PREVENTION OF TRAUMATIC GASTRITIS BY THE USE OF PERMANENT BAR MAGNETS IN THE RETICULUM

by

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I. INTRODUCTION

Traumatic gastritis in the bovine species as a result of ingestion of foreign objects, especially those of a ferrous nature, annually causes a serious economic loss. Studies were begun in January, 1954 in an attempt to determine if any method of prevention could be developed to reduce this loss. In November, 1954, Alnico type V magnets[1] were procured, and the efficiency of these magnets in preventing penetration of the reticulum by foreign objects of a ferrous nature was studied.

The economic loss resulting from this disease is not only due to the death loss, but is also due to the loss of reproduction in breeding animals, the loss resulting from emergency slaughter of valuable animals or those not in condition to be slaughtered, the loss of milk production in dairy animals, and finally the loss resulting from animals failing to produce milk or gain weight in a profitable manner due to the effects of chronic traumatic gastritis.

To date, much effort has been expended upon the diagnosis and treatment of this disease, but very little upon the prevention. Some devices have been proposed and used to magnetically or otherwise screen the feed for foreign objects,

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[1]Alnico type V permanent bar magnet. Indiana Steel Products Co., Valparaiso, Indiana.

and several devices have been used with inconsistent results in attempts to remove foreign objects of a ferrous nature from the reticulum. These latter devices have generally been magnets of some sort introduced into the reticulum through a tube, in attempts to attract ferrous objects from the reticulum. However, these devices have been only partially effective in prevention of the disease.

The problem of controlling the disease is partly one of management, and partly one inherently due to the manner in which the bovine normally prehends, masticates, and swallows its food. Management enters into the problem mainly as a result of carelessness in allowing cattle access to nails, wires, boards containing loose nails, and in cutting the wires of bales of straw or hay over feed bunks and mangers. The use of field choppers in putting up hay has had disastrous results on some farms, due to the incorporation of bits of wire into the hay as it is chopped and picked up, and later fed to cattle. Cattle will also commonly lick or chew on old boards, pieces of wire or other metallic objects around buildings or dumps if allowed access to them. This is particularly true if the plane of nutrition is low, or if the animal is suffering from a deprivation of the normal amount of minerals in the feed. Drouth conditions also enter into the problem, as during periods of drouth cattle tend to graze closely and to graze around fence rows, wood-

lots, ditches and other areas where they would not normally be pastured, and where there are numerous opportunities to ingest foreign objects.

From the above statements it can be seen that the problem of prevention of traumatic gastritis is quite complex, and even in the presence of good management practices, there are numerous instances in which an animal might ingest foreign objects. In the absence of preventive measures, the problem has been dealt with by attempting to diagnose the condition and either recommending emergency slaughter, surgical removal of the offending object, or in some cases by attempting medicinal or expectant treatment. Since this usually incurs a rather large economic loss to the owner, it was felt that a practical and economical method of prevention should be determined. To this end, experimental animals were obtained through the Department of Medicine and Surgery and the Department of Obstetrics and Radiology. Magnets for use in the study were provided by the Department of Medicine and Surgery.

II. REVIEW OF THE LITERATURE

A review of the literature indicates that traumatic gastritis is one of the more common surgical conditions encountered in cattle. The disease is becoming more prevalent, or it is being recognized with more frequency. Aitken (1954) reported in an editorial, that the increasing number of cases presented to the veterinary clinics operated by the various veterinary schools was probably due both to the greater prevalence, and to the recognition that improved methods of therapy would save numerous animals. Maddy (1954) stated that the incidence of reticular adhesions in 44,200 cattle slaughtered was much higher than he had expected. He stated that of 16,713 dairy cattle, 79.6% were affected; and that of 27,487 beef cattle, 20.9% were affected. He further stated that certain lots of beef cattle showed an incidence of 80.2% reticular adhesions at the time of slaughter. He believed that this high incidence was due to their environment. Hutyra and Marek (1938, p. 86) stated that the percentages of foreign bodies found in the fore-stomachs of cattle in various slaughter houses varied from 37.33% to 57.7%, and of these, 34% were found in the reticulum.

Most of the objects found in the reticulum are of a ferrous nature. Maddy (1954) stated that in his experience, 75% were bits of baling wire, 20% were nails, and 5% were miscellaneous objects. Hutyra and Marek (1938, p. 86)

quoted Wenger as stating that of 110 cases of penetration of the reticulum, 48 were by wire, 46 were by nails, and 16 were by miscellaneous objects. Nusbaum (1955) stated that most of the objects found in the reticulum causing traumatic gastritis were of a ferrous nature.

Hutyra and Marek (1938, p. 87) stated that heavy objects fall into the reticulum when swallowed by cattle. Runnells (1941, p. 324) stated that heavier objects lodged in the reticulum. Dukes (1942, p. 291) stated that the reticulum and abomasum were apt to be the seat of the trouble resulting from swallowing foreign objects. He further stated that anything swallowed in the normal manner in the mature ruminant, went into the anterior dorsal sac of the rumen, and that a good deal of the heavier ingesta soon found its way into the reticulum. Cooper (1954) administered a magnet to each of 11 cows. He found the magnet on the floor of the posterior chamber of the rumen in 9 of the cows, and in the reticulum in 2 of the animals. Nusbaum (1955) administered No. 10 gelatin capsules filled with lead to several cattle, and in each instance the lead was recovered from the reticulum when the animals were slaughtered. Kingrey (1955) administered 30 foreign bodies orally to 10 cows and recovered 25 from the reticulum, 3 from the anterior dorsal sac of the rumen, and 2 from the floor of the posterior compartment of the rumen. He also stated that sharp objects

were apt to penetrate the wall of the reticulum within 3 days after administration.

Bosshart (1926), Bardwell (1927), Gibbons (1932), Hutyra and Marek (1938, p. 95), Udall (1939, p. 104), Ryan (1947), and Kingrey (1955) all indicated that the diagnosis was not easy to differentiate from other digestive disorders. They stated that the most constant symptoms observed were pain over the region of the xyphoid cartilage, loss of appetite, loss of milk flow, rise in the pulse rate, and a rise in the temperature.

Bosshart (1926), Bardwell (1927), Gibbons (1932), Jensen (1945), and Hansen (1953) stated that pain upon pressure over the region of the xyphoid cartilage was one of the symptoms noted in traumatic gastritis. Kingrey (1955) stated that this symptom was the most pathognomonic of the clinical manifestations of traumatic gastritis. Ryan (1947) stated that this symptom was not always present, nor was it a constant diagnostic feature. Milne (1953) stated that the pain upon pressure over the region of the xyphoid cartilage may not always be due to a penetrating foreign object, but that one must differentiate between wire and physical and bacterial agents involving the area.

