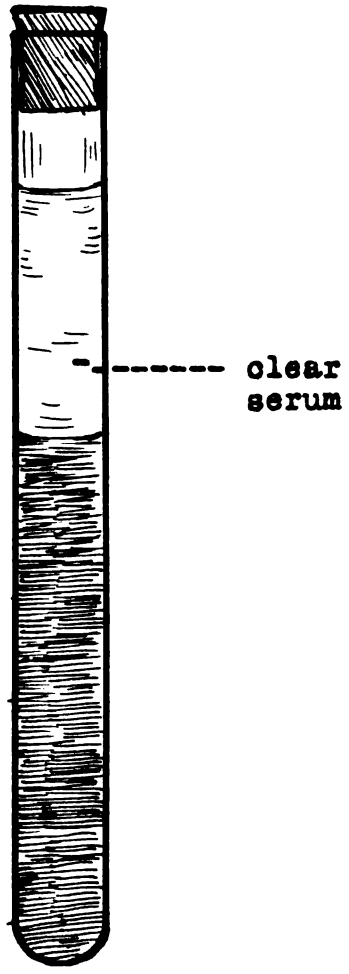


Figure 8 Tube after centrifuging

in the arterial blood is the same as that of expired air. There seems to be an equilibrium established between the carbondioxide of the inspired air and the carbon dioxide of the venous blood, the venous blood losing carbon dioxide and the inspired air gaining until an equilibrium is established. This would account for the lower alkaline reserve readings obtained by the use of the Mac Rae needle method as the blood is lowered nearly to an arterial basis and must lose from 3 - 4 % free carbon dioxide. The time limit and the amount of air to which the blood is exposed in the Mac Rae needle method is thought to be sufficient to lower the venous blood to an arterial basis.

It appears that the MacRae needle method is sufficiently accurate for clinical purposes and will give results indicative of the bicarbonate level of arterial blood.

Modified Technic Employed by Reed and Huffman.

The modified MacRae needle method as applied by Reed and Huffman (39) consists of using stasis for a few seconds, just long enough to make the jugular vein prominent, then puncturing it with an ordinary 16 gauge hypodermic needle. Stasis is applied until the sample is drawn and then released. The venous blood is allowed to fall through air into a 20 cc test tube, (see Figure 7) containing the anticoagulant and the preservative, until the tube was about three fourths full. The tube is then stoppered and the anticoagulant and preservative mixed with the blood by

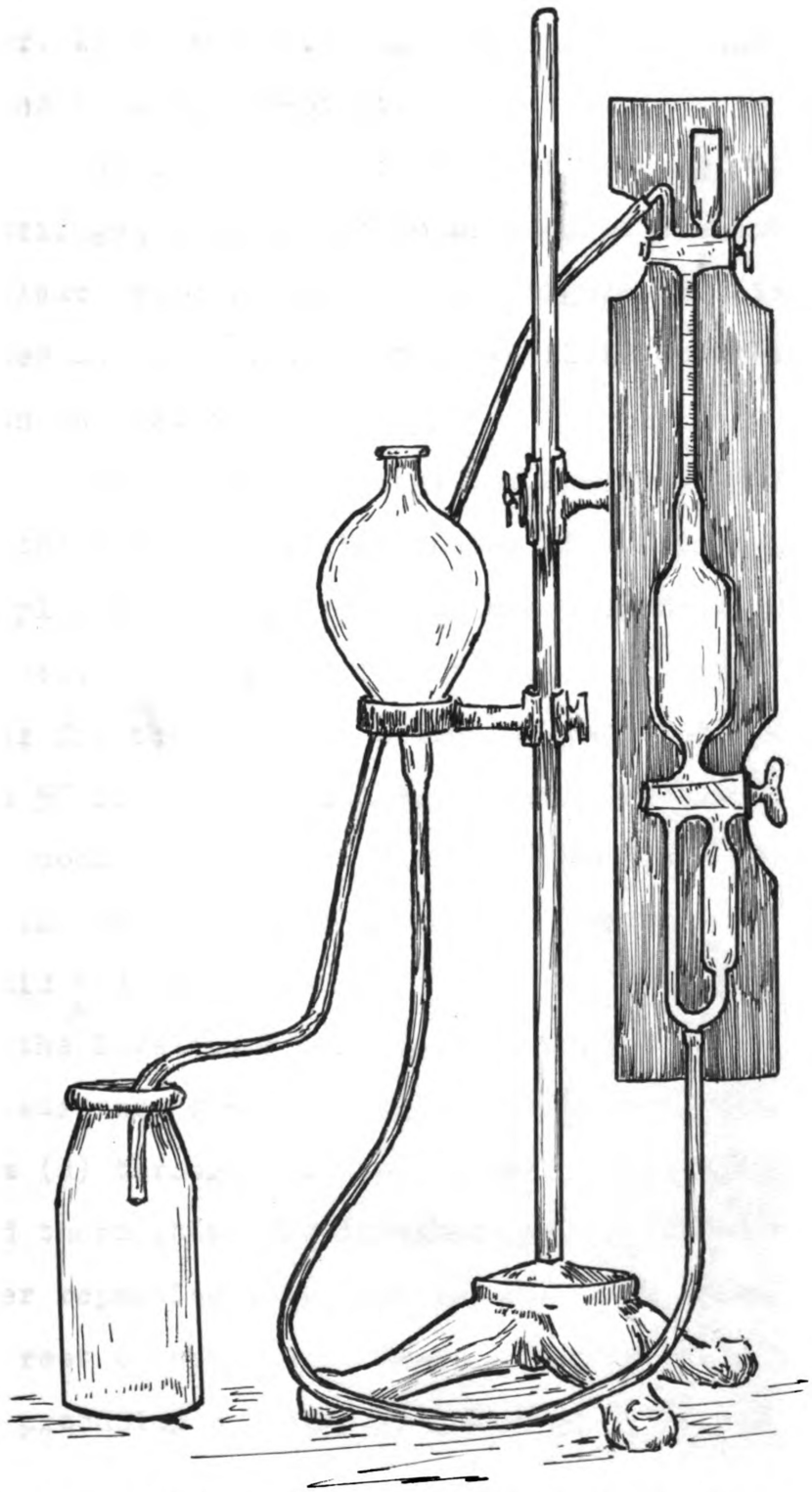


Figure 6. Setup of the Van Slyke Apparatus as used by Reed and Huffman.

allowing the blood to flow from one end of the tube to the other. As a precaution against infection the needle is dipped in a disinfectant.

As soon as possible after drawing, the samples are centrifuged long enough to give about one and one half inches of clear serum on the top (see Figure 8) This serum is then analyzed as follows using the Van Slyke apparatus set up as shown in Figure 6.

After the apparatus had been tested for freedom of air and the capilliaries sealed with mercury, one cc of serum was placed in (b). The serum was then drawn in and (b) washed down twice unsing a total of one cc of boiled distilled water for the purpose. A drop of caprillic alcohol and one cc of a 5% solution of sulphuric acid was then placed in (b).The stop cock (e) was then closed after these had been drawn in and the leveling bulb lowered to position 3. After all the liquid had been drawn into (d) the cock (f) was then closed and the leveling bulb raised to position (1). The stop cock (f) was then opened slightly causing the liquid to rush from (d) through the opening and mixing the serum and the acid thoroughly. Considerable gas is liberated by this process. After repeating this process until the serum ceases to foam the rest of the gas is drawn out by putting all the liquid in(d) and producing a Torricellian vacuum. When all the gas was extracted the cock (f) was turned so as to trap all the liquid and none of the gas in (d). The stop cock (f) was then turned

to allow the mercury to pass through (c) and force the gas up into the neck where it was read, the reading giving the per cent of carbon dioxide liberated from the one cc of plasma tested.

After making the reading the mercury bulb which had been placed on a level with the mercury in the apparatus was lowered to below the 2.5 cc mark and the stop cock (f) turned so that with the raising of the mercury bulb the liquid was forced from (d) up into the neck of the apparatus. The stop cock (e) was then turned so as to let the liquid flow out through a rubber tube into a receptacle which served to collect the material so that the mercury could be salvaged.

The apparatus was then washed with distilled water and again sealed, after which it was ready for a second determination.

The above method of extraction was checked by Reed and Huffman (39) against shaking as advised by Van Slyke and found to be as accurate. This modification as well as saving considerable time eliminated the danger of breaking the apparatus due to the removing and replacing it on the stand.

Each sample was run in duplicate. When two people were working one would run the sample on one apparatus and the other checked it on the second apparatus. In this manner errors due to faulty machines and to incomplete reactions were immediately discovered and remedied.

The amount of acid used by Reed and Huffman was

in excess of the amount recommended but as it did not cause any error, and made absolutely certain that enough acid was present to liberate all the carbon dioxide contained in the sample, its use was thought to be justified.

The readings obtained on the apparatus had to be corrected for temperature and pressure. A table computed from the Van Slyke formula: the corrected reading is equal to the observed reading times, the observed barometric pressure divided by 760mm.; was used to determine corrections for pressure. By using another of Van Slykes tables the readings corrected for pressure were reduced from the temperature of the laboratory to 0°C. Reed and Huffman considered the temperature of the laboratory in which the readings were made to be fairly constant, averaging 30°C, all corrections were based on this temperature.

Use of Anticoagulants

Investigators found that in the determination of the alkaline reserve it was better to use the serum rather than the whole blood. The whole blood because of its protein content and corpuscles, particularly the latter, made it very difficult to keep the machine clean. As both gave nearly the same results the use of the serum was adopted.

In order to use either one, the blood had to be kept in a fluid condition if a definite amount is to be analyzed.

The natural thing for blood to do upon being drawn is

clot,this being natures way of preventing the loss of blood in such quantities to endanger life. Why does'nt blood clot in the veins? Howell (40) states that in the circulating blood we have as constant constituents,pro-thrombin,calcium salts and anti-thrombin. The anti-thrombin holds the pro-thrombin in combination and thus prevents the coagulation of the blood as the pro-thrombin cannot be converted into thrombin. The anti-thrombin in the blood upon withdrawl from the body ceases to hold the pro-thrombin in check and the following occurs:

pro-thrombin plus soluble calcium salts = thrombin

thrombin(fibrin ferment) plus fibrinogen = fibrin.

Fibrin is the essential substance in the clotting of the blood, its formation is the controlling factor in blood coagulation.

Bordet and Delange (41) are of the opinion that the soluble calcium salts are the limiting factor in the clotting of the blood. They state that thrombin cannot be formed in the absence of some calcium salts. The action of fibrinogen and thrombin does not require the presence of the calcium salts.

If Bordet and Delange are correct(most investigators substiantiate their belief) then to prevent the coagulation of the blood would simply involve the removal of the soluble calcium salts. This can be accomplished in two ways, either by precipitating the calcium salts or getting them in combination with something so as to keep them from acting

to form the thrombin.

Oxalates as Anticoagulants

Mathews (42) Lee and Vincent (43) state that oxalates precipitate the calcium salts of the blood and thus prevent the formation of thrombin and the subsequent clotting of the blood. Van Slyke (44) recommended the use of oxalates to prevent the coagulation of the blood. He found that the use of oxalates to the extent of .5% of the weight of the blood drawn was sufficient to keep it in a fluid condition.

Reed and Huffman (39) following the recommendation of Van Slyke used neutral potassium oxalate as an anti-coagulant. They found that .1 gram in a 20 cc test tube would give the 0.5% concentration recommended by Van Slyke. This did not introduce any error and kept the blood in a fluid condition.

Citrates as Anticoagulants

Citrates have been used to some extent as anti coagulants and the results have been very satisfactory. They act, according to Mathews (42) not by precipitating the calcium but rather by holding it in an unionized state. Lewis (45) recommends the use of 0.3% citrates while Jones and Rye (46) recommend the use of one drop of saturated solution of sodium citrate to each 5 cc of blood in which it is desirable to prevent coagulation.

Hirudin as an Anticoagulant

It has long been known that leeches secreted some substance that prevented the coagulation of blood. This

substance was found to be hirudin and is thought by Abderhalden (47) to act by neutralizing a part of the fibrin formed. Mathews (48) thinks that hirudin is a deutero albuminose. Van Slyke and Cullen give results comparing hirudin with oxalates showing that they check. The main objections to the use of hirudin is its cost and variability.

Fluorides as Anticoagulants

Sodium fluoride another anticoagulant is used extensively and according to Pettger (49) gives very satisfactory results. It prevents coagulation not by the precipitation of the calcium salts but by holding them in combination so that they cannot react with the pro-thrombin to give thrombin. Arthus (50) recommends the use of .3% to prevent the clotting of blood and render a non - coagulable serum.

The Use of Preservatives

Sodium Fluoride as a Preservative

Rosenau (51) states that sodium fluoride is extensively used as a preservative as well as an anti-coagulant. Its preservative action is not due to the coagulation of the protoplasm but to the fact that it acts as a poison to the protoplasm. A solution of 1 to 200 is sufficient to prevent all bacterial growth.

Reed and Huffman (52) in making their alkaline reserve determinations always run duplicate samples. When attempting

to run duplicate determinations on some samples that were allowed to stand over night a loss of from 3 - 5 volumes per cent in alkaline reserve was observed. Following this observation Reed and Huffman made it a practise to run all samples as soon as possible after drawing.

About this time the work of Evans(32) was published in which he showed that the addition of a small amount of sodium fluoride would prevent the formation of acids in blood in vitro. Evans recommends a mixture of one part sodium fluoride and four parts neutral potassium oxalate to prevent coagulation as well as to preserve the samples.

Reed and Huffman needing something to enable them to hold their samples for a time tried the mixture recommended by Evans. They found that 10 samples allowed to stand from 4 to 6 hours that contained the mixture did not show any loss in alkaline reserve. Reed and Huffman then concluded that sodium fluoride in this proportion would prevent a change in the carbon dioxide content for at least six hours.

Barr, Hamwich and Green (33) found the .1% neutral sodium fluoride prevented a change in the carbon dioxide content at room temperatures. Without its use a loss of from 0.5 to 2.2 volumes per cent occurred in two hours. The sodium fluoride prevented a readable loss in the carbon dioxide content at room temperatures.

Saunders (54) found that .01 gram of sodium fluoride and .001 gram of thymol per cc of blood would prevent any appreciable change in blood for from 6 to 14 days. These preservatives are not practible for use in blood on which the alkaline reserves are to be determined as the amounts are too great and would introduce a considerable error. It does however, indicate that the use of sodium fluoride prevents the decomposition of blood in vitro for a considerable time.