A neutrophile leucocytosis was mentioned as an important feature in the diagnosis of traumatic gastritis by Hutyra and Marek (1938, p. 96), Jensen (1945), Arthur (1946), Ryan

(1947), and Kingrey (1955). Jensen (1945) and Ryan (1947) stressed the increased leucocyte count, while Kingrey (1955) stated that the rise in the leucocyte count occurred early and tended to drop to normal limits within 2 or 3 days after penetration had occurred. Arthur (1946) stressed the differential leucocyte count, stating that the nonsegmented neutrophiles varied from 8% to 38% in traumatic reticulitis, and from 22% to 66% in pericarditis. Churchill (1950) stated that the differential leucocyte count was a valuable aid in the diagnosis, especially in the acute type of traumatic gastritis. Kingrey (1955) stated that even if the total leucocyte count seemed to be within normal limits, the increased percentage of stab cells could be relied upon to indicate the presence of infection resulting from penetration of the reticulum.

Bosshart (1926), Gibbons (1932), Hutyra and Marek (1938, p. 95), Udall (1939, p. 104), Jensen (1945), Ryan (1947), Churchill (1950), and Kingrey (1955) all stated that the temperature rose in the early stage of the disease. Gibbons (1932) stated that the peracute type showed a temperature rise to 104°F or 105°F, but that in the acute type, according to his method of classification, the temperature might or might not be elevated, and in the subacute and chronic types the temperature was not mentioned as a diagnostic feature. Hansen (1953) stated that a temperature rise of ½°F or more

was significant. Kingrey (1955) stated that the rise in the temperature was seen at about the time of the penetration, but was apt to drop within a few hours.

The pulse rate was mentioned by several authors as an aid in the diagnosis of the disease. Bosshart (1926) mentioned a pulse rate of 56 to 80 per minute as occurring during the course of the disease. Gibbons (1932) stated that the pulse was weak and fast with a rate of 90 to 100 per minute. Hutyra and Marek (1938, p. 92) stated that the pulse rate rose to 72 to 100 per minute, and up. Udall (1939, p. 107) stated that the pulse rate rose to 80 per minute and up in the acute type of the disease. Jensen (1945) stated that the pulse rate was 100 per minute or more in the disease. Kingrey (1955) stated that the pulse rate tended to rise after the onset of the other symptoms, but stated that the wide variation noted and the tendency of the animal to show a temporary return of the rate to normal limits during the course of the disease made the evaluation of the pulse rate as a diagnostic feature difficult to interpret.

The respiratory rate and the character of the respiratory movements were mentioned by several authors as a diagnostic feature. Bosshart (1926) and Bardwell (1927) stated that the rate was increased. Gibbons (1932) stated that the rate might or might not be increased. Hutyra and Marek (1938, p. 92) and Udall (1939, p. 107) stated that the respirations

were noted to be shallow. Kingrey (1955) stated that the respiratory rate during the course of the disease was difficult to interpret, as external influences altered the rate appreciably.

The rate and the character of the rumen movements were stated by several authors to be of some significance in the diagnosis of the disease. Gibbons (1932) stated that in the peracute and acute types of the disease peristalsis was decreased. Hutyra and Marek (1938, p. 91) stated that the ruminations were slow and irregular. Udall (1939, p. 107) stated that the ruminations were suppressed. Jensen (1945) stated that the rumen movements were slow and weak. Hansen (1953) stated that the ruminations were reduced. Kingrey (1955) stated that the rate of the movements was variable in the animals in which he produced traumatic gastritis. In some cases the rate was markedly reduced, and in some the reduction of the rate was slight. He also stated that weakened rumen contractions were of greater diagnostic significance than the slowing of the rate, and that the disturbance in the strength of the rumen movements did not tend to disappear up to the time that he performed a rumenotomy upon the animals.

Bardwell (1927) stated that the fecal evacuations were normal or suppressed in the course of the disease. Gibbons (1932) stated that in the acute type of traumatic gastritis,

constipation was frequent. Ryan (1947) stated that the feces were reduced in amouht, and that the consistency was normal or slightly firmer than normal. Kingrey (1955) stated that there was a tendency for the feces to be reduced in amount in the course of the disease.

Clay (1946) stated that the metal (mine) detector was a valuable aid in the diagnosis of the disease. Louwagie (1950) stated that the electronic metal detector was a valuable aid in the diagnosis of traumatic gastritis, and that he performed rumenotomies only when the clinical manifestations of the disease were confirmed with the detector. Churchill (1950) stated that 90% of the cattle he checked with an electronic metal detector gave a positive reaction, and therefore its usefulness was of little value in the diagnosis. Bradbury (1947) stated that the other symptoms of traumatic gastritis must be weighed before deciding as to the significance of a positive finding with the electronic metal detector. Cooper (1954) stated that he checked 300 cattle with the electronic metal detector, and that 70% were found to give a positive reaction for the presence of ferrous metal in the forestomachs.

Surgical treatment was indicated as being the method of choice by Bosshart (1926), Bardwell (1927), Gibbons (1932), Ryan (1947), Churchill (1950), Hansen (1953), and Kingrey (1955). Ryan (1947) stated that he obtained almost 100%

recoveries in the cases he treated surgically. Hansen (1953) reported 92 recoveries in 100 cases operated. Kingrey (1955) stated that almost 100% recovery could be expected if surgery was performed within the first 48 hours after the symptoms were first noted. Other investigators reported a lower rate of recovery following surgical treatment. Bosshart (1926) reported 19 recoveries in 25 cases operated upon. Bardwell (1927) stated that 3 of 12 animals that he operated upon died. Hutyra and Marek (1938, p. 100) stated that the recovery rate following rumenotomies varied from 34.8% to 80.7%. Naismith (1950) reported that of 50 cases that he operated upon, 35 made good recoveries, 12 died within a month, and 3 were slaughtered.

Hutyra and Marek (1938, p. 98), and Udall (1939, p. 106) stated that expectant treatment and placing the animal on an inclined plane might often be successful in the treatment of traumatic gastritis. Jensen (1945) stated that placing the animal on an inclined plane and light feeding with employment of a mild cathartic was successful in the treatment of many animals. He also recommended emergency slaughter if the animal showed no rise in the temperature, or if the symptoms exhibited were not severe. Hansen (1953) stated that many cows would recover from one or more attacks if expectant treatment was employed. Merriman (1953) interposed medical treatment between the tentative and positive

diagnosis of the disease, and stated that many cases of traumatic gastritis responded to medical treatment if the digestive functions were maintained and if the infection was controlled.