It is then apparent that either oxalates, citrates hirudin or fluorides can be used as anticoagulants. It is also noted that oxalates or citrates are best adapted to use as anticoagulants on account of the ease with which they can be obtained and the fact that they are of standard strength. The hirudin as before mentioned is expensive and is not always of a reliable strength. Sodium fluoride, although it can be used as an anticoagulant, is best adapted to use as a preservative. Its use will prevent the formation of acids, in the blood, due to bacterial action for several hours after it is drawn.

The use of Caprillic Alcohol

In the application of the Van Slyke method for the determination of the alkaline reserve investigators found that the blood foamed considerable, after the addition of the acid To prevent this foaming Van Slyke (55) recommends the use of .02 cc of pure caprillic alcohol. This was shown not to introduce any error if the alcohol was pure. He suggests that all caprillic alcohol be tested for purity.

Mitchell and Eckstein (56) recommend either Kahlbaums

secondary caprilic alcohol or phenyl ether as foam inhibitors suitable to use in the Van Slyke apparatus for the determination of the carbon dioxide content of the blood.

Reed and Huffman (39) recommend the use of caprillic alcohol which they found did not alter the readings and made it possible to make the determinations in half the time.

The use of caprillic alcohol in small amounts since it decreases the time necessary for the application of the test and does not influence the results is to be recommended.

Methods Used to Check the Van Slyke Method

The Van Slyke method, now universally used to determine the alkaline reserve, because of its simplicity and ease of application has been checked by the use of other known methods and its accuracy confirmed.

Stillman (57) found that the titration method of estimating the alkaline reserve checked very closely with the Van Slyke method; being off less than two volumes per cent. He concludes that the two methods can be used interchangeably. for clinical purposes.

Van Slyke, Stillman and Cullen (58) also found that by titration they obtained results that checked very close with the results obtained by the carbon dioxide capacity method of Van Slyke.

Haggard (59) found that the Henderson-Morrice method gave results that agreed with those obtained by the

application of the Van Slyke method.

Cullen (60) states that the gas chain method of determination of the hydrogen ion concentration has been utilized in the titration of plasma and conditions for its successful application found. The results obtained by this method parallel those obtained by the Van Slyke method and hence give an accurate indication of the alkaline reserve.

The method of Boycott and Chrisolm (61) has been found to give results comparable with those obtained by the carbon dioxide capacity method.

The various methods whose accuracy had been demonstrated were used to check up on the Van Slyke method and inasmuch as the results obtained check very closely, the accuracy of the Van Slyke method for clinical purposes is firmly established.

The Normal Alkaline Reserve

Since the advent of the Van Slyke method of determination considerable work has been done on the establishing of normal values. Most of this work has, however, been done on humans. The work with the alkaline reserve of man has progressed far enough so that tables have been compiled giving the alkaline reserve levels of the normal healthy individual.

Normal Alkaline Reserve of Man

Peters, Barr and Bule (62) give the normal level of

the alkaline reserve of the healthy adult as 49.3 volumes per cent with variations between 55.9 and 43.3 volumes per cent.

Gettler and Baker (63) set the normal for adults at 63.1 volumes per cent with variations between 77.8 and 55.5 volumes per cent.

Stillman, Van Slyke, Cullen and Fitz (64) do not set any definite normal for healthy adults but state that it lies between 77 and 53 volumes per cent. Mathews (65) does not set a definite normal but indicates the same limits as Stillman,Van Slyke, Cullen and Fitz.

Schloss (66) sets the normal for healthy children at ten volumes per cent lower than adults and narrows the limits for variations to between 63 and 46 volumes per cent.

Sarvyn,Stevens and Bauman (67) set the normal for healthy children at 54 volumes per cent but allow variations on either side of this figure.

Normal Alkaline Reserve of Animals

The work on animals is rather limited and with the exception of cattle the cases covered are insufficient to warrant the establishment of definite normals.

The Normal Alkaline Reserve Of Swine

Forbes,Halverson and Schulz (68) give the only data available on swine. These figures represent the result of a seven day grain trial previous to the feeding of minerals. These few cases give an average alkaline reserve of 68.4 volumes per cent.

Normal Alkaline Reserve of Horses

N.Ijichi (69) in experimenting with thirty military horses found that the alkaline reserve varied from 52.8 to 72.1 volumes per cent with an average of 62.6 volumes per cent.

Normal Alkaline Reserve of Cattle.

Blatherwick (70) found that the alkaline reserve of cattle as determined by the Van Slyke method using a modification of the Mac Lae needle method for securing the samples was very constant. The 82 determinations covering 16 individuals gave an average of 62.3 volumes per cent with a variation from 55.1 to 68.3 volumes per cent. The alkaline reserve of calves was found to be higher.Seven calves varying in age from 2 to 14 days gave an average of 73 volumes per cent with a variation from 68.3 to 80.6 volumes per cent.

Reed and Huffman (39) bled the animals in the dairy herd at the experiment station from time to time.The animals were receiving a mineral supplement at the time and were being fed for highest production. The alkaline reserves as determined were tabulated and the average of 150 cases found to be 56.06d volumes per cent. A variation,from 42.5 to 74.9 volumes per cent,was noted.

However the experimental herd which contained no animals in milk and received for the most part some mineral supplement in addition to the ration showed a variation in alkaline reserve from 42.5 to 72.4 volumes

per cent. The average of the 346 cases studied was 59.910 volumes per cent, a little higher than the average obtained on the dairy herd.

During these determinations Reed and Huffman noticed that the alkaline reserve was subject to considerable variation. It was not known if the alkaline reserve varied during the day. To determine the variation apt to occur during the day eight animals were placed under observation. These were bled in the morning before feeding. One hour later, after feeding, they were again bled. Following this they were bled every two hours for the rest of the day until it was time for the evening feed.

No very marked variation was noted except for a drop of about 3 volumes per cent following the morning feed. After this drop there was a gradual rise in alkaline reserve until at the time just previous to the evening feed the alkaline reserve had reached a point almost as high as it was in the morning previous to feeding.

Following this Reed and Huffman (39) made a study to determine the variation in alkaline reserve apt to occur from day to day. Sixteen animals in the experimental herd were bled every morning for ten consecutive mornings previous to feeding. Animals under different feed conditions were included.

Except for the first morning when the readings were below normal it was found that the rest of the time the animals were above normal. The average for the

entire group for the ten days was 61.61 volumes per cent, about three volumes per cent above the normal established for this group. After the first day there was less than two volumes per cent variation from day to day. The results indicate that the alkaline reserve of dairy animals is subject to variation from day to day.

Normal figures for the alkaline reserve of man swine, horses and cattle have been established as follows:

The normal, healthy adult has an alkaline reserve between 53 and 77.8 volumes per cent.

The normal for childres lies between 46 and 76.1 volumes per cent.

The only available data for swine gives an average alkaline reserve of 66.4 volumes per cent.

Horses have an alkaline reserve varying from 52.8 to 72.1 volumes per cent the average being 62.6 volumes per cent.

The normal for cattle as established by Blatherwick is between 55.1 and 68.3 volumes per cent with an average of 61.5 volumes per cent. The normal for calves is a little higher varying from 66.3 to 80.6 volumes per cent and averaging 73.0 volumes per cent.

Reed and Huffman give the normal alkaline reserve for lactating animals under good feeding conditions to be 56.068 volumes per cent. Variations from 42.5 to 74.9 volumes per cent were found. In the experimental herd where none of the animals are milking the variations were

from 42.5 to 72.4 volumes per cent giving an average alkaline reserve of 59.9±0 volumes per cent. A variation in alkaline reserve from day to day and also a variation during the day was observed by Reed and Huffman.

Variations from these normal values are due to some upset in the normal functioning of the body and indicative of some pathological condition.

The Relation of Alkaline Reserve to Acidosis

Any disturbance in the body that causes a lowering of the alkaline reserve produces a condition known as acidosis, Van Slyke, Stillman, Cullen and Fitz(64) after extensive study of the alkaline reserve have formulated the following table showing the level of the alkaline reserve at which acidosis is indicated.

Normal Adult	Alkaline reserve 53 - 77 vol.%
Mild acidosis - no visible symptoms	45 - 50 " "
Moderate acidosis-symptoms may be apparent	30 - 45 " "
Severe acidosis symptoms apparent	Below 30 " "
Lowest alkaline reserve with recovery	15 " "

Van Slyke states after observing three cases that a reduction of alkaline reserve to 14 volumes per cent will cause death.

Acidosis according to Sellards (71) is a general impoverishment of body bases or substances that give rise to bases. In other words a depletion of the alkaline reserve.

Frothingham and Channing (72) speak of acidosis as

being a term applied to a variety of conditions in which there is a lack of substances that readily give rise to bases. Such an impoverishment may be due to:

1. An unusual loss of bases from the body.
2. Faulty absorption of bases.
3. Lack of bases in the diet
4. Abnormal amounts of acids thrown into the blood.

   This may be due to:

   a. An over production of normal body acids.
   b. The production of an abnormal acid.
   c. The accumulation of normal acids due to faulty excretion.

Von Noorden (73) gives two types of acidosis depending upon the causes. The causes are in reality a summation of the causes as given by Frothingham and Channing:

1. Absolute acidosis - An increased production of acid.
2. Relative acidosis *- A decreased amount of alkali present.

Late investigations indicate that majority of the acidosis is due to an impoverishment of bases. This loss or decrease in bases may be due to an abnormal amount of acids thrown into the blood stream to be neutralized.

Dorland (74) in the American Illustrated Dictionary defines acidosis as an increased acidity or rather a decreased alkalinity of the blood;a depletion of the alkaline reserve resulting in acid intoxication.

In bringing about this condition of acidosis Whitney (75) considers that two factors control it.

1. The rate of the appearance of the acid ions.
2. The rate of excretion of the acid ions.

This depends on:

a. Factors of kidney sufficiency.

b. Other means of elimination.

c. The affinity of the tissues for certain radicles.

To determine if a condition of acidosis really exists one can, according to Fothingham (76) use four methods.

1. Direct examination of the blood. Determination of the alkaline reserve.
2. Study of the urine
3. Study of the products of respiration
4. Estimation of the amount of alkali necessary to turn the urine alkaline.

Van Slyke, Stillman and Cullen (77) give two methods of determining the condition of acidosis.

1. Determination of the alveolar carbon dioxide.
2. Determination of the carbon dioxide capacity of the plasma.

Gettler and George (78) state that the degree of acidosis can be determined by the decreased value of the alkaline reserve as determined on the Van Slyke apparatus.

It is then evident that a condition of acidosis is indicated when there is an impoverishment of bases. This condition can be determined by several different methods. The majority of investigators use the Van Slyke method of determining the alkaline reserve of the blood to determine if acidosis exists.

Acidosis can be detected by the level of the alkaline reserve. The change in the alkaline reserve may be due to a number of factors chief of which is the over production of acid ions or the lack of basic material with which to neutralize the acids. It is evident that alkaline reserve bears a definite relation to acidosis.

Relation of Alkaline Reserve to Alkalosis.

The opposite condition to acidosis is alkalosis; this is the presence of an overabundance of alkaline materials in the blood. Its causes would obviously be the opposite of those of acidosis, an increased alkali production with a lessened acid production. Most authorities do not believe that such a condition can exist. However, Wells (70) says that an unusually high alkaline reserve may exist occasionally but is not frequently found.

As the condition of alkalosis is not generally found it is not of great importance in the studying of the alkaline reserve. If a condition of this kind existed the probability is that the animal would refuse to eat and the production of acids due to katabolic processes

would soon lower the alkaline reserve to some where near normal and the animal would again resume eating.

Until recently a number of authorities thought that there was a definite relationship between the level of the alkaline reserve and tetany.

Wilson, Stearns and Downey (22) believed tetany to be due to alkalosis. Their work with sodium bicarbonate and sodium acetate showed them to be harmful when used in the treatment of tetany. Salts of calcium, magnesium, strontium, and barium, were found to give relief to animals suffering from tetany. Colby and Fuchs (21) also thought that tetany was due to alkalosis. However, Henderson (22) was unable to produce tetany by the administration of an excess of alkalies.

It is admitted that tetany may be accompanied by a high or low alkaline reserve but that the level of the alkaline reserve bears no definite relation to the degree of tetany. It is thought that tetany is due either to toxic products in the blood or to an improper relation of the ions.

A high alkaline reserve or a condition of alkalosis may be found in some instances but is not common.

Factors Influencing the Alkaline Reserve

From the review of literature thus far, it is evident that the alkaline reserve is subject to considerable

variation. A further study will show causes for these variations and indicate some of the factors that might influence the alkaline reserve of dairy cattle under ordinary farm conditions.

The Effect of Diet on the Alkaline Reserve

As the body is maintained by the food consumed, diet might be expected to exert an influence on the level of the alkaline reserve.

General Effect of Diet

McClendon, Von Meysenbarg, Engstrand and King (83) were not able to materially change the alkaline reserve by changing the diet. Van Slyke, Stillman and Cullen (84) on the other hand found that the plasma bicarbonate increased in some cases following a meal. Schloss and Harrington (85) were able to increase the plasma bicarbonate of infants by appropriate changes in diet.

Von Noorden (86) states that except during absolute drunkeness the alkaline reserve is not influenced by a diet of alcohol.

Page (87) found that a diet with an acid ~~forming~~ ash tended to lower the alkaline reserve while a diet with an alkaline ash tended to raise the alkaline reserve.

Asada (88) found that starving animals showed a decided drop in alkaline reserve on the third day. They were then constant until the ninth day when a moderate drop occurred. After this the alkaline reserve was fairly constant until death.

Blatherwick (39) working with cattle found that fasting did not change the alkaline reserve but presents the following table to show that diet can cause a change in the alkaline reserve of dairy cattle.

Date	Alkaline Reserve in Volumes Per Cent	Diet
Mar. 1	58.6	Grain alone 4 days
4	59.2	Alfalfa hay 3 "
9	54.3	Silage only 5 "
Another trial		
Oct. 19	60.7	Silage 16# Grain 2#
20	64.1	Alfalfa alone 5#
21	61.5	Silage 16# Grain 2#
Nov. 4	63.6	Grain only
17	67.4	Silage 16# Grain 2#
20	61.7	Silage alone

Effect of a Grain Ration on Alkaline Reserve

Reed and Huffman (39) found that diet influenced the alkaline reserve of dairy cattle. The general dairy herd showed a lower alkaline reserve than the animals in the experimental herd. This was due, no doubt to the heavier feeding of grain that was practised in the general dairy herd. Grains contain less basic mineral matter and so might be expected to cause a lowered alkaline reserve.