Cooper (1954) first reported the use of magnets administered orally for the proposed prevention of traumatic gastritis. His work was rather preliminary, and of 11 cattle he gave magnets, in only 2 was he able to recover the magnet in the reticulum. In the other 9 animals the magnet was found in the rumen. Five of the animals were slaughtered 24 hours after administration of the magnets, and in all of these the magnet was found in the rumen. In 3 animals slaughtered 14 days after administration of the magnets, the magnet was recovered from the rumen in 1, and from the reticulum in 2 animals. Three animals were each given a magnet orally, followed by 12, 18, and 24 eight penny nails respectively. The animals were slaughtered 14 days later. In each of these animals the magnet was recovered from the rumen. In the animal given 12 nails, all of the nails were attached to the magnet. In the animal given 18, and in the animal given 24 nails, he stated that the magnets were overloaded and that not all of the nails were attached to the magnet. He also stated that the oral administration of magnets might be feasible in herds showing a high incidence of ferrous metal upon examination with a metal detector.

Carroll (1955) stated that he administered 2½" x ½" magnets to 42 animals, and used 58 animals in the same herd and age group as controls. He stated that only 2 of the animals administered magnets required rumenotomies for the relief of traumatic gastritis, while 33 of the 58 control animals required rumenotomies in a period of six months following the administration of the magnets. In one animal in which a rumenotomy was performed one month after administration of the magnet, the magnet was found in the reticulum, and attached to the magnet was the penetrating foreign body (wire). In a second animal that he performed a rumenotomy upon, the magnet was found on the floor of the reticulum, and a nail had penetrated the floor of the rumen. He stated that he performed a rumenotomy upon one animal six months after the administration of the magnet to check on its location in the animal, and found it in the reticulum. Attached to this magnet were 2 wires, 1 piece of ferrous material, and numerous iron filings.

Muffly (1955) stated that he used a magnet passed into the reticulum as a method of treatment of field cases of traumatic gastritis. He passed the magnet, measuring 3½" x 7/8", through a plastic tubing and attempted to enter the reticulum with it and withdraw, attached to the magnet, any ferrous material present in the reticulum. He stated that he had 41 successes in 53 cases of traumatic gastritis. He

stated that some of the 12 failures were due to the failure of the magnet to enter the reticulum, and that the procedure was considered to be of no value where the disease had progressed to traumatic pericarditis or penetration of the liver or of the spleen. Nusbaum (1955) was not successful in passing a permanent magnet through a stomach tube and recovering nails that had been previously administered orally to cattle. He stated that he believed this to be due to insufficient magnetic force of the magnet that he used. He then constructed and used a 13 volt electromagnet of soft iron wound with copper wire, and insulated. The iron rod measured 7" x ¼". With this he tested 10 cows that had been given orally a total of 25 nails. He was successful in passing the magnet into the reticulum in 9 cows, and in recovering 16 of the 25 nails. In 1 animal he had a complete failure. He also stated that he attempted to pass the electromagnet into the reticulum of a steer with a rumen fistula, and he felt that the magnet was too long and would not pass into the cardia.

III. METHOD OF PROCEDURE AND OBSERVATIONS

A. Determination of the Most Efficient Method of Administration of the Magnets

A total of 34 cattle were used in an attempt to determine the most efficient method of administration of the magnet[1] to insure that it would enter the reticulum. No attempt was made to identify the animals as to breed, sex, age, weight, or whether or not they were positive to the electronic metal detector[2]. If the animal was noted to be excessively full of ingesta at the time the magnet was administered, this fact was recorded.

The magnet used in each case was an Alnico type V rod, measuring 50 mm x 12 mm. The magnet itself is composed of a precipitation hardened alloy of nickel, aluminum, cobalt, copper, and iron. It is cast in sand to the desired shape, as the material is very hard and brittle and cannot be readily machined. The magnet is anisotropic, having superior magnetic properties in one preferred axis.

The magnets were administered to the cattle enclosed in a gelatin capsule of sufficient size to contain the magnet. The filled capsule was administered using an aluminum

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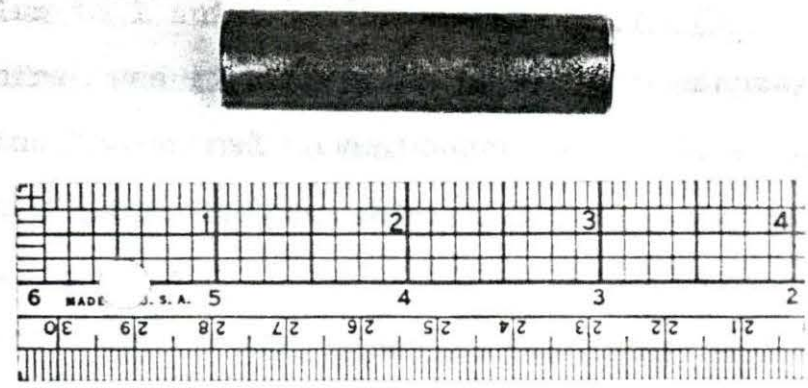
[1]Alnico type V permanent bar magnet. Indiana Steel Products Co., Valparaiso, Indiana.

[2]Electro-Geraetebau-Bavaria, Ing. Kurt Liersch.

Photo #1. Actual size of magnet used in all experiments



headed balling gun of the required size, to prevent the magnet from attaching itself to the head of the balling gun.

Twelve of these animals were given magnets orally within 30 minutes prior to performing rumenotomies upon the animals. None of the animals had been deprived of hay prior to administration of the magnets. The magnets were recovered from the anterior dorsal sac of the rumen in 11 animals, and from the reticulum in 1 animal.

One animal was given a magnet within 30 minutes prior to subjecting the animal to a rumenotomy. This animal had not eaten anything for three days prior to performing the rumenotomy, and the rumen was nearly empty. The magnet was recovered from the anterior dorsal sac of the rumen.

Four animals were given magnets orally 24 hours prior to subjecting them to a rumenotomy. These animals had not been deprived of hay prior to the administration of the magnets, and the rumen in each animal was noted to be rather full of ingesta. In each animal the magnet was recovered from the anterior dorsal sac of the rumen.

Twelve animals were deprived of hay for 24 hours. Each animal was then given a magnet. Twenty four hours after the administration of the magnet, each animal was subjected to a rumenotomy. Ten of the magnets were recovered from the reticulum and 2 of the magnets were recovered from the anterior dorsal sac of the rumen.

Five animals were deprived of hay for 24 hours. Each animal was then given a magnet. Forty eight hours after the administration of the magnets rumenotomies were performed on the animals. All 5 of the magnets were recovered from the reticulum.

B. Determination of the Mechanical Effect of the Magnet on the Tissues and the Efficiency of the Magnets in Preventing Penetration of the Reticulum

Ten cows were used in an attempt to determine the effect of the magnet itself on the animal, and if the magnet would prevent penetration of the reticulum by sharpened wires and nails. The cows under study were all animals maintained by the Department of Obstetrics and Radiology for exercises in the obstetrics laboratory. Each animal was identified by breed, approximate age, and chain number. The ration fed the cows consisted entirely of a medium grade of red clover, alfalfa, or mixed legume hay. The animals were kept in stanchions throughout the entire period of the study. Only one of the cows was in lactation at the time the study began.

Clinical observations were made on each animal for a period of five days to three weeks prior to the administration of the magnets, or magnets and nails and wire. This was done in an attempt to establish a normal set of values for each animal with regard to the temperature, respiratory rate, heart rate, character and rate of the rumen movements,

Table 1. Location of Magnet Following Administration

Number of animals	Starved prior to administration	Time between administration and rumenotomy	Magnet in reticulum	Magnet in rumen
12	no	30 minutes	1	11
1	yes	30 minutes	0	1
4	no	24 hours	0	4
12	yes	24 hours	10	2
5	yes	48 hours	5	0

amount and character of the feces voided, reaction to pressure over the area of the xyphoid cartilage, and the total and differential leucocyte count. The clinical observations were made once each day at approximately the same time daily, with the exception of the total and differential leucocyte counts. These were made at irregular intervals during this preliminary study. Each animal was also examined once at the beginning of the study in an attempt to determine the presence or absence of ferrous material in the rumen or reticulum. This was done by examining each animal with an electronic metal detector.

Following the administration of magnets, or magnets and nails and wire, the animals were examined daily for a period of five days, recording the same clinical observations. After the fifth day the procedure was the same, except that the total and differential leucocyte counts were made only once weekly for the balance of the study, or until the animals were subjected to a rumenotomy. The animals were not examined with the electronic metal detector after administration of the magnet, as it was found that the magnet caused the detector to indicate a positive result in each instance.

Rumenotomies were performed on 9 of the 10 cows after varying periods of time. During the rumenotomy the final location of the magnet was recorded, and the location and disposition of the nails and wire was also recorded. At

this time an attempt was made to determine if any evidence of penetration of the reticulum had occurred, or if any adhesions were present. The one animal that was not subjected to a rumenotomy was examined after dissection by the Department of Anatomy.

The respiratory rate was recorded in each instance prior to conducting any other examination of the animal. Each animal was approached only closely enough to allow observation of the rise and fall of the ribs and the abdominal wall to determine the rate. The recording was taken in most instances in the standing animal. Usually the animals were ruminating at the time of the recording. The rate was observed for several minutes in each animal, and the average rate of respirations per minute was recorded.

The procedure of recording the temperature was the second examination conducted upon the animal. The temperatures were obtained by inserting a standard blunt rectal thermometer into the rectum and leaving it in place for at least three minutes. In the event that the animal defecated during this time, the thermometer was reinserted and left in the rectum for five minutes before recording the temperature. In event the animal was lying down, the animal was allowed to stand for several minutes prior to recording the temperature.

The rumen movements were recorded by applying the closed fist in the left paralumbar fossa rather firmly and counting the rumen movements for a minimum of three minutes, and determining the average rate per minute from this. The character of the rumen movements as to their force was also observed and recorded at this time. In one animal it was noted that the excitement produced by palpating the paralumbar fossa was enough to cause cessation of the rumen movements at certain times, and in this animal the rate of the rumen movements was obtained by observation from a distance.

The heart rate was recorded in each instance in the animals by use of a stethescope. This was applied over the left chest wall and several minutes were allowed to elapse before recording the rate. If the animal was of a nervous disposition, a longer period of time was allowed to elapse before recording the rate so as to minimize the effect of the excitement produced by approaching the animal and applying the head of the stethescope. The heart rate was observed for a period of two minutes, and the average rate per minute was determined from this.

The examination to detect pain produced by applying pressure over the area of the xyphoid cartilage was conducted by the author kneeling at the left shoulder of the animal. A stethescope was placed over the trachea of the animal, being held in the left hand. The right hand was balled into

a fist with the thumb extended rigidly. The thumb was placed firmly against the skin just posterior to the xyphoid cartilage. When the author could hear the normal respirations through the trachea with the stethescope, the thumb was pushed rather swiftly and smoothly, and with some force, in an upward direction. This was repeated in an area of approximately 10 inches surrounding the posterior end of the xyphoid cartilage. A positive recording to this examination would be made when the animal would grunt or gasp during this procedure. This grunt or gasp could be determined by auscultation through the stethescope.

The character and amount of feces produced by each cow were determined by observing the amount and consistency of the feces behind each cow in the gutter at the same time each morning. Some difficulty was encountered in this procedure, as it was found that the palpation the animal was subjected to during the obstetrics laboratory would on certain occasions alter the amount and character of the feces voided to a great extent.

The blood studies conducted during this portion of the study consisted of a total and a differential leucocyte count. Standard laboratory procedures were followed in this. The samples of blood were collected at approximately the same time of the day in each instance. Venipuncture was per-

formed on the jugular vein. Care was taken to not reenter any previously traumatized tissue or hematomas.

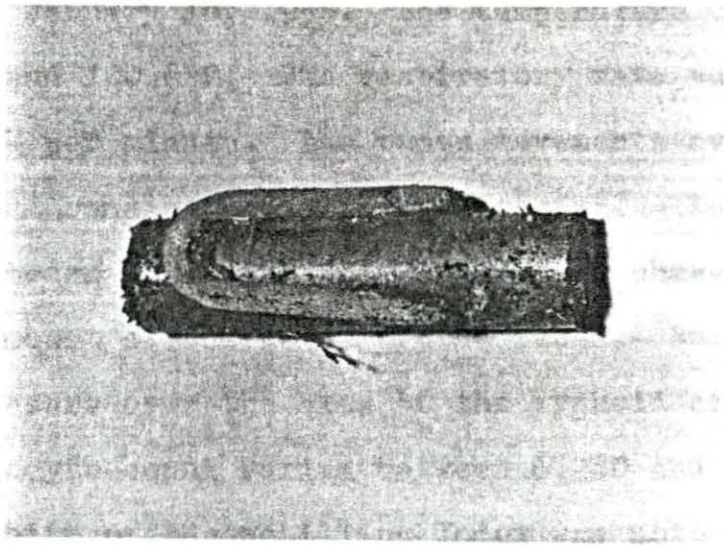
Cow #9. Holstein cow approximately 5 years of age, weighing about 850 pounds, and in rather poor condition. Negative to the metal detector at the beginning of the study. Preliminary examinations to establish a normal set of values were made between December 1, 1954 and December 14, 1954. The temperature varied between 100°F and 101.2°F. The respiratory rate varied between 40 and 48 per minute. The rumen movements averaged 1½ per minute and were moderately forceful. The heart rate varied between 48 and 60 per minute. The character and the amount of feces voided were considered to be normal. Pressure over the area of the xyphoid cartilage did not produce any evidence of pain. The total leucocyte count varied between 16,160 per cmm and 17,640 per cmm, lymphocytes making up 48% to 62% of the total. An Alnico type V magnet was administered to the animal on December 14, 1954. The animal was not starved prior to the administration of the magnet. Examinations were carried out on the cow from December 15, 1954 until January 13, 1955. The temperature varied between 100.4°F and 101.2°F. The respiratory rate varied between 44 and 50 per minute. The rumen movements averaged 1½ per minute, and remained moderately forceful. The heart rate varied between 44 and 56 per minute. The character and amount of the feces voided con-