Effect of a Silage Diet on the Alkaline Reserve

To determine the effect of a restricted diet Reed and Huffman (39) fed four cows silage and a neutral grain ration(one having an equal amount of basic

and acid forming ash).The grain was fed according to milk production while they were allowed all the silage they would consume. The animals were bled from time to time and the results noted.

Silage seems to hold the alkaline reserve about normal,although a slight increase over the level at the start was noticed. A fourth bleeding after being on a silage diet for thirty days was taken at noon after they had had some exercise so could not properly be counted in the results.

Effect of a Diet of Straw on the Alkaline Reserve

After changing the ration to straw in connection with the neutral grain ration Reed and Huffman (39) found that the alkaline reserve of the animals rose to a point about as high as when they first started on the silage diet. After twenty days on the straw diet 10% finely ground calcium carbonate in the rock form was added to the ration. The alkaline reserve,three days later,had raised 7 volumes per cent, which is much higher than that obtained on a diet of either straw or silage.

Effect of a Milk Diet on the Alkaline Reserve.

Reed and Huffman (39) to determine the effect of a milk diet on the alkaline reserve,fed several calves on whole milk alone.Their results indicate that a diet of whole milk does not cause much change in the alkaline reserve of dairy calves.

Reed and Huffman (39) made a practise of bleeding each cow after freshening and of bleeding the calf before it had had colostrum milk. The average alkaline reserve of thirteen cows immediately after freshening was 55.11 volumes per cent. The fifteen calves, prior to suckling, had an average alkaline reserve of 55.91 volumes per cent. After they had consumed colostrum milk the alkaline reserves were again determined and found to have raised, averaging 60.99 volumes per cent. This would indicate that colostrum milk contains some material that causes a rise in the alkaline reserve of new born calves.

Effect of Minerals in the Diet on Alkaline Reserve.

As minerals comprise the greater part of the alkaline reserve it might be expected that the addition of more minerals to a normal diet might cause a change in the alkaline reserve.

Sherman (30) indicates that a man under normal conditions excretes about thirty grams of mineral salts per day. Rosenau(31) tells of the use of sodium bicarbonate to neutralize the acid in milk. As sodium bicarbonate is a normal constituent of blood and lactic acid is also found in the blood stream it is only natural to expect that the feeding of sodium bicarbonate would have an influence on the alkaline reserve.

Van Slyke and Cullen (32) report that the alkaline reserve may be increased by the eating of an alkaline diet,

one that contains an excess of alkaline minerals in the ash.

Palmer and Henderson (93) have shown that the feeding of from 5 to 10 grams of sodium bicarbonate will turn the urine alkaline. They also noted an increase in the alkaline reserve following its use. Of the nine cases fed sodium bicarbonate in varying amounts, decided increases in the alkaline reserves of eight and a slight increase in the other were noticed. This indicates that sodium bicarbonate can be used to increase the alkaline reserve. They also demonstrated in connection with this work that a person with a low alkaline reserve required more sodium bicarbonate to turn the urine alkaline. They were able to compute the following table:

Amount of Sodium Bicarbonate per Kgm. body weight to turn the urine alkaline.	Minimum alkaline reserve at which this amount turns the urine alkaline
0.0 - 0.5	55 volumes per cent
0.5 - 0.8	40 -55 " " "
0.8 - 1.1	30 -40 " " "
above 1.1	below 30 " " "

They were also able to show the amount of sodium bicarbonate necessary to raise the plasma bicarbonate one volume per cent.

Weight of patient	Amount of sodium bicarbonate necessary per day.
42#	0.5 grams
84#	1.0 "

Weight of patient	Amount of sodium bicarbonate necessary per day.
126#	1.5 grams
168#	2.0 "
210#	2.5 "

Von Noorden (94) reports that it takes from 20 to 40 grams of sodium bicarbonate to turn the urine alkaline in mild cases of diabetes, in severe cases 80 to 100 grams is usually required.

Palmer and Van Slyke (95) found that when sodium bicarbonate was administered the rise in blood carbonate was approximately that calculated on the assumption that the alkali was evenly distributed between the blood and the tissues.

Mormose (96) found that the ingestion of urea, sodium lactate, and sodium bicarbonate all caused the blood to become more alkaline.

Eggstein (97) found that the alkaline reserve, lowered during shock, could be restored by the intravenous injection of sodium bicarbonate. He also states that the use of sodium bicarbonate before shock had a beneficial effect, lowering the mortality due to shock.

Forbes, Halverson and Schulz (98) working with swine found that in the two cases observed that the addition of calcium carbonate to the cereal ration caused an increase in the alkaline reserve of the plasma of

10.1 volumes per cent in one case and 10.8 volumes per cent in the other. The substitution of precipitated bone phosphate for the calcium carbonate caused a reduction in the alkaline reserve of 14.8 volumes per cent in one case and 15.4 volumes per cent in the other, this reduction brought the alkaline reserves to a level lower than they were on a grain ration alone. This work indicates that minerals can influence the alkaline reserve of swine.

Blatherwick (6) while working with cattle found that sodium bicarbonate raised the alkaline reserve in a single case studied.

Reed and Huffman (39) conducted a number of experiments to determine the effect of minerals on the alkaline reserve. Calves were fed calcium carbonate in addition to a ration of whole milk. The results indicate that the mineral calcium carbonate will cause changes in the alkaline reserves of calves.

Following these results six heifers were placed on a diet containing calcium carbonate in addition to the regular ration. The calcium carbonate was fed at the rate of 200 grams per day per animal. No change in the alkaline reserve was noted until the beginning of the third week when there was a considerable increase. The alkaline reserve of the animals was soon above normal where it remained until the mineral was removed from the ration. Following the removal of the calcium carbonate the

alkaline reserves fell to a point lower than when the animals were placed on experiment.

This trial indicates that the feeding of calcium carbonate to older animals caused only a slight increase in the alkaline reserve.

Another experiment conducted to determine the effect of feeding bone meal. A commercial bone meal that contains 74% bone calcium phosphate, 3% protein and 10 % moisture and other ingredients was used. Six heifers were fed this mineral at the rate of 200 grams each per day in addition to the regular ration. It was found to cause a general increase in the alkaline reserve.

A calf received 25 grams of bone meal per day in addition to the regular ration and showed a gradual increase in the alkaline reserve.

Four cows that received 400 grams of bone meal daily, in addition to their regular ration showed the same general increase in alkaline reserve indicating that bone meal can cause an increase in the alkaline reserve of dairy animals.

In another experiment Reed and Huffman (52) fed minerals to four calves in addition to a whole milk diet. The results indicate that minerals fed with whole milk do not have much influence on the alkaline reserve of dairy calves.

The conclusion from the work reviewed is that minerals can cause a change in the alkaline reserve.

Effect of Acids on the Alkaline Reserve.

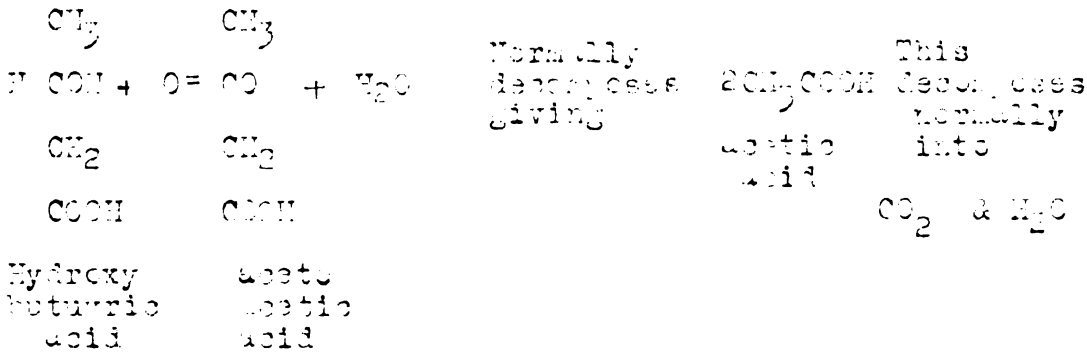
In the normal process of digestion and assimilation many acids are produced, these must be neutralized and their neutralization, inasmuch as it is accomplished for the most part by minerals, might be expected to have some influence on the alkaline reserve.

Sherman (99) states that the entrance of any acid into the blood stream requires neutralization and this is accomplished by the sodium carbonate or potassium carbonate and the resulting sulphate is eliminated with the loss of sodium and potassium and the accompanying lowering of the alkaline reserve.

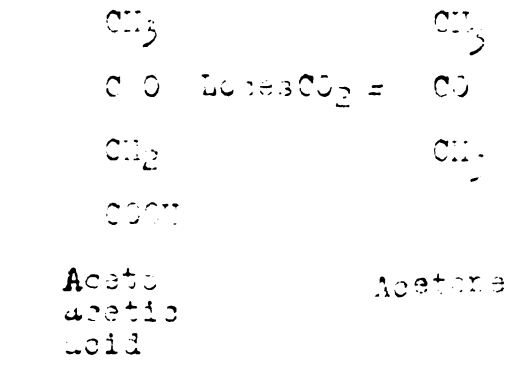
Von Noorden (100) shows that the entry of an acid material into the blood stream liberated carbonic acid from its compounds. The bicarbonate capacity of the blood therefore falls and the alkalinity is lowered. Von Noorden (101) also states that the most dangerous result of the formation of acetone and its allies is the flooding of the system with acids. This produces the condition known as acidosis. He attributes oxybutyric acid as being the cause of acidosis although acetic and a few other acids may aid in the production of this condition. It is evident that if the acids produced enter the blood stream the alkaline reserve

is lowered, resulting in acidosis.

Stadleman (102) was the first to discover oxybutyric acid in the blood and recognise that acidosis was due to an increased production of acids. A. Hewes (103) in his physiological chemistry gives the following equations showing the decomposition of hydroxy butyric acid.



If however the alkaline reserve is low or other pathological conditions exist the following may occur:



Acetone that is not excreted as soon as formed piles up in the system. The other intermediate products, aceto acetic acid and hydroxy butyric acid, also pile up in the blood-stream and cause a lowering of the alkaline reserve and a condition of acidosis.

Van Slyke, Cullen and Stillman (104) found that the

alkaline reserve rose during gastric digestion due to the secretion of hydrochloric acid from the blood to the stomach.

Cutts (105) found that the daily administration of from 25 to 75 cc of .25 normal hydrochloric acid lowered the plasma bicarbonate. Van Slyke and Cullen (106) found that acid injected into the system lowered the bicarbonate content but not as much as was expected. The rest of the acid not neutralized in the blood stream was probably neutralized in the tissues or by alkali drawn from them.

It appears that acids tend to lower the alkaline reserve as we would naturally expect. The lowering of the alkaline reserve of the blood is not directly proportional to the amount of acid thrown into the blood as the alkaline reserve of the entire body fluids must be changed. It was noticed that acids produced during normal digestion and metabolism tended to lower the alkaline reserve. The alkaline reserve would soon be depleted were it not for the fact that at the same time the acids are being produced the blood is replenishing its supply of alkaline materials from the foods consumed. If any condition occurs that prevents the absorption of alkaline materials it is evident that a condition of acidosis would soon occur due to the lack of material with which to neutralize the normally produced acids.

The literature on diet seems to uphold the idea that diet does cause a change in the alkaline reserve. A change in the diet of dairy cattle was found to cause considerable variation in the alkaline reserve.

Effect of Lactation on the Alkaline Reserve.

Since milk contains considerable mineral matter it might be expected that lactation would have an influence on the alkaline reserve. Reed and Huffman (79) in an effort to determine the effect that lactation might have on alkaline reserve bled a large number of cows as they freshened and at two month intervals during that lactation period. It was found that at the time of freshening the alkaline reserves were below normal. However at the end of the first two months the alkaline reserves had risen to a point above normal. Later there was a drop, due perhaps to the turning of the cattle on pasture. After the animals returned to dry feed the alkaline reserves again became above normal.

From the work it seems that lactation does not have a very decided influence on the alkaline reserve.

Effect of Exercise on the Alkaline Reserve

Barr, Hildreth and Green (107) found that following vigorous muscular exercise there were changes in the acid-base equilibrium of the blood consisting a lowering of the carbon dioxide combining capacity. Moderate exercise did not, however, cause any appreciable change.

Hasburg(108) reported that exercise produced a

diminution of the alkaline reserve but not to a great extent. Pooper(109) notes that excessive exercise lowers the alkaline reserve.

Christen, Hurdo, Carl, and Moller (110) found that running up and down a flight of stairs five times did not materially change the alkaline reserve. However, after a few minutes following the exercise a drop in alkaline reserve is found. This is followed by a rise to a point higher than before the exercise.

Harry (111) reports a decrease in the carbon dioxide combining capacity of the blood following heavy muscular work or fatiguing exercise. Hastings(112) reports the same results as Harry, indicating that a decrease in alkaline reserve follows heavy muscular work or excessive exercise.

Fries (113) demonstrated that following exercise or muscular exertion there was an increase in the amount of lactic acid found in the blood. He also reports that an increased amount of lactic acid is found in post mortem blood samples.

To determine the effect of exercise on the alkaline reserve of dairy cattle Woodward Huffman (93) conducted several experiments. The results show a decrease of 4 volumes per cent in the alkaline reserve of the animals following strenuous exercise for thirty minutes.

The consensus of opinion is that the alkaline reserve is decreased following severe exercise. Majority of investigators report a slight drop following moderate exercise. The theory advanced by Fries (117) that muscular activity increases the amount of lactic acid in the blood readily accounts for the lowering of the alkaline reserve.

Effect of Breathing on the Alkaline Reserve.

Henderson and Haggard (114) found that excessive pulmonary ventilation due to artificial respiration induces not only a lowering of the free carbon dioxide content of the blood but also a lowering of the alkaline reserve.

Davies, Haldane and Kennaway (115) showed that breathing air containing a higher per cent of carbon dioxide up to 5% increased pulmonary ventilation but did not change the alkaline reserve.

Campbell and Turner (116) report that patients suffering with diabetic acidosis have an increased pulmonary ventilation following an increase in the alkaline reserve of the blood.

It seems that the function of breathing is to keep the free carbon dioxide of the blood at a level of about 5%. Any increase in the free carbon dioxide above this amount will cause an increase in the rate of pulmonary ventilation until the amount of free carbon dioxide of the blood is reduced to 5 per cent.