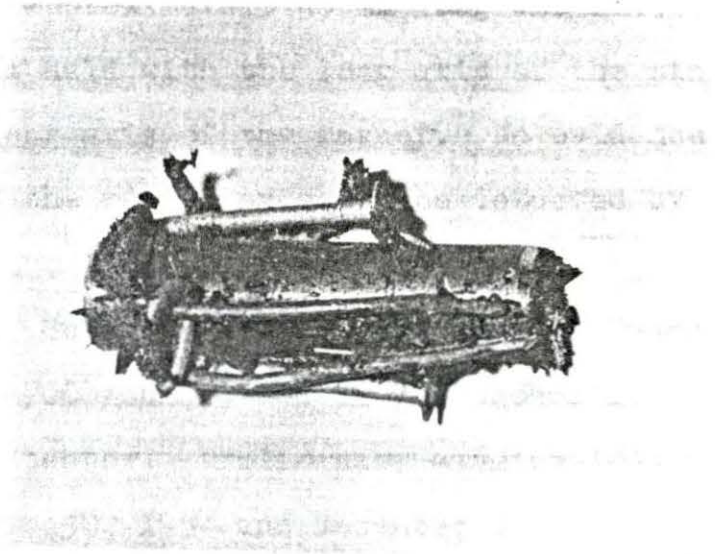
tinued to be normal. Pressure over the area of the xyphoid cartilage did not produce any evidence of pain. The total leucocyte count varied between 15,660 per cmm and 16,640 per cmm, with the percentage of lymphocytes remaining rather high. From this it was concluded that no evidence of peritonitis or of penetration of the reticulum had occurred. On January 13, 1955 the animal was subjected to a rumenotomy, and the magnet was recovered from the reticulum. No foreign objects other than the magnet were found. No adhesions between the reticulum and other adjacent structures could be detected by palpation.

Cow #20. Brown Swiss cow approximately 3 years of age, weighing 900 pounds, in fair condition. Positive to the metal detector over the region of the reticulum. Preliminary examinations to establish a normal set of values were made between November 30, 1954 and December 8, 1954. The temperature varied between 100°F and 100.8°F. The respiratory rate varied between 34 and 40 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 56 and 68 per minute. The amount and character of feces voided were considered to be normal. The animal showed no evidence of pain upon pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 7,020 per cmm and 8,400 per cmm. The differential leucocyte count remained in the normal range.

Photo #2. Magnet recovered from the reticulum of cow #20 with staple adherent to the magnet

Photo #3. Magnet recovered from the reticulum of cow #16. The two nails and the piece of baling wire that were administered are adherent to the magnet, plus one other piece of baling wire, and one other nail





An Alnico type V magnet was administered on December 9, 1954. The examinations were continued upon the cow from December 10, 1954 until January 10, 1955. The temperature varied between 100.2°F and 100.6°F. The respiratory rate varied between 40 and 44 per minute. The rumen movements averaged 2 per minute and remained moderately forceful. The heart rate varied between 48 and 58 per minute. No change was noted in the amount or character of the feces. No pain was shown upon pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 6,280 and 7,100 per cmm. No shift of the Schilling Index was noted. A rumenotomy was performed on the animal on January 11, 1955 and the magnet was recovered from the floor of the reticulum. A fence staple approximately 35 mm long was attached to the magnet, and was held with the long axis of the staple parallel with the long axis of the magnet. No evidence of injury to the wall of the reticulum could be detected by digital palpation.

Cow # 16. Guernsey cow approximately 4 years of age, weighing about 700 pounds, and in fair condition. Positive to the metal detector. Preliminary examinations were made between November 30, 1954 and December 8, 1954. The temperature varied between 100.6°F and 101°F. The respiratory rate varied between 30 and 44 per minute. The rumen movements averaged 2 per minute and were moderately forceful in char-

acter. The heart rate varied between 58 and 72 per minute. The amount and the character of the feces voided were considered to be normal, except for one instance when the character of the feces was of more fluid consistency than normal. This instance occurred after rectal palpation had resulted in lacerations of the rectal mucosa. No pain was shown to pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 9,840 per cmm and 13,600 per cmm. This high count occurred 48 hours after the lacerations of the rectal mucosa had occurred. No shift of the Schilling Index was noted, except on the date of the count of 13,600 per cmm when the Index shifted to the left. An Alnico type V magnet was administered to the cow on December 9, 1954. The examinations were carried out from December 10, 1954 until January 10, 1955 in the usual manner. The temperature varied between 100.6°F and 101.2°F. The respiratory rate varied between 42 and 48 per minute. The rumen movements averaged 2 per minute for the most part, but increased to $2\frac{1}{2}$ per minute for a period of about 7 days at the seventh to the thirteenth day following administration of the magnet. The force of the rumen movements remained moderate. The heart rate varied between 54 and 68 per minute. The character and the amount of feces voided remained normal. Pressure over the area of the xyphoid cartilage did not cause any evidence of pain. The total leucocyte count var-

ied between 8,360 per cmm and 8,960 per cmm. No shift in the Schilling Index was noted. On January 11, 1955 two nails 32 mm long and 2 mm in diameter, and two pieces of baling wire 45 mm long were administered enclosed in a gelatin capsule. The pieces of baling wire were sharpened on one end, and the opposite end of each piece of wire was coiled. The animal was not starved prior to the administration of these objects. Examinations were again carried out in the usual manner between January 11, 1955 and January 17, 1955. The temperature varied between 100.2°F and 100.8°F. The respiratory rate varied between 42 and 46 per minute. The rumen movements averaged 2 per minute, and continued to be moderately forceful. The heart rate varied between 56 and 62 per minute. No change was noted in the amount or character of the feces voided. No pain was shown upon pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 7,640 per cmm and 9,960 per cmm. No shift of the Schilling Index was noted. A rumenotomy was performed upon the animal on January 18, 1955. The two nails and the two pieces of baling wire were attached to the magnet, which was found on the floor of the reticulum. One other piece of baling wire 35 mm long was also found attached to the magnet, plus numerous iron filings. The wires and the nails were attached with their long axis parallel with