Haldane and Priestly (117) found that with a rapid air the breathing was normal and the carbon dioxide content of normal inspired air is .3 per cent. If the content of carbon dioxide is increased in the inspired air the following results are obtained.

2 % CO_2 in inspired air pulmonary ventilation increases 50%
3 " " " " " " " " 100%
4 " " " " " " " " 200%
5 " " " " " " " " 300%
6 " " " " " " " " 500%

The increase in lung ventilation to keep the level of the free carbon dioxide of the blood constant is automatic and unless especially high concentrations are made the patient is not aware of the increase. As soon as the carbon dioxide content of the air is lowered to the proper level the rate of pulmonary ventilation decreases to keep the free carbon dioxide content of the arterial blood constant.

Henderson and Russell (118) failed to find an increase in the per cent of carbon dioxide in expired air when the patient went from rest to strenuous exercise and state that the increased pulmonary ventilation takes care of the added amount of carbon dioxide produced.

It appears that breathing exerts no influence on the alkaline reserve. Experiments show that pulmonary ventilation is so regulated as to keep the free carbon dioxide of the arterial blood at a given level of five per cent.

Naturally since there is an equilibrium established between the inspired air and the carbon dioxide of the venous blood the expired air would have the same carbon dioxide content as the arterial blood. Any excess carbon dioxide in the venous blood would be taken care of by an increase in lung ventialtion rather than an increase in the carbon dioxide content of the expired air.

Effect of Body Temperature on Alkaline Reserve.

Reed and Huffman (39) determined the alkaline reserve on several animals while their body temperatures were above normal and again when their temperatures had become normal.The results show that for every degree the body temperature was above normal there was a lowering of one volume per cent in the alkaline reserve.

Minor Factors Influencing the Alkaline Reserve.

Raymond (119) reports that anaesthesia lowered the alkaline reserve and gives data showing that the alkaline reserve of patients when first under the influence of the anaesthesia was 33.9 volumes per cent,while after 45 minutes to two hours the alkaline reserve drops to 28 volumes per cent.If kept under the influence of anaesthesia for from four to six hours the alkaline reserve falls to 26.1 volumes per cent,a longer period than this causes but a small additional drop.

Caldwell and Cleveland (120) observed a drop in the plasma bicarbonate following anaesthesia and operation.

Cannon(121) made similar observations. The work of Bourn and Bloom (122) shows that 61 patients had an average decrease of 3.6 volumes per cent in alkaline reserve following the administration of an anaesthesia.

On the other hand Short(123) reports that the alkaline reserve seems to increase during anaesthesia.

The effect of sleep on the alkaline reserve was studied by Collip (124) who reports that the alkaline reserve is either depressed or unaltered during sleep.

Another factor to consider is the excessive loss of blood due to hemorrhage. Wilroy (125) found that when one third of the blood was removed from dogs a distinct lowering of the alkaline reserve was produced. Von Noorden (126) quotes Luntz as stating that an acute loss of blood diminishes its alkalinity. Buell (127) reports that after hemorrhages the alkaline reserve is lowered for a few hours. If the animal fights and is nervous the drop is much larger than if the animal is quiet. Tatum(128) working with rabbits showed that hemorrhage reduced the alkaline reserve of the blood. All evidence seems to indicate that a lowering of the alkaline reserve follows hemorrhage. It is interesting to note that Luntz(129) working with wounded soldiers found that only in cases of pronounced infection or excessive loss of blood was there a lowering of the alkaline reserve.

Vomiting was found by Hillaby (130) to cause a lowering of the alkaline reserve of a child when continued for

several days. Murry (131) reports that vomiting due to an obstruction near the pylorus caused the alkaline reserve to increase. It would seem that the extent and cause of the vomiting would determine the direction of the change in the alkaline reserve.

Shock resulting from various causes has found to cause changes in alkaline reserve. Underhill and Kruger (132) found a lowering in alkaline reserve due to shock and attributed it to the failure of the kidneys to excrete acids. Eggstein (133) found that protein shock lowered the alkaline reserve and that the alkaline reserve of a dog was lowered by an acute anaphylactic shock. However,if the dog survives the shock recovery is rapid and the alkaline reserve again becomes normal. Raymond (134) found that a quick surgical shock did not change the alkaline reserve but if it was continued over a long period of time there was an appreciable lowering. No definite relationship could be established between the alkaline reserve and the extent of the shock. It then appears that shock may cause a lowering in the alkaline reserve but that the alkaline reserve returns to normal shortly after the animal recovers from the shock.

Of passing interest is the work of Otto(135) in which he found that nicotine lowered the alkalinity of the blood of rabbits.

General Discussion and Summary of Review of Literature

A review of the literature shows that the reserve mineral matter in the blood stream for the purpose of neutralizing the acids thrown into it and thus maintain body neutrality is termed the alkaline reserve.

Previous to the perfection of the Van Slyke method it was a long and tedious task to estimate the alkaline reserve. Following the general adoption of the Van Slyke method investigators found that either oxalates, citrates, hirudin or fluorides could be successfully used as anticoagulants. They also found that by the use of small amounts of sodium fluoride the blood samples could be kept at room temperatures for a time without loss of carbon dioxide. The use of caprillic alcohol to prevent the foaming of the blood after the addition of the acid was recommended by the majority of investigators.

Two methods of collecting blood for analysis are outlined. The true Van Slyke method, where the blood is collected under oil and the MacRae needle method where the blood is allowed to fall through air reducing it approximately to arterial basis. A slight modification of the MacRae needle method introduced by Reed and Hoffman was found to be practical and accurate.

Some investigators doubting the accuracy of the Van Slyke method used other known and proven methods to check the Van Slyke method and found it accurate. On

account of the fact that the Van Slyke method is easier to apply and gives accurate results it has been adopted for use in the estimation of the alkaline reserve.

Since the adoption of the Van Slyke method much work has been done on the alkaline reserve of the blood. A review of the literature shows that the following normals have been established.

Normal adults adults from 55 to 77.8 volumes per cent
" " children " 43 " 67.8 " " " " .
Normal Horses " 52.8" 72.1 " " "
Swine 64.1 " " "
Normal Dairy Cattle
Plutherwick Cows 53.1 to 66.3 " " "
Calves 62.3 " 66.1 " " "

Reed and Huffman:

Heavy Milking well fed dairy cattle average 56.66 Vol.%
Non lactating well fed dairy heifers " 59.92 " ".

A variation in the alkaline reserve of dairy cattle during the day was observed.An unexplainable lowering of the alkaline reserve occurred immediately after feeding. This was followed by a gradual rise to about the level previous to feeding.

There was a slight variation in alkaline reserve from day to day. This variation would not materially in-

fluence the results obtained from bleeding a number of animals on the same experiment. The average would be about the same because the variation was not all in the same direction. The total average variation was less than two volumes per cent.

In pathological conditions such as acidosis and alkalosis the variations are large and no definite alkaline reserves could be stated. Acidosis a condition caused by a lowering of the alkaline reserve is accepted as due to a diminuation of the mineral matter of the blood resulting from an upset in the normal functioning of the body. A table has been worked out that gives the general levels at which the alkaline reserve indicates a condition of acidosis. Alkalosis, however, is a condition that does not frequently occur. It was found to be caused by an abnormally high alkaline reserve due to some upset in the functioning of the body.

No relationship was found to exist between alkaline reserve and tetany.

A number of factors were found to exert an influence on the alkaline reserve. Diet was found to cause a change in the level of the alkaline reserve. This change was probably due to two factors, the relation of the acid and basic minerals in the ash of the food and the protein contained. An increase in the amount of grain consumed causes a lowering of the alkaline reserve due to the acid character

of the ash of the grains. An increased protein intake causes an increase in the acid intermediate products of digestion and metabolism. Upon neutralization of these acid products a diminution in the alkaline reserve occurs.

Minerals were shown to cause considerable change in the alkaline reserve.

Acids introduced from the outside or as a result of metabolic processes cause a lowering of the alkaline reserve.

Colostrum milk, probably due to its high mineral content causes a rise in the alkaline reserve of calves. Whole milk on the other hand has but very little influence on the alkaline reserve of calves.

A diet of straw or silage did not have much effect on the alkaline reserve of dairy cattle.

Strenuous exercise was found to cause a marked lowering in the alkaline reserve, due no doubt to the formation of lactic acid in the tissues as a result of the muscular activity. This acid enters the blood stream and must be neutralized. The neutralization causes a drop in the alkaline reserve. Moderate exercise caused only a slight reduction of the alkaline reserve of dairy cattle.

Breathing unless artificially stimulated does not have any influence on the alkaline reserve.

Body temperature was shown to bear a direct.

relationship to the alkaline reserve of dairy cattle. For every degree the temperature was above normal there was a one volume per cent reduction in the alkaline reserve.

Hemorrhage causes a lowering of the alkaline reserve.

Sleep does not exert any influence upon the alkaline reserve.

Anaesthesia does not have any permanent influence on the alkaline reserve although a marked lowering is apparent at the time the patient is put under the influence of the anaesthesia. As soon as the patient came out from under the influence of the anaesthesia the alkaline reserve returned to normal.

A temporary decrease in the alkaline reserve was caused by severe shock.

Vomiting was shown to cause a change in the alkaline reserve. The direction of the change was dependent upon the cause and extent of the vomiting.

It is evident from the review of literature that the proper health and well being of an animal is dependent quite largely upon the level of the alkaline reserve.

The work of Platherwick and that of Reed and Huffman shows conclusively that the alkaline reserve of dairy cattle is subject to considerable variation and that it can be influenced by a number of factors. Their results suggest a study of the alkaline reserve of dairy cattle kept under ordinary farm conditions with a view of establishing the normal alkaline reserve.

EXPERIMENTAL WORK

Plan of the Experimental Work

Object of the Experimental Work

The object of this experimental work is to study the alkaline reserve of dairy cattle under ordinary farm conditions. This study will lead to the establishment of a normal alkaline reserve for dairy cattle under such conditions. The effect of diet, milk production, exercise, weather conditions, and body condition on alkaline reserve is to be studied at the same time.

General Plan and Outline

Several herds of dairy cattle on neighboring farms are to be selected for this study. Effort will be made to select herds that represent the ordinary variation in feeding practises.

Blood samples will be taken, previous to the morning feed, at intervals which will permit a study of a variety of conditions of feed and management. Attempt will be made to secure blood samples from the herds under the following conditions:

1. While the cattle are on dry feed.
2. After the cattle have been on pasture for two weeks.
3. Late in the summer when the pastures have dried up.
4. Two weeks after changing from pasture to dry feed.
5. After two months on dry feed.

The Reed and Huffman modification of the MacFae needle method will be used to secure the blood samples.

The alkaline reserves are to be determined in duplicate on the Van Slyke apparatus using the technic employed by Reed and Huffman.(see p.25 to 27)

Selection of the Herds

Five herds are to be selected showing the following feed conditions:

1.No pasture or soiling crop,dry feed the year around.

2.No legume but receiving pasture.

3.Legume,pasture, and silage.

4.Legume,pasture but no silage.

5.Legume,pasture,silage and 1% bone meal.

Observations to be Made in the Field

The following observations are to be made:

1.Date of bleeding.

2.Feed conditions.

3.Body condition;good,fair or poor.

4.Amount of exercise before bleeding,if other than on pasture.

5.Weather conditions;clear or cloudy.

6.Milking and the amount;heavy,medium,or light.

Heavy above 20# per day

Medium between 10 and 20# per day.

Light below 10# per day.

The animals were to be identified either by color markings,ear tags, or in instances where the owner knew the cows by name this method of identification was used. Color

markings were to be used to identify all animals not in milk.

Experimental Data

It was not possible to secure herds that just fitted the desired conditions but those showing the following feed conditions were obtained.

1. Herd receiving silage, alfalfa, light grain ration and pasture
2. " " " " medium " " " "
3. " " " " " " " "
4. " " " mixed hay and pasture, no grain.
5. " " " " " and some grain no pasture.

The herds were composed of the following breeds:

Herd no 1. Grade holsteins.

" " 2. Pure bred and grade guernseys.

" " 3. Pure bred jerseys.

" " 4. Grade holsteins.

" " 5. Grade holsteins.

They will be referred to as numbered. The collected data, by herds, is found in the following tables:

HERD NO 1

Cow No.	Date	Feed	Condition	Amount of milk	Weather	Exercise	Av. Alk Reserve
1.	Apr. 9	Silage, corn and oats	Poor	None	Clear	None	59.3
	This animal was sold.						
2.	Apr. 9	Silage, corn and oats	Fair	"	"	"	56.2
	June 2	Pasture	"	"	"	"	57.3
	This animal was sold.						
3.	Apr. 9	Silage, corn and oats	"	Medium	"	"	61.1
	June 2	Pasture	"	Medium	"	"	64.7
	Aug. 4	Pasture	"	"	"	"	58.2
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	74.9
	Jan.12	" " "	"	"	"	"	77.0
4.	Apr. 9	Silage, corn and oats	"	"	Clear	"	56.6
	June 2	Pasture	"	"	"	"	62.1
	Aug. 4	Pasture	Good	"	"	"	74.2
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	71.9
	Jan.12	" " "	"	"	"	"	74.0
5.	Apr. 9	Silage, corn and oats	Fair	Light	Clear	"	62.5
	June 2	Pasture	"	"	"	"	59.8
	Aug. 3	Pasture	Good	"	"	"	58.2
	This animal was sold.						
6.	Apr. 9	Silage, corn and oats	Fair	None	Clear	"	58.2
	June 2	Pasture	Good	"	"	"	57.6
	Aug. 3	Pasture	"	"	"	"	62.1
	Nov. 7	Silage and alfalfa	Fair	Heavy	Cloudy	"	69.3
	Jan.12	" " "	"	"	"	"	71.0

HERD NO 1

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk Reserve
7.	Apr. 9	Silage, corn and oats	Fair	Heavy	Clear	None	[illegible]
	June 1	Pasture	"	Medium	" [illegible]	"	[illegible]
	Aug. 8	Pasture	"	"	" "	"	[illegible]
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	[illegible]
	Jan. 12	" " "	"	"	"	"	[illegible]
8.	Apr. 9	Silage, corn and alfalfa	"	"	Clear	"	[illegible]
	June 1	Pasture	Poor	"	" [illegible]	"	[illegible]
	Aug. 8	Pasture	Fair	"	" "	"	[illegible]
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	[illegible]
	Jan. 12	" " "	"	"	"	"	72.2
9.	Apr. 9	Silage, corn and oats	"	"	Clear	"	[illegible]
	June 2	Pasture	"	Light	" [illegible]	"	[illegible]
	Aug. 8	Pasture	"	Heavy	" "	"	[illegible]
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	[illegible]
	Jan. 12	" " "	"	Medium	"	"	[illegible]
10.	Apr. 9	Silage, corn and oats	"	None	Clear	"	[illegible]
	June 1	Pasture	"	"	" [illegible]	"	[illegible]
	Aug. 8	Pasture	"	Heavy	" "	"	[illegible]
	Nov. 7	Silage and alfalfa	"	Medium	Cloudy	"	[illegible]
	Jan. 12	" " "	"	"	"	"	65.0
11.	Apr. 9	Silage, corn and oats	"	"	Clear	"	[illegible]
	June 2	Pasture	"	"	" [illegible]	"	[illegible]
	Aug. 8	Pasture	"	"	" "	"	[illegible]
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	[illegible]
	Jan. 12	" " "	"	"	"	"	72.2

HERD NO 1

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Milk Previous
12.	Apr. 2	Silage, corn and oats	Fair	Heavy	Clear	Fair	65.2
	June 2	Pasture	"	"	" S.S	"	60.7
	This animal was sold.						
13.	Apr. 2	Silage, corn and oats	"	Heavy	Clear	"	57.1
	June 2	Pasture	"	Heavy	" S.S	"	50.3
	Aug. 3	Pasture	"	"	" "	"	43.4
	Nov. 7	Silage and alfalfa	"	Medium	Cloudy	"	31.3
	Jan.12	" " "	"	"	"	"	32.2
14.	Apr. 2	Silage, corn and oats	Good	Heavy	Clear	"	59.2
	June 2	Pasture	Fair	"	" S.S.	"	50.7
	This animal was sold.						
15.	Apr. 2	Silage, corn and oats	Good	"	Clear	"	57.1
	June 2	Pasture	Fair	"	" S.S	"	49.7
	Aug.3	Pasture	Good	"	" "	"	43.1
	Nov. 7	Silage and alfalfa	Fair	"	Cloudy	"	33.3
	This animal was sold.						
16.	Apr. 2	Silage, corn and oats	"	"	Clear	"	58.3
	June 2	Pasture	"	"	" S.S	"	51.7
	Aug. 3	Pasture	Good	"	" "	"	39.1
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	32.3
	Jan.12	" " "	"	"	"	"	32.3
17.	Apr. 2	Silage, corn and oats	Fair	"	Clear	"	57.3
	June 2	Pasture	"	"	" S.S	"	54.7
	Aug. 3	Pasture	Good	"	" "	"	37.1
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	31.3
	Jan.12	" " "	Fair	"	"	"	30.3

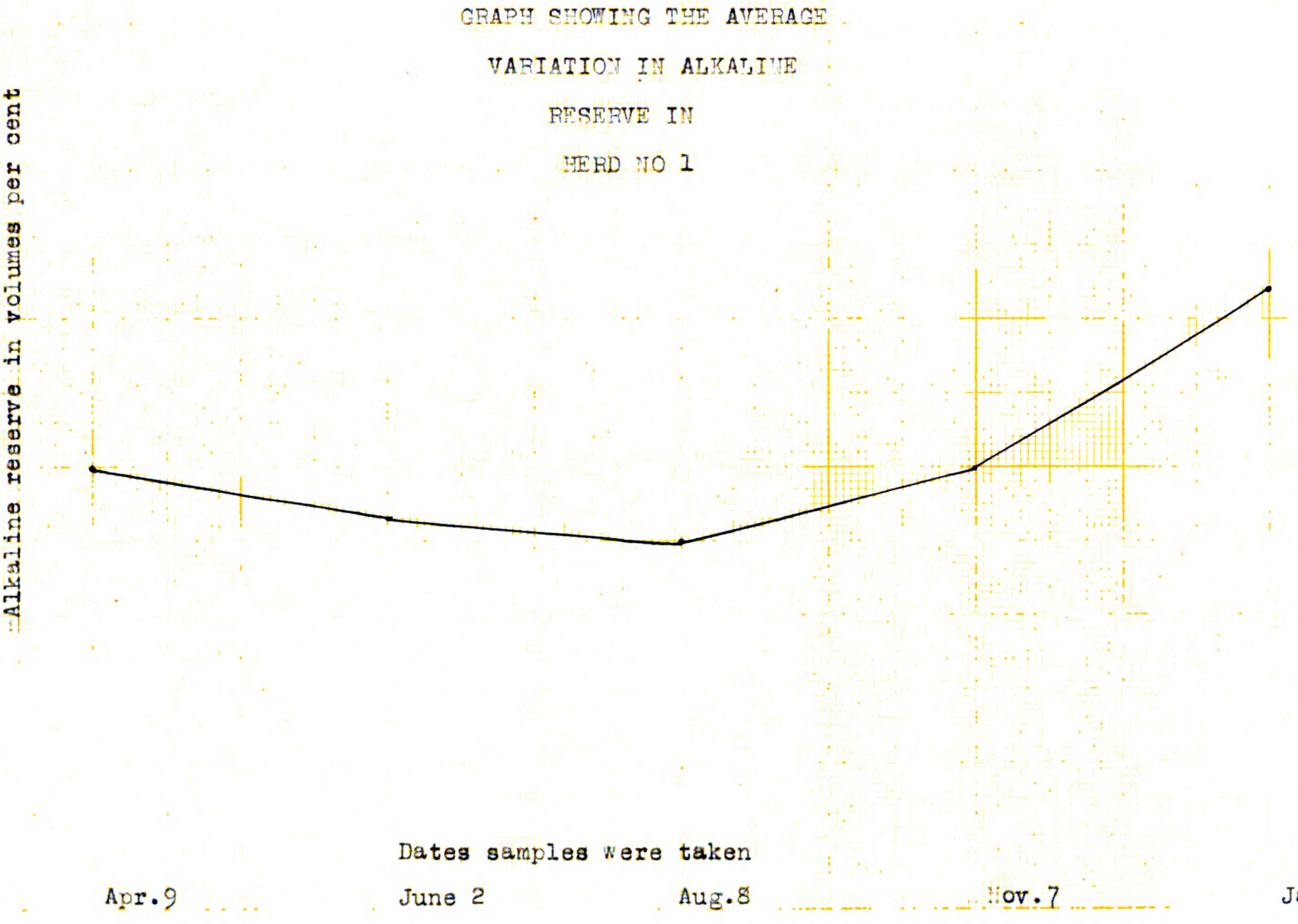
HERD NO 1

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
11.	June 2	Colostrum milk	Good	None	Clear [illegible]	None	6[illegible].[illegible]
	This animal was sold						
1[illegible].	June 2	Colostrum milk	"	"	" "	"	[illegible]
	Aug. 8	Pasture	Fair	"	" "	"	[illegible]
	Nov. 7	Silage and alfalfa	"	"	Cloudy	"	[illegible]
	Jan. 12	" " "	"	"	"	"	[illegible]

TABLE SHOWING THE ALKALINE RESERVES, IN VOLUMES PER CENT OF HERD NO. 1

Cow No.	Date of Bleeding					
	Apr. 9	June 2	Aug. 3	Nov. 7	Jan. 12	Average
1.	[illegible]					[illegible]
2.	[illegible]	67.3				[illegible]
3.	[illegible]	[illegible]	56.7	61.6	77.[illegible]	[illegible]
4.	[illegible]	62.1	[illegible]	[illegible]	[illegible]	[illegible]
5.	[illegible]	[illegible]	56.5			[illegible]
6.	[illegible]	[illegible]	[illegible]	62.5	[illegible]	[illegible]
7.	[illegible]	[illegible]	57.2	[illegible]	[illegible]	[illegible]
8.	[illegible]	[illegible]	[illegible]	[illegible]	72.2	[illegible]
9.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.	[illegible]	[illegible]	53.6	[illegible]	72.2	[illegible]
12.	[illegible]	[illegible]				[illegible]
13.	[illegible]	[illegible]	[illegible]	60.6	[illegible]	[illegible]
14.	[illegible]	[illegible]				58.7[illegible]
15.	57.[illegible]	[illegible]	55.4	[illegible]		[illegible]
16.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.	[illegible]	[illegible]	52.7	[illegible]	[illegible]	[illegible]
18.		54.2				[illegible]
19.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Average	60.[illegible]	57.[illegible]	[illegible]	[illegible]	[illegible]	

GRAPH SHOWING THE AVERAGE
VARIATION IN ALKALINE
RESERVE IN
HERD NO 1



EXPT NO 2

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk Reserve
1.	Apr.27	Alfalfa, silage and grain	Fair	More	Clear S.S	None	54.1
	May 31	Pasture, some hay	"	Heavy	" "	"	55.2
	Aug. 8	Pasture	Good	"	Cloudy	"	47.9
	Oct.31	Alfalfa and silage	"	"	Clear	"	50.8
	Jan.10	Alfalfa, silage and grain	"	Medium	Cloudy	"	55.7
2.	Apr.27	Alfalfa, silage and grain	"	Heavy	Clear S.S	"	51.6
	May 31	Pasture some hay	"	"	" "	"	57.1
	Aug. 8	Pasture	"	Medium	Cloudy	"	47.9
	Oct.31	Alfalfa and silage	"	"	Clear	"	49.2
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	46.8
3.	Apr.27	Alfalfa, silage and grain	"	Heavy	Clear S.S	"	60.4
	May 31	Pasture some hay	"	"	" "	"	61.4
	Aug. 8	Pasture	"	Medium	Cloudy	"	49.5
	Oct.31	Alfalfa and silage	"	"	Clear	"	51.2
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	55.6
4.	Apr.27	Alfalfa, silage and grain	"	Heavy	Clear S.S	"	55.1
	May 31	Pasture some hay	"	"	" "	"	54.3
	Aug. 8	Pasture	"	"	Cloudy	"	48.9
	Oct.31	Alfalfa and silage	"	"	Clear	"	47.7
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	47.6
5.	Apr.27	Alfalfa, silage and grain	"	Medium	Clear S.S	"	66.3
	May 31	Pasture some hay	"	"	" "	"	60.1
	Aug. 8	Pasture	"	"	Cloudy	"	50.3
	Oct.31	Alfalfa and silage	"	"	Clear	"	53.3
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	55.2

HERD NO 2

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk Reserve
6.	Apr.23	Alfalfa, silage and grain	Fair	Medium	Clear S.S	None	57.2
	May 31	Pasture some hay	Good	"	" "	"	52.1
	Aug. 8	Pasture	Fair	Light	Cloudy	"	50.6
	Oct.31	Alfalfa and silage	"	"	Clear	"	52.0
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	52.2
7.	Apr.23	Alfalfa, silage and grain	Good	Medium	Clear S.S	"	57.8
	May 31	Pasture some hay	"	"	" "	"	51.7
	Aug. 8	Pasture	"	"	Cloudy	"	50.0
	Oct.31	Alfalfa and silage	"	"	Clear	"	50.1
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	52.3
8.	Apr.23	Alfalfa, silage and grain	Fair	Heavy	Clear S.S	"	60.4
	May 31	Pasture some hay	Good	Medium	" "	"	53.0
	Aug. 8	Pasture	Fair	"	Cloudy	"	50.0
	Oct.31	Alfalfa and silage	Good	"	Clear	"	53.0
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	54.0
9.	Apr.23	Alfalfa, silage and grain	Good	"	Clear S.S	"	57.7
	May 31	Pasture some hay	"	"	" "	"	52.7
	Aug. 8	Pasture	"	Light	Cloudy	"	51.7
	Oct.31	Alfalfa and silage	"	"	Clear	"	52.0
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	53.0
10.	Apr.23	Alfalfa, silage and grain	Fair	Medium	Clear S.S	"	57.3
	May 31	Pasture some hay	"	"	" "	"	53.0
	Aug. 8	Pasture	"	"	Cloudy	"	51.4
	Oct.31	Alfalfa and silage	"	Light	Clear	"	53.7
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	53.3

HERD NO. 2

Cow No.	Date	Feed	Condition	Amount of milk	Weather	Exercise	Av. Alk Reserve
11.	Apr.23	Alfalfa, silage and grain	Fair	Medium	Clear S.S	None	56.8
	May 31	Pasture some hay	"	"	" "	"	54.8
	Aug. 8	Pasture	"	"	Cloudy	"	53.3
	This animal was sold.						
12.	Apr.23	Alfalfa, silage and grain	"	Light	Clear S.S	"	64.3
	May 31	Pasture some hay	"	"	" "	"	63.1
	Aug. 8	Pasture	"	"	Cloudy	"	57.6
	Oct.31	Alfalfa and silage	"	"	Clear	"	60.3
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	57.5
13.	Apr.23	Alfalfa, silage and grain	Good	Medium	Clear S.S	"	56.8
	May 31	Pasture some hay	"	"	" "	"	54.3
	Aug. 8	Pasture	"	"	Cloudy	"	50.2
	Oct.31	Alfalfa and silage	"	Light	Clear	"	58.4
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	55.6
14.	Apr.23	Alfalfa, silage and grain	"	Medium	Clear S.S	"	56.0
	May 31	Pasture some hay	"	"	" "	"	56.0
	Aug. 8	Pasture	"	"	Cloudy	"	51.2
	Oct.31	Alfalfa and silage	"	Light	Clear	"	55.6
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	53.6
15.	Apr.23	Alfalfa, silage and grain	Fair	Medium	Clear S.S	"	51.5
	May 31	Pasture some hay	"	"	" "	"	50.9
	Aug. 8	Pasture	"	Light	Cloudy	"	45.9
	Oct.31	Alfalfa and silage	"	"	Clear	"	50.8
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	48.0