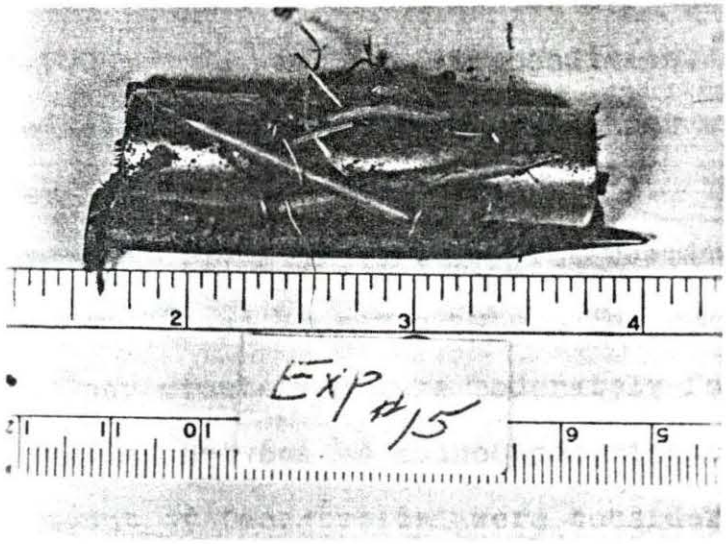
that of the magnet. No evidence of penetration of the wall of the reticulum could be detected by digital palpation.

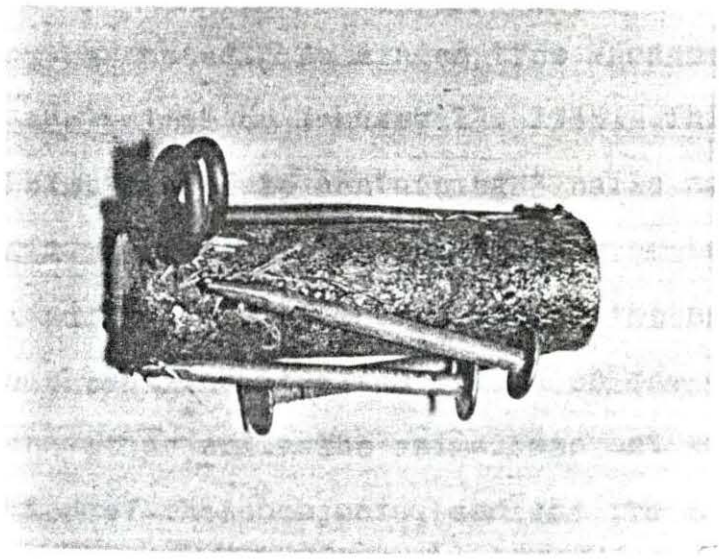
Cow # 15. Holstein cow approximately 4 years of age, weighing about 900 pounds, and in fair condition. Positive to the metal detector. Preliminary examinations were made on the animal between December 2, 1954 and December 8, 1954. The temperature varied between 100.4°F and 100.8°F. The respiratory rate varied between 40 and 48 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 60 and 64 per minute. The character and amount of feces voided were considered to be normal. A slight pain reflex was noted upon pressure over the area of the xyphoid cartilage, but no grunt or forced expiratory noise could be noted by auscultation. The total leucocyte count varied between 7,040 per cmm and 8,280 per cmm. No shift of the Schilling Index was noted. The animal was given an Alnico type V magnet on December 8, 1954. The animal was not starved prior to administration of the magnet. Examinations were carried out in the usual manner between December 9, 1954 and April 1, 1955. The temperature varied between 100.2°F and 100.8°F. The respirations varied between 44 and 52 per minute. The rumen movements averaged 2 per minute and remained moderately forceful. The heart rate varied between 60 and 68 per minute. No pain reflex as shown by grunting or forced expiratory noise could be

elicited by pressure over the area of the xyphoid cartilage, though the animal would continue to show discomfort to the pressure at times. The total leucocyte count varied between 7,640 per cmm and 7,920 per cmm. No shift of the Schilling Index was noted. On April 1, 1955, 2 short nails measuring 32 mm long and 2 mm in diameter, and 1 long nail measuring 65 mm long and 4 mm in diameter were administered in a gelatin capsule. The nails were all sharpened. The animal was not starved prior to the administration of the nails. The examinations were continued until April 11, 1955. The temperature varied between 100.6°F and 101°F. The respiratory rate varied between 44 and 48 per minute. The rumen movements averaged 2 per minute and remained moderately forceful. The amount and the character of the feces voided did not change. The animal did not show any grunting or forced expiratory sound upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 6,840 per cmm and 7,420 per cmm. The Schilling Index showed no shift. The animal was subjected to a rumenotomy on April 12, 1955. The magnet and the three nails were recovered from the reticulum. One piece of baling wire approximately 50 mm long was also attached to the magnet. The nails and the baling wire were attached to the magnet with their long axis parallel with that of the magnet. No evidence of penetration of the reticulum, nor of any adhesions of the retic-

Photo #4. Magnet recovered from the reticulum of cow #15. The three nails that were administered are adherent to the magnet, as is one extraneous piece of baling wire, and numerous bits of iron filings

Photo #5. Magnet recovered from the posterior chamber of the rumen of cow #26. The three nails and the piece of baling wire that were administered are adherent to the magnet


Exp #15



ulum to adjacent structures could be determined on digital palpation.

Cow # 26. Guernsey cow approximately 3 years of age, weighing about 700 pounds, and in fair condition. Negative to the metal detector. Preliminary examinations were made between December 14, 1954 and January 13, 1955. The temperature varied between 100.4°F and 101°F. The respiratory rate varied between 38 and 48 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 48 and 60 per minute. The character and amount of feces voided were considered to be normal. No pain was shown upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 6,260 per cmm and 6,980 per cmm. No shift of the Schilling Index was noted. An Alnico type V magnet was administered to the animal on January 13, 1955. Thirty minutes later a gelatin capsule containing 3 nails measuring 32 mm long and 2 mm in diameter, and 1 piece of baling wire 50 mm long was administered. The points of the nails were sharpened, and the baling wire was coiled on one end and sharpened on the other end. The animal was not starved prior to administration of these objects, and the rumen was noted to be very full of ingesta. Examinations were carried out upon the animal in the usual manner until January 24, 1955. The temperature varied between 100.6°F and 101.4°F. The

respiratory rate varied between 40 and 48 per minute. The rumen movements averaged 2 per minute, and continued to be moderately forceful. On two occasions the rate of the rumen movements dropped to 1½ per minute. The heart rate varied between 48 and 62 per minute. The character and the amount of feces voided remained normal. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 6,640 per cmm and 7,620 per cmm. No shift of the Schilling Index was noted. A rumenotomy was performed on the animal on January 25, 1955. The magnet with the 3 nails and the 1 wire attached to it, was recovered from the posterior chamber of the rumen. The wire and the nails were attached to the magnet with their long axis parallel with that of the magnet. No adhesions or thickening of the wall of the reticulum or of the rumen were noted.

Cow # 27. Guernsey cow approximately 5 years of age, weighing about 750 pounds, and in fair condition. Positive to the metal detector. Preliminary examinations were carried out between December 18, 1954 and December 22, 1954. The temperature varied between 100.6°F and 101°F. The respiratory rate varied between 42 and 52 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 48 and 60 per minute. The amount and the character of the feces voided were considered

to be normal. The animal showed no pain to deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied from 6,660 per cmm to 8,840 per cmm. No shift of the Schilling Index was observed. An Alnico type V magnet was administered to the animal on December 23, 1954. Thirty minutes later 2 nails measuring 32 mm long and 2 mm in diameter, and 1 nail measuring 50 mm long and 4 mm in diameter were administered to the animal enclosed in a gelatin capsule. The 3 nails were sharpened. The animal had not been starved prior to the administration of the magnet or the nails, and the rumen was noted to be very full of ingesta. Examinations were conducted in the usual manner from December 24, 1954 until January 13, 1955. The temperature varied between 100.4°F and 101.6°F. The respiratory rate varied between 44 and 48 per minute. The heart rate varied between 54 and 58 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The character and amount of feces voided remained normal. The animal showed no pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 5,720 per cmm and 9,360 per cmm. The count of 9,360 per cmm was made on December 30, 1954. No marked shift of the Schilling Index was noted. A rumenotomy was performed on the animal on January 13, 1955. The magnet was found in the anterior dorsal sac of the rumen. The 2 short nails and

the 1 long nail that had been administered were found in the reticulum. Two pieces of baling wire 35 mm long were also found in the reticulum. No adhesions could be palpated between the reticulum and adjoining tissues. However, a thickened area of the wall of the reticulum approximately 25 mm in diameter was noted on the ventral floor.

Cow # 24. Jersey cow approximately 4 years of age weighing about 700 pounds, and in fair condition. Positive to the metal detector over the area of the reticulum. Preliminary examinations were carried out between December 2, 1954 and January 21, 1955. The temperature varied between 100.4°F and 100.8°F. The respiratory rate varied between 36 and 46 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 52 and 64 per minute. The amount and character of feces voided were considered to be normal. The animal showed no pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 7,800 per cmm and 11,920 per cmm. The animal was given an Alnico type V magnet on January 21, 1955. Thirty minutes later 3 short nails measuring 32 mm long and 2 mm in diameter were administered in a gelatin capsule. The nails were sharpened. The animal had been deprived of hay for 24 hours prior to the administration of the magnet and the nails. Examinations were conducted in the usual manner between January 22, 1955

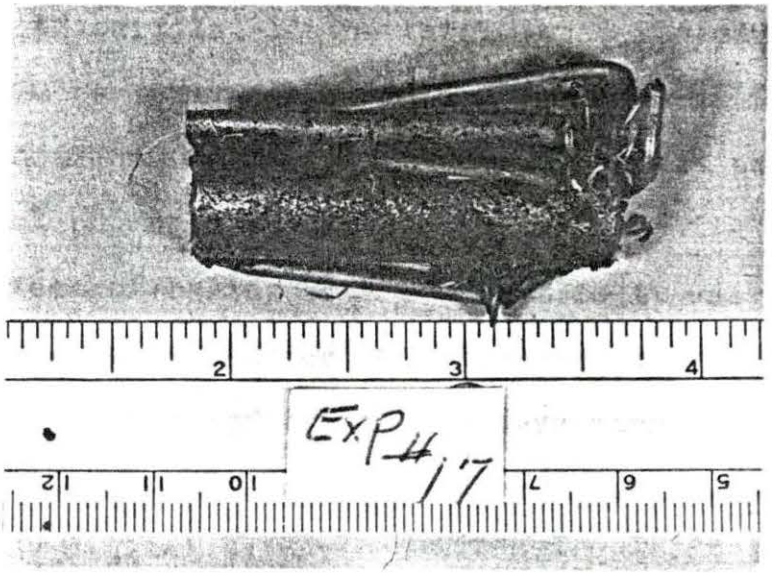
and April 8, 1955. The temperature varied between 100.4°F and 101.2°F. The respiratory rate varied between 40 and 48 per minute. The rumen movements averaged 2 per minute and remained moderately forceful. The heart rate varied between 48 and 58 per minute. The amount and character of the feces voided remained normal. The animal showed no pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 5,520 per cmm and 10,920 per cmm. The count of 5,520 per cmm was noted on February 14, 1955, and was due almost entirely to the low number of immature neutrophiles. This low count did not continue for more than three days, and on February 17, 1955 the total leucocyte count was 8,040 per cmm. The immature neutrophiles forming approximately 18% of the total on this date. A rumenotomy was performed upon the animal on April 8, 1955 and the magnet and the 3 nails were recovered from the reticulum. One other nail 25 mm long, and 2 pieces of baling wire, one 30 mm long and one 50 mm long were also recovered from the reticulum. All of the nails and both pieces of baling wire were found attached to the magnet with the long axis of the nails and of the wires parallel with that of the magnet. No evidence of injury or penetration of the wall of the reticulum could be determined by digital palpation.

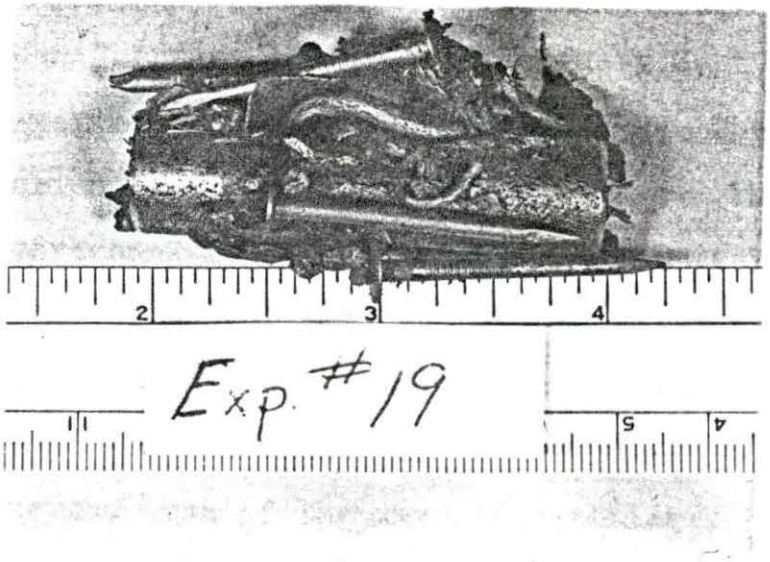
Cow # 17. Guernsey cow approximately 3 years of age weighing about 800 pounds, and in fair condition. Negative

to the metal detector. Preliminary examinations were conducted between January 22, 1955 and January 28, 1955. The temperature varied between 100°F and 100.6°F. The respiratory rate varied between 42 and 52 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 60 and 68 per minute. The amount and character of the feces voided were considered to be normal. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 7,900 per cmm and 9,800 per cmm. No shift of the Schilling Index was noted. An Alnico type V magnet was administered to the animal on January 29, 1955. The animal was deprived of hay for 24 hours prior to the administration of the magnet. On February 7, 1955 3 nails measuring 32 mm long and 2 mm in diameter, and 1 piece of baling wire measuring 50 mm long were administered in a gelatin capsule. The nails were sharpened. The baling wire was sharpened on one end, and the other end was coiled. The animal was not deprived of hay prior to the administration of these objects. Examinations were conducted as usual between January 29, 1955 and March 29, 1955. The temperature varied between 100.6°F and 101.2°F. The respiratory rate varied between 44 and 58 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 58 and 68 per minute. The character and