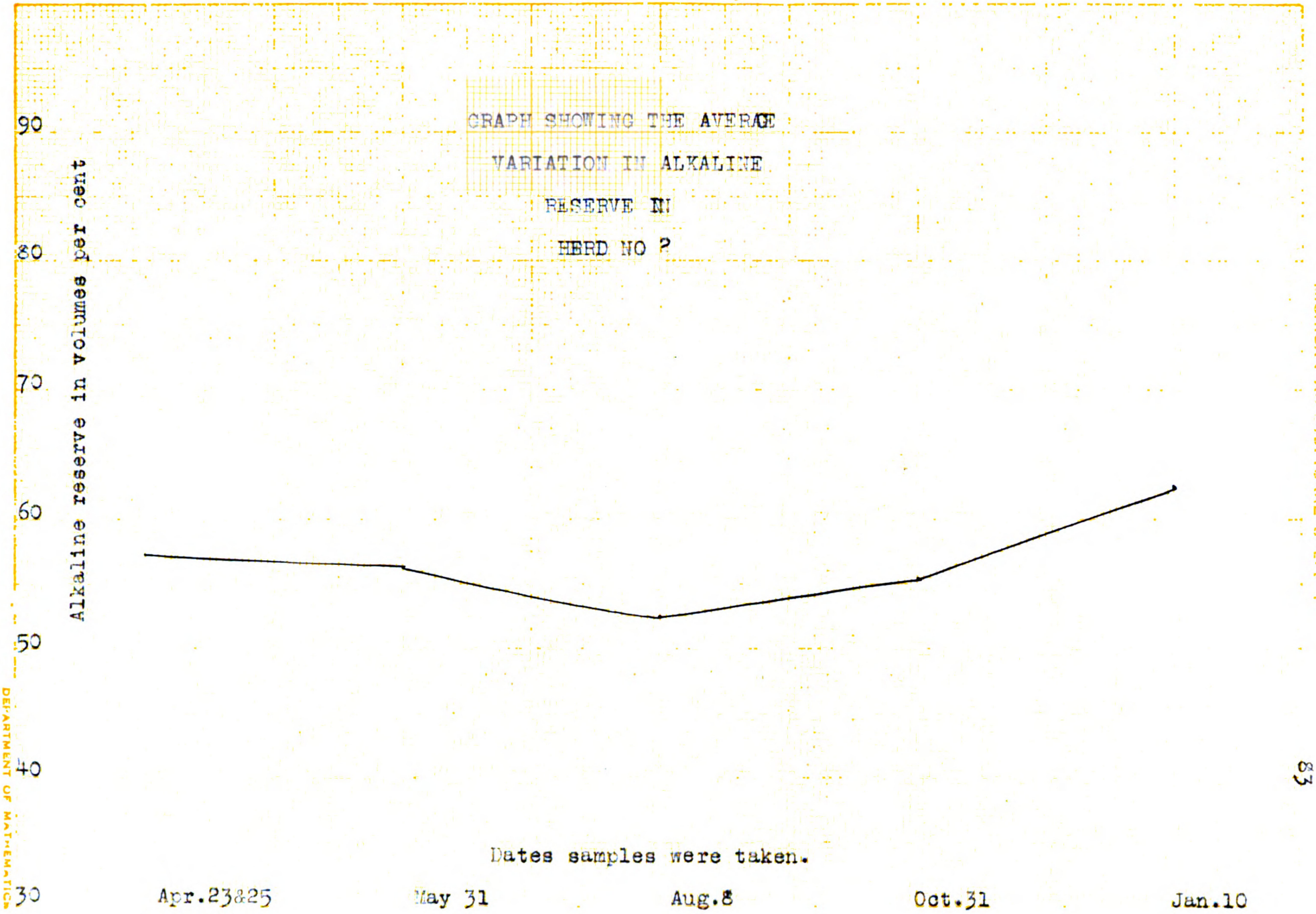
HERD NO 2

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
16.	Apr.25	Alfalfa, silage and grain	Fair	Medium	Clear S.S	None	51.
	May 31	Pasture some hay	"	"	" "	"	50.
	Aug. 6	Pasture	"	"	Cloudy	"	48.
	Oct.31	Alfalfa and silage	"	Light	Clear	"	51.
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	47.
17.	Apr.25	Alfalfa, silage and grain	"	"	Clear S.S	"	54.
	May 31	Pasture some hay	"	"	" "	"	55.
	Aug. 6	Pasture	"	"	Cloudy	"	50.
	Oct.31	Alfalfa and silage	Poor	"	Clear	"	53.
	Jan.10	Alfalfa, silage and grain	"	"	Cloudy	"	51.
18.	Apr.25	Alfalfa, silage and grain	Fair	None	Clear S.S	"	50.
	May 31	Pasture some hay	"	"	" "	"	48.
	Aug. 6	Pasture	"	"	Cloudy	"	49.
	This animal was sold.						
19.	Apr.25	Alfalfa, silage and grain	"	"	Clear S.S	"	51.
	May 31	Pasture some hay	"	"	" "	"	50.
	Aug. 6	Pasture	"	"	Cloudy	"	51.
	This animal was sold.						
20.	Apr.25	Alfalfa, silage and grain	"	"	Clear S.S	"	53.
	May 31	Pasture some hay	"	"	" "	"	52.
	Aug. 6	Pasture	"	"	Cloudy	"	52.
	This animal was sold						
21.	Apr.25	Alfalfa, silage and grain	Good	"	Clear S.S	"	57.
	May 31	Pasture some hay	"	"	" "	"	56.
	Aug. 6	Pasture	"	"	Cloudy	"	54.
	Oct.31	Alfalfa and silage	"	"	Clear	"	56.
	Jan.10	" , silage and grain	"	"	Cloudy	"	56.

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
22.	Apr.25	Alfalfa, silage and grain	Fair	None	Clear S.S	None	50.1
	May 31	Pasture some hay	"	"	" "	"	55.7
	Aug. 8	Pasture	"	"	Cloudy	"	59.5
	This animal was sold.						
23.	Unable to bleed this animal						
24.	Apr. 25	Alfalfa, silage and grain	"	"	Clear S.S	"	54.8
	May 31	Pasture	Good	"	" "	"	59.9
	Aug. 8	Pasture	"	"	Cloudy	"	59.3
	Oct.31	Alfalfa and silage	"	"	Clear	"	56.2
	Jan.10	" " "	"	"	Cloudy	"	57.7
25.	Apr.25	Milk	"	"	Clear S.S	"	58.8
	May 31	"	Fair	"	" "	"	57.4
	Aug. 8	Skim milk and oats	"	"	Cloudy	"	54.4
	Oct.31	Alfalfa and silage	"	"	Clear	"	57.7
	Jan.10	" " "	"	"	Cloudy	"	52.5
26.	Apr.25	Alfalfa and silage	Good	"	Clear S.S	"	58.9
	May 31	Pasture	"	"	" "	"	56.4
	Aug. 8	"	"	"	Cloudy	"	54.7
	Oct.31	Alfalfa and silage	"	"	Clear	"	58.9
	This animal was sold.						
27.	Apr.25	Milk	Good	"	Clear S.S	"	57.3
	May 31	Skim milk and oats	Fair	"	" "	"	54.4
	Aug. 8	Pasture	"	"	Cloudy	"	52.0
	Oct.31	Silage and alfalfa	"	"	Clear	"	58.2
	Jan.15	" " "	"	"	Cloudy	"	54.1

HERD NO. 2

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. All. Reserve
23.	Apr.23	Before sucking	Fair	None	Clear C.S	None	3[illegible].3
	Apr.25	Colustrum Milk	"	"	" "	"	[illegible].5
	May 31	Milk	Good	" "	" "	" "	[illegible].7
	Aug. [illegible]	Pasture	"	"	Cloudy	"	[illegible]
	Oct.[illegible]1	Alfalfa and silage	"	"	Clear	"	37.2
	Jan.[illegible]	" " "	"	"	Cloudy	"	34.[illegible]



Co. No.	Date	Feed	Condition	Amount of Milk	Weather	Pasture	Av./lb. Fat Test
1.	Apr.10	Silage, alfalfa, C.Sts., Corn Potatoes and corn stalks	Fair	Medium	Clear	None	3.1
	June 1	Pasture, corn gluten, silage	"	"	" "	"	3.1
	Aug.20	Pasture, alfalfa, oats, barley	"	"	" "	"	3.1
	Oct.30	Corn stalks, alfalfa, CSM, barley	"	"	Cloudy	"	3.2
	Jan.11	Silage, alfalfa, dry meal, barley	"	"	"	"	3.0
2.	Apr.12	Silage, alfalfa, CSM, corn Potatoes and corn stalks.	"	"	Clear	"	3.6
	June 1	Pasture, corn gluten, silage	"	"	" "	"	3.4
	Aug.10	Pasture, alfalfa, oats, barley	Cloud	Light	" "	"	3.3
	Oct.30	Corn stalks, alfalfa, CSM, barley	"	"	Cloudy	"	3.6
	Jan.11	Silage, alfalfa, dry meal, barley	"	"	"	"	3.7
3.	Apr.12	Silage, alfalfa, CSM, corn Potatoes and corn stalks	Fair	Medium	Clear	"	3.5
	June 1	Pasture, bran, gluten, silage	Cloud	"	" "	"	3.4
	Aug.20	Pasture, alfalfa, oats, barley	"	None	" "	"	3.5
	Oct.30	Corn stalks, alfalfa, CSM, barley	Fair	"	Cloudy	"	3.5
	Jan.11	Silage, alfalfa, dry meal, barley	"	"	"	"	3.5
4.	Apr.12	Silage, alfalfa, CSM, corn Potatoes and corn stalks	"	Light	Clear	"	3.4
	June 1	Pasture, bran, gluten, silage	"	Medium	" "	"	3.7
	Aug.20	Pasture, alfalfa, oats, barley	Cloud	"	" "	"	3.4
	Oct.30	Corn stalks, alfalfa, CSM, barley	Fair	"	Cloudy	"	3.6
	Jan.11	Silage, alfalfa, dry meal, barley	"	"	"	"	3.8
5.	Apr.12	Silage, alfalfa, CSM, corn	"	Light	Clear	"	3.4
	June 1	Pasture, bran, gluten, silage	"	Medium	" "	"	3.5
	Aug.20	Pasture, alfalfa, oats, barley	Good	Light	" "	"	3.4
	Oct.30	Corn stalks, alfalfa, CSM, barley	"	"	Cloudy	"	3.7
	Jan.11	Silage, alfalfa, dry meal, barley	"	"	"	"	3.7

HERD NO. [illegible]

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
6.	Apr.18	Silage, alfalfa, CCM, corn Potatoes and corn stalks.	Fair	None	Clear	None	54.0
	June 1	Pasture, bran, gluten, silage	"	"	" S.S	"	52.2
	Aug.10	Pasture, alfalfa, [illegible], barley	Good	Light	" "	"	51.6
	Oct.30	Silage, alfalfa, CCM, barley	Fair	"	Cloudy	"	[illegible]
	Jan.11	Silage, alfalfa, oil meal, barley	"	"	"	"	51.6
7.	Apr.18	Silage, alfalfa, CCM, corn Potatoes and corn stalks.	"	None	Clear	"	[illegible]
	June 1	Pasture	"	"	" S.S	"	56.2
	Aug.10	Pasture	"	"	" "	Little	54.7
	Oct.30	Corn stalks, alfalfa, CCM, barley	"	Medium	Cloudy	"	[illegible]
	Jan.11	Silage, alfalfa, oil meal, barley	"	"	"	"	50.5
8.	Apr.18	Silage, alfalfa, CCM, corn Potatoes and corn stalks.	Good	None	Clear	None	54.4
	June 1	Pasture	"	"	" S.S	"	[illegible]
	Aug.10	"	"	"	" "	Little	[illegible]
	Oct.30	Corn stalks, alfalfa, CCM, barley	Fair	"	Cloudy	"	[illegible]
	Jan.11	Silage, alfalfa, oil meal, barley	"	"	"	None	[illegible]
9.	Apr.18	Silage, alfalfa, CCM, corn, Potatoes and corn stalks	"	"	Clear	"	53.7
	June 1	Pasture	Good	"	" S.S	"	[illegible]
	Aug.10	"	"	"	" "	Little	[illegible]
	Oct.30	Corn stalks, alfalfa, CCM, barley	Fair	"	Cloudy	"	[illegible]
	Jan.11	Silage, alfalfa, oil meal, barley	"	"	"	None	52.5
10.	Apr.18	Silage, alfalfa, CCM, corn, Potatoes and corn stalks.	"	"	Clear	"	[illegible]
	June 1	Pasture	Good	"	" S.S	"	57.1
	Aug.10	"	Fair	"	" "	Little	[illegible]
	Oct.30	Corn stalks, alfalfa, CCM, barley	"	"	Cloudy	"	[illegible]
	Jan.11	Silage, alfalfa, oil meal, barley	"	"	"	None	[illegible]

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Ac.Alk. Reserve
11.	Apr.16	Silage,alfalfa,CSM,corn. Potatoes and corn stalks	Fair	None	Clear	None	61.2
	June 1	Pasture	"	"	" C.C	"	[illegible]
	Aug.10	"	"	"	" "	Little	[illegible]
	Oct.30	Silage,alfalfa,CSM,barley	"	"	Cloudy	"	[illegible]
	Jan.11	Silage,alfalfa,oil meal,barley	"	"	"	None	[illegible]
12.	Apr.16	Whole milk,alfalfa	"	"	Clear	"	67.4
	June 1	Skim milk,pasture	Good	"	" C.C	"	[illegible]
	Aug.10	Pasture	Fair	"	" "	"	[illegible]
	Oct.30	Silage,alfalfa,CSM, barley	"	"	Cloudy	"	[illegible]
	Jan.11	Silage,alfalfa,oil meal,barley	"	"	"	"	[illegible]

TABLE [illegible]
[illegible]
[illegible]

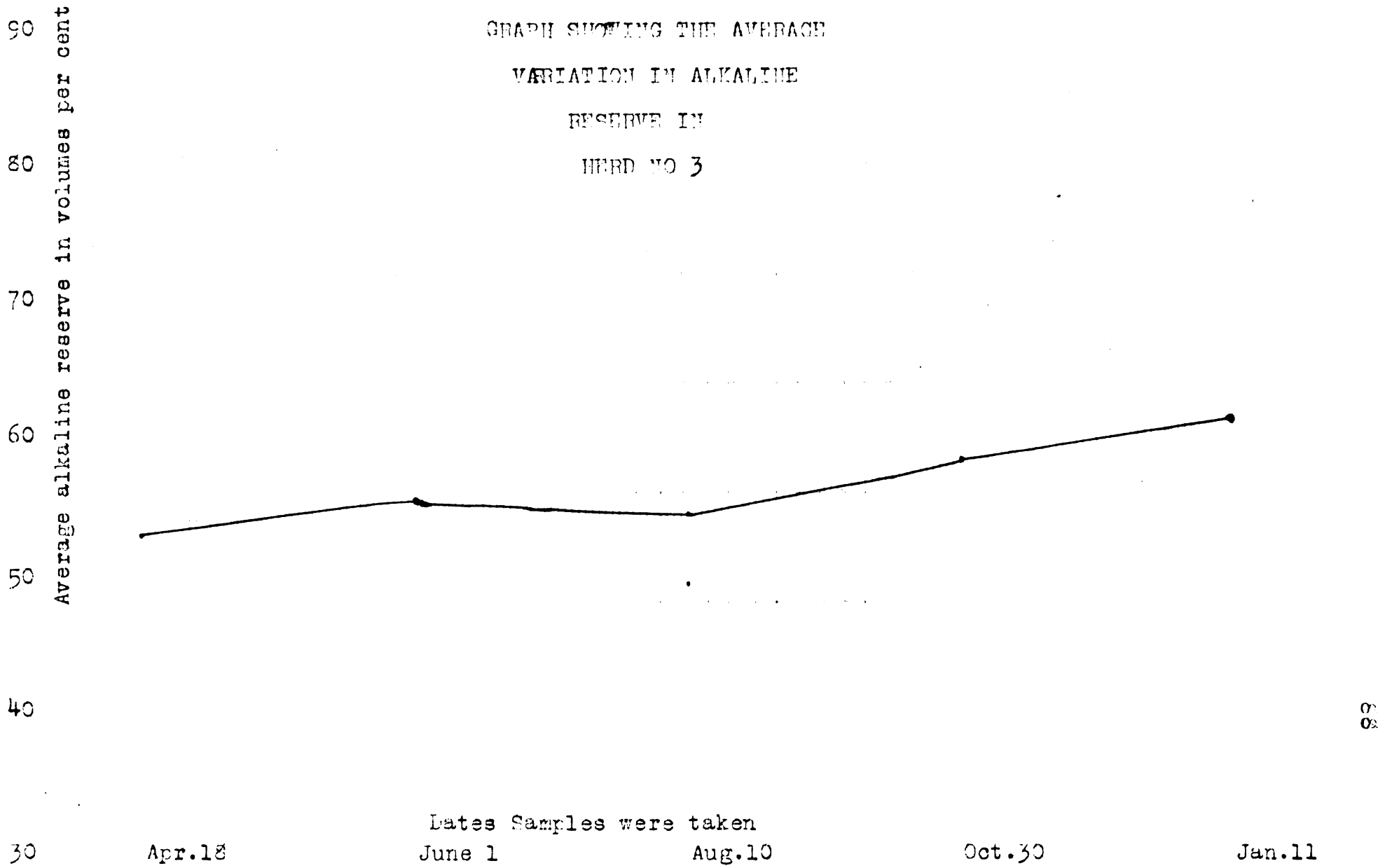
Cow No.	Apr.13	June 1	Aug. [illegible]	Oct.[illegible]	Jan.11	Average
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	57.1	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	67.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aver.	[illegible]	[illegible]	[illegible]	[illegible]	62.65	

GRAPH SHOWING THE AVERAGE

VARIATION IN ALKALINE

RESERVE IN

HERD NO 3



HERD NO 4

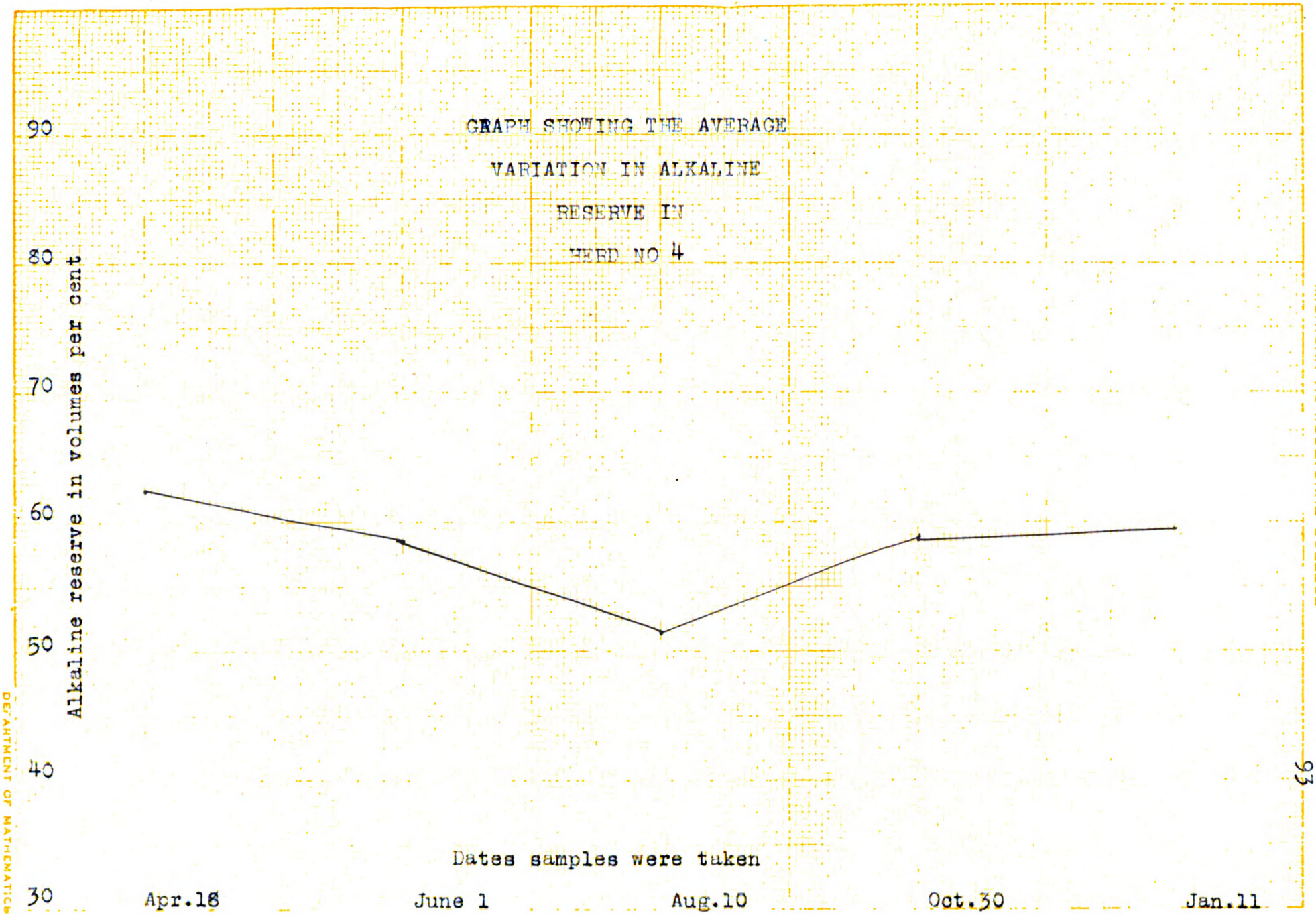
Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
13.	Apr.13	Silage and timothy	Fair	Medium	Clear	None	53.5
	June 1	Pasture	"	"	" S.S	"	51.7
	Aug.10	Pasture and green corn	"	"	" "	"	49.7
	Oct.30	Weedy soy bean hay	"	None	Cloudy	"	52.7
	Jan.11	Silage,hay,rye and oats	"	"	"	"	67.9
14.	Apr.13	Silage and timothy	"	Heavy	Clear	"	60.2
	June 1	Pasture	"	"	" S.S	"	61.7
	Aug.10	Pasture and green corn	"	Medium	" "	"	50.4
	Oct.30	Weedy soy bean hay	Poor	"	Cloudy	"	57.4
	Jan.11	Silage,hay,rye and oats	"	"	"	"	62.9
15.	Apr.13	Silage and timothy	"	"	Clear	"	70.1
	June 1	Pasture	"	Light	" S.S	"	64.7
	Aug.10	Pasture and green corn	"	"	" "	"	57.5
	Oct.30	Weedy soy bean hay	"	"	Cloudy	"	66.7
	Jan.11	Silage,hay,rye and oats	"	"	"	"	65.4
16.	Apr.16	Silage and timothy	"	Medium	Clear	"	72.7
	June 1	Pasture	"	"	" S.S	"	71.3
	Aug.10	Pasture and green corn	"	Heavy	" "	"	71.4
	Oct.30	Weedy soy bean hay	"	Medium	Cloudy	"	68.3
	Jan.11	Silage,hay,rye and oats	"	"	"	"	65.3
17.	Apr.16	Silage and timothy	Fair	Heavy	Clear	"	64.3
	June 1	Pasture	"	Medium	" S.S	"	61.2
	Aug.10	Pasture and green corn	"	Light	" "	"	52.7
	Oct.30	Weedy soy bean hay	"	"	Cloudy	" "	64.7
	Jan.11	Silage,hay,rye and oats	"	"	"	"	63.1

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
18.	Apr.18	Silage and timothy	Fair	None	Clear	None	57.6
	June 1	Pasture	"	"	" S.S	"	55.7
	Aug.10	Pasture and green corn	"	Light	" "	"	54.7
	Oct.30	Weedy soy bean hay	"	"	Cloudy	"	52.2
	Jan.11	Silage,hay,rye and oats	"	"	"	"	52.7
19.	Apr.18	Silage and timothy	"	None	Clear	"	57.6
	June 1	Pasture	"	"	" S.S	"	57.1
	Aug.10	Pasture and green corn	Good	"	" "	"	56.6
	Oct.30	Weedy soy bean hay	Fair	Light	Cloudy	"	53.2
	Jan.11	Silage,hay,rye and oats	"	"	"	"	54.4
20.	Apr.18	Silage and timothy	"	None	Clear	"	57.6
	June 1	Pasture	"	"	" S.S	"	57.1
	Aug.10	Pasture and green corn	"	"	" "	"	56.6
	Oct.30	Weedy soy bean hay	"	"	Cloudy	"	53.2
	Jan.11	Silage,hay,rye and oats	"	"	"	"	54.4
21.	Apr.18	Silage and timothy	"	"	Clear	"	59.2
	June 1	Pasture	"	"	" S.S	"	58.7
	Aug.10	Pasture and green corn	"	"	" "	"	58.2
	Oct.30	Weedy soy bean hay	"	"	Cloudy	"	55.7
	Jan.11	Silage,hay,rye and oats	"	"	"	"	56.4
22.	Apr.18	Silage and timothy	"	"	Clear	Little	60.1
	June 1	Pasture	"	"	" S.S	Some	59.6
	Aug.10	Pasture and green corn	"	"	" "	None	59.1
	Oct.30	Weedy soy bean hay	"	"	Cloudy	"	56.7
	Jan.11	Silage,hay,rye and oats	"	"	"	"	57.4

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
29.	Apr.17	Silage and timothy	Fair	None	Clear	Little	60.2
	June 1	Pasture	Good	"	"	None	48.6
	Aug.15	Pasture and green corn	Fair	"	"	"	50.7
	Oct.20	Woody dry bean hay	"	"	Cloudy	"	57.2
	Jan.11	Silage, hay, rye and oats	"	"	"	"	59.6

[illegible]

Cow No.	Dates of Bleeding					Average
	Apr.12	June 1	Aug.20	Oct.30	Jan.11	
[illegible]						
Average						



EXPT NO 5

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Mlk. Reserve
1	Apr.11	Alfalfa, silage and grain	Poor	Light	Clear	None	22.3
	June 7	" " " "	"	"	Rainy	"	20.1
	Aug.11	Clover, silage and grain	"	"	Cloudy	"	21.3
	Nov.11	" " " "	"	"	Clear	"	18.4
	Jan.11	" " " "	"	"	"	"	No Sample
2.	Apr.11	Alfalfa, silage and grain	Fair	Medium	Clear	"	26.2
	June 7	" " " "	"	"	Rainy	"	23.7
	Aug.11	Clover silage and grain	"	"	Cloudy	"	24.3
	This animal was discarded.						
3.	Apr.11	Alfalfa, silage and grain	"	Heavy	Clear	"	27.7
	June 7	" " " "	"	"	Rainy	"	24.1
	Aug.11	Clover " " "	"	"	Cloudy	"	25.2
	Nov.11	" " " "	"	Medium	Clear	"	26.3
	Jan.11	Alfalfa " " "	"	"	"	"	29.2
4.	Apr.11	Alfalfa, silage and grain	Poor	"	"	"	22.3
	June 7	" " " "	"	"	Rainy	"	20.2
	Aug.11	Clover " " "	Fair	Light	Cloudy	"	21.1
	Nov.11	" " " "	"	Light	Clear	"	24.2
	Jan.11	Alfalfa " " "	"	"	"	"	23.3
5.	Apr.11	Alfalfa, silage and grain	"	Heavy	"	"	27.4
	June 7	" " " "	"	"	Rainy	"	24.2
	Aug.11	Clover " " "	"	Medium	Cloudy	"	25.1
	Nov.11	" " " "	"	Light	Clear	"	22.4
	Jan.11	Alfalfa " " "	"	"	"	"	23.1

Cow No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av. Alk. Reserve
6.	Apr.11	Alfalfa, silage and grain	Poor	Low	Clear	None	56.2
	June 7	" " " "	"	Heavy	Rainy	"	57.7
	Aug.11	Clover " " "	"	"	Cloudy	"	61.3
	This animal disposed of.						
7.	Apr.11	Alfalfa, silage and grain	Poor	Low	Clear	"	58.1
	June 7	" " " "	"	"	Rainy	"	58.4
	Aug.11	Clover " " "	"	"	Cloudy	"	59.3
	Nov.11	" " " "	"	"	Clear	"	59.7
	Jan.11	Alfalfa, " " "	"	"	"	"	61.0
8.	Apr.11	Alfalfa, silage and grain	"	"	"	"	57.2
	Nov.11	Clover " " "	"	"	"	"	61.3
	No other samples obtained.						
9.	Apr.11	Alfalfa, silage and grain	"	"	"	"	57.3
	Aug.11	Clover " " "	"	"	Cloudy	"	59.5
	Jan.11	Alfalfa " " "	"	"	Clear	"	60.3
	No other samples this month.						
10.	Apr.11	Alfalfa, silage and grain	"	"	"	"	60.1
	June 7	" " " "	"	"	Rainy	"	61.2
	Aug.11	Clover " " "	"	"	Cloudy	"	62.3
	Nov.11	" " " "	"	"	Clear	"	63.4
	Jan.11	Alfalfa " " "	"	"	"	"	70.0
11.	Apr.11	Alfalfa, silage and grain	"	"	"	"	67.4
	No other samples obtained.						
12.	Apr.11	Alfalfa, silage and grain	"	"	"	"	55.3
	June 7	" " " "	"	"	Rainy	"	57.7
	Nov.11	Clover " " "	"	"	Clear	"	60.4
	Jan.11	Alfalfa " " "	"	"	"	"	64.3
	No other samples secured.						

Co. No.	Date	Feed	Condition	Amount of Milk	Weather	Exercise	Av.Alk. Reserve
13	Apr.11	Alfalfa, silage and grain	Fair	Some	Clear	Yes	67.+
		No other samples secured.					
14.	Apr.11	Alfalfa, silage and grain	"	"	"	"	62.1
		No other samples secured					
15.	Apr.11	Alfalfa, silage and grain	"	"	"	"	63.1
		No other samples secured.					
16.	Apr.11	Alfalfa, silage and grain	"	"	"	"	67.+
	Nov.11	Clover " " "	"	"	"	"	57.1
	Jan.12	Alfalfa " " "	"	"	"	"	51.3
		No other samples secured.					

TABLE [illegible]

[illegible]

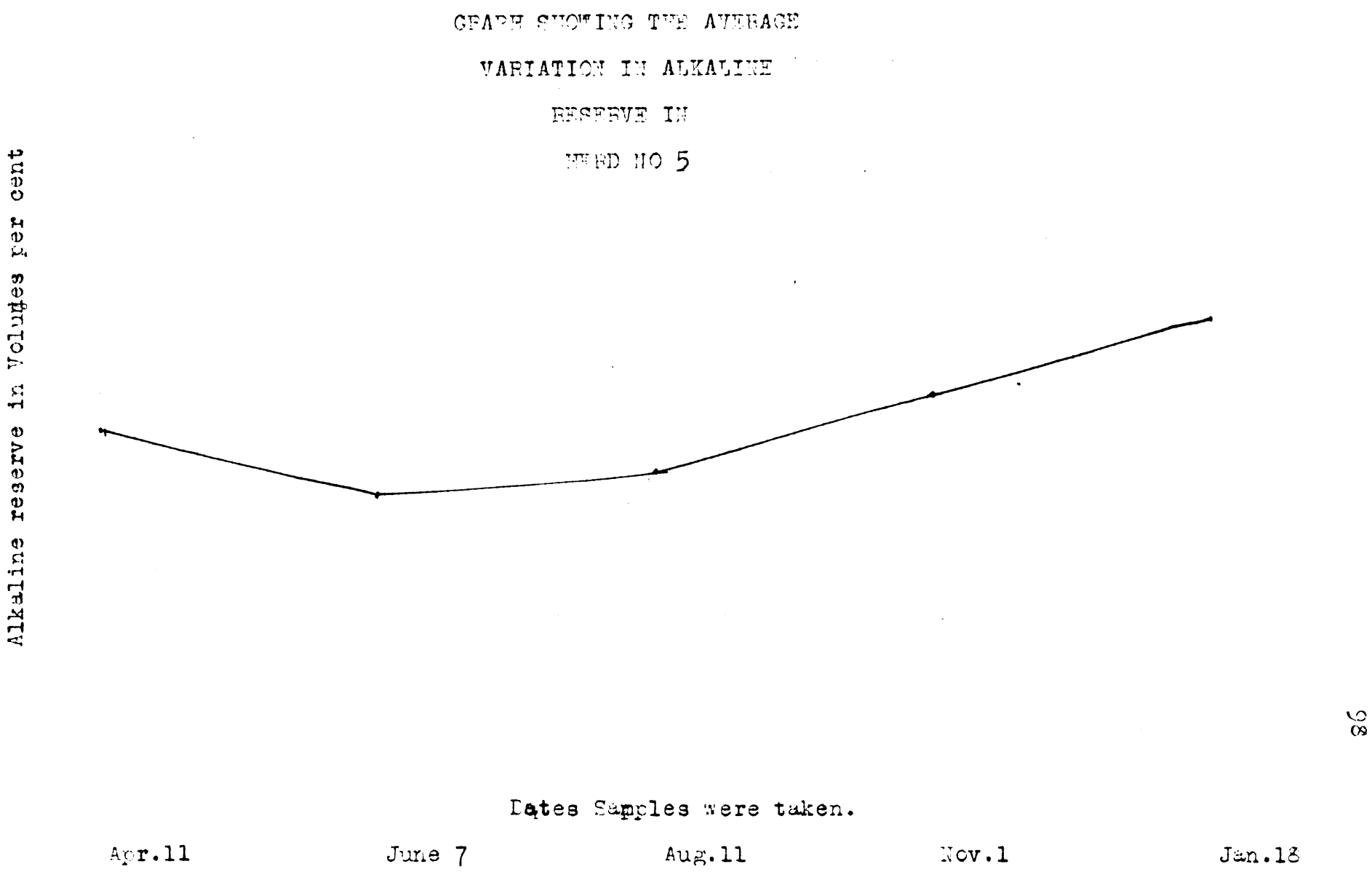
Dec.	Date of Flowering					
No.	April 11	June 7	July 11	Nov. 11	June 11	Average
1.	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
2.	[illegible]	[illegible]	[illegible]			[illegible]
3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6.	[illegible]	[illegible]	[illegible]			[illegible]
7.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8.	[illegible]		[illegible]			[illegible]
9.	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
10.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11.	[illegible]					[illegible]
12.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.	[illegible]					[illegible]
14.	[illegible]					[illegible]
15.	[illegible]					[illegible]
16.	[illegible]			[illegible]	[illegible]	[illegible]
17.	[illegible]					[illegible]
Average	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

GRAPH SHOWING THE AVERAGE

VARIATION IN ALKALINE

RESERVE IN

WARD NO 5



Results of Experimental Work.

The Average Alkaline Reserve of Dairy Cattle Under Ordinary Farm Conditions.

The alkaline reserve was determined on the 362 cases with a view of determining the average or normal alkaline reserve under ordinary farm conditions. The average alkaline reserve was found to be 58.392 volumes per cent. While extreme variations of from 40.0 to 79.1 volumes per cent were found the majority of the 362 cases ranged between 55 and 65 volumes per cent. These results were obtained on animals under normal conditions where they did not receive any mineral supplements.

Effect of Diet on the Alkaline Reserve of Dairy Cattle.

Effect of a Grain Diet or Roughage Diet on the Alkaline Reserve of Dairy Cattle.

Herds number 2 and 3 were receiving considerable grain at the time the first blood samples were taken. The average alkaline reserve of the 39 cases in these herds was 56.364 volumes per cent, 2.428 volumes per cent below normal, indicating that the heavy grain ration caused a lowering of the alkaline reserve. The rations of herds 1, 4 and 5 consisted mainly of roughages with very little grain. The average alkaline reserve of the 45 cases in these herds was 61.322 volumes per cent which is 2.430 volumes per cent above normal. These results seem to indicate that

the alkaline reserve of dairy cattle will be higher when they are fed on a ration composed largely of roughages.

There same relationships were shown in the fall when the herds were again placed on dry feed. Herds 2 and 3 received a medium grain ration at this time. The 55 cases showed an average alkaline reserve of 62.827 volumes per cent which is 4.065 volumes per cent above normal. Herds 1, 4 and 5 on a diet of roughages showed an average alkaline reserve of 66.384 volumes per cent, 7.622 volumes per cent above normal. These results again indicate that the feeding of grains causes a diminution in the alkaline reserve and that the heavy feeding of roughages will cause a rise in the alkaline reserve of dairy cattle.

Effect of Pasture on the Alkaline Reserve of Dairy Cattle.

The alkaline reserve was determined on the cattle in all the herds before being turned on pasture, while on pasture, and again after being taken off the pasture. The following table gives the results.

Condition	Cases	Average Alkaline Reserve In Volumes Per Cent
Dry feed	67	59.31
Pasture	130	55.30
Dry feed	114	61.36

This data indicates that the alkaline reserve of dairy cattle is diminished when they are turned onto

pasture. A decrease of about 3 volumes per cent was obtained when they were changed from dry feed to pasture while an increase of 6 volumes per cent is recorded when the cattle were changed from pasture to dry feed.

It is not known whether this decrease in alkaline reserve is due to the pasture itself or to the increased exercise received.

Effect of Exercise on the Alkaline Reserve of Dairy Cattle.

The effect of exercise was not studied separately as it was so closely associated with other factors.

Effect of Body Condition on the Alkaline Reserve of Dairy Cattle

The cattle were classified into three classes, poor, fair and good, according to their body condition in an effort to find the effect of this factor on the alkaline reserve. The following table gives the results:

Condition	Cases	Average Alkaline Reserve In Volumes Per Cent
Poor	43	61.37
Fair	134	59.51
Good	106	57.40

It is apparent from the above table that the better the body condition the animal is in the lower the alkaline reserve will be. Majority of the animals that were classed as being in good condition were in the herds that received considerable grain in their diet, while the animals in poor

condition were being fed mainly on roughages. Grain rations as previously shown will cause a lowering of the alkaline reserve while the heavy feeding of roughages will cause a rise in the alkaline reserve of dairy cattle. The effect of diet would be sufficient to cause this difference in alkaline reserve due to body condition.

Effect of Weather Conditions on the Alkaline Reserve of Dairy Cattle.

Since several investigators believe that sunlight causes a retention of certain minerals the weather conditions were noted in an effort to determine whether the alkaline reserve is influenced either by clear or cloudy weather. The following results were obtained.

Weather Condition	Cases	Average Alkaline Reserve In Volumes Per Cent
Clear	199	56.96
Cloudy	147	58.57

This data indicates that the alkaline reserve is not affected by weather conditions.

Effect of Milk Production on the Alkaline Reserve of Dairy Cattle.

As milk contains considerable mineral matter its production might cause a change in the alkaline reserve of dairy cattle. To study the effect of milk production on alkaline reserve the animals were classified as heavy milkers, above 20 pounds; medium milkers, between 10 and 20 pounds; light milkers, below 10 pounds; and dry animals,

including heifers and dry cows. The results obtained are given in the following table.

Amount of Milk	Cases	Average Alkaline Reserve In Volumes Per Cent
Heavy	33	58.205
Medium	112	59.498
Light	37	59.136
Dry	135	56.546

Milk production did not materially affect the alkaline reserve. The data shows that the animals that were not milking had a lower alkaline reserve than those that were milking. This lower alkaline reserve of non-lactating animals was probably due to the fact that they received more exercise as they usually had the run of a small pen or a portion of the barn.

Effect of an Abnormally High Alkaline Reserve.

An interesting case was noticed in herd number 4 in which the alkaline reserve of animal number 19 was 79.1 volumes per cent on April 18. This animal at the time, was off feed and had dropped in milk production. The next time she was bled, June 1, the alkaline reserve had dropped to 64.5 volumes per cent and the animal was eating good and apparently normal.

This, it seems, was a case of alkalosis, as the alkaline reserve had risen to a such a point that the body functions were not properly being carried out.

Following the drop in alkaline reserve the animal returned to normal and resumed eating and increased in milk production. This case would indicate that an abnormally high alkaline reserve is not conducive to proper physiological functioning.

General Discussion and Summary.

The average alkaline reserve of dairy cattle under ordinary farm conditions was found to be 58.892 volumes per cent. This figure was used as a normal to determine the variations in alkaline reserve that might be caused by a change in conditions.

Diet was found to cause a considerable change in the alkaline reserve. The feeding of a ration containing a large proportion of grain was found to cause a lowering of the alkaline reserve. This was probably due partially to the increased acid production that accompanies the digestion and assimiliation of a grain ration. A grain ration contains proteins, these upon digestion and metabolism give rise to acids that must be neutralized. The neutralization of these acids will cause a lowering of the alkaline reserve. The other point that might account for this lowering, due to the feeding of a grain ration, is the character of the ash. The ash of most grains contains an excess of acid radicles over base radicles. This alone would cause a lowering in the alkaline reserve of dairy cattle.

The feeding of a ration containing a large proportion of roughages was found to cause a rise in the alkaline reserve. This rise may be partially due to the fact that the roughages do not contain as much protein as the more concentrated rations. When less protein is consumed fewer

organic acids are produced upon digestion and metabolism. As the ash of roughages contains a considerable excess of basic mineral matter the blood stream has a larger source of materials with which it can build up the alkaline reserve. This may account for an increase in the alkaline reserve when a diet consists mainly of roughages.

When the cattle were turned on pasture, where they received continuous exercise, a lowering of the alkaline reserve was noticed. It is not known whether this lowering in alkaline reserve is due to the exercise received or to the food consumed.

The results of this work have shown that the better the body condition of the animal the lower the alkaline reserve. The animal, to be in better condition, must have been fed a ration that more than satisfied the requirements for maintenance and production. This was probably accomplished by the feeding of grains with an acid ash, as most of the animals in good condition were in the herds that received considerable grain. Such a ration, containing grain would be able to cause the difference in alkaline reserve indicated by body condition.

Majority of modern investigators agree that sunlight aids in the retention of certain minerals and hence tends to increase the minerals in the blood. In view of this the alkaline reserve might be higher on a clear day than on a cloudy one. The animals observed showed only a slight

variation indicating that weather conditions do not exert any marked influence on the alkaline reserve.

The production of milk inasmuch as it requires mineral matter might be expected to cause a lowering of the plasma bicarbonate. However in this experiment it was found that milk production did not have any definite effect on the level of the alkaline reserve.

A case was observed in which the alkaline reserve was exceptionally high, the animal was off feed and had dropped in milk production. The next time this animal was bled the alkaline reserve was nearly normal and the animal was eating good and giving a normal amount of milk. This suggests that the level of the alkaline reserve has an influence on the functioning of the animal body. The level at which the body seems to best function is thought, as a result of this work, to be between 55 and 65 volumes per cent.

CONCLUSIONS

1. The average alkaline reserve of dairy cattle kept under ordinary farm conditions where minerals are not fed is 58.342 volumes per cent.
2. A ration containing a large proportion of grains when fed to dairy cattle causes a lowering of the alkaline reserve.
3. A ration containing a large proportion of roughages when fed to dairy cattle causes a rise in the alkaline reserve.
4. The placing of dairy cattle under pasture conditions causes a lowering of the alkaline reserve.
5. Weather conditions do not seem to have any material effect upon the alkaline reserve of dairy cattle.
6. The amount of milk produced does not seem to affect the level of the alkaline reserve of dairy cattle.

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