Photo #6. Magnet recovered from the reticulum of cow #17. The three nails and the one piece of baling wire that were administered are adherent to the magnet

Photo #7. Magnet recovered from the reticulum of cow #19. The three nails that were administered to the cow plus one other nail and numerous bits of wire and nails are adherent to the magnet


Exp #17

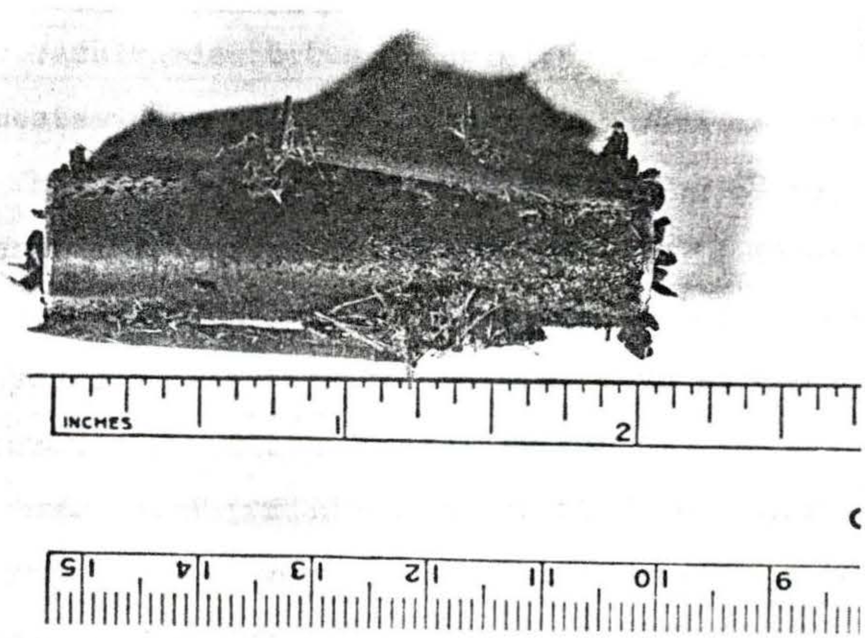

Exp. #19

the amount of feces voided remained normal. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 8,120 per cmm and 10,080 per cmm. No shift of the Schilling Index was observed. A rumenotomy was performed on the animal on March 29, 1955. The magnet with the 3 nails and the 1 piece of baling wire attached to it was recovered from the floor of the reticulum. The long axis of the nails and the wire and that of the magnet were parallel. No evidence of injury to the wall of the reticulum could be determined by digital palpation.

Cow # 19. Guernsey cow approximately 4 years of age weighing about 700 pounds, in fair condition. Negative to the metal detector. The preliminary examinations were conducted between February 1, 1955 and February 8, 1955. The temperature varied between 100.4°F and 101°F. The respiratory rate varied between 36 and 44 per minute. The rumen movements averaged 2 per minute and were moderately forceful. The heart rate varied between 52 and 60 per minute. The amount and character of feces voided were considered to be normal. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 6,880 per cmm and 9,240 per cmm. No shift of the Schilling Index was noted. An Alnico type V magnet was administered to the animal on February 9,

1955. The animal had been deprived of hay for 24 hours prior to the administration of the magnet. On February 18, 1955 3 nails measuring 32 mm long and 2 mm in diameter were administered to the animal enclosed in a gelatin capsule. The animal was not deprived of hay prior to this administration. Clinical examinations were conducted in the usual manner between February 9, 1955 and March 31, 1955. The temperature varied between 100.2°F and 101.4°F. The respiratory rate varied between 40 and 48 per minute. The amount and character of feces voided remained normal. The rumen movements averaged 2 per minute, and continued to be moderately forceful. The heart rate varied between 50 and 66 per minute. The total leucocyte count varied between 8,460 per cmm and 10,320 per cmm. No shift was noted of the Schilling Index. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. A rumenotomy was performed on the animal on March 31, 1955. The magnet with the three nails attached to it was found on the floor of the reticulum. One other nail plus numerous bits of wire were also found adherent to the magnet. The long axis of the nails and that of the magnet were parallel. No evidence of injury to the wall of the reticulum or any adhesions of the reticulum to adjacent structures could be detected by digital palpation.

Photo #8. Magnet recovered from the reticulum of cow #25. The three nails that were administered to the cow, plus numerous iron filings, are adherent to the magnet


INCHES

Cow # 25. Jersey x Angus cross, approximately 6 years of age, weighing about 700 pounds and in fair condition. Negative to the metal detector. Preliminary examinations were conducted between February 2, 1955 and February 9, 1955. The temperature varied between 100.4°F and 101.2°F. The respiratory rate varied between 38 and 52 per minute. The rumen movements averaged 2 per minute, and were moderately forceful. The heart rate varied between 54 and 68 per minute. The character and the amount of feces voided were considered to be normal. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 9,800 per cmm to 11,240 per cmm. No shift of the Schilling Index was noted. An Alnico type V magnet was administered to the cow on February 9, 1955, and thirty minutes later a gelatin capsule containing 3 nails was administered. The nails measured 32 mm long and 2 mm in diameter, and were sharpened. The animal had been deprived of hay for 24 hours prior to administration of the magnet and the nails. Clinical observations were carried out in the usual manner between February 10, 1955 and May 25, 1955. At the latter date, the animal was sold and no further observations could be made. The temperature varied between 100.6°F and 101.4°F. The respiratory rate varied between 40 and 56 per minute. The rumen movements averaged 2 per minute and were moderately

forceful. The heart rate varied between 50 and 72 per minute. The character and amount of feces voided remained normal. The animal showed no evidence of pain upon deep pressure over the area of the xyphoid cartilage. The total leucocyte count varied between 8,860 per cmm and 11,280 per cmm. The Schilling Index showed no shift. After the animal was sold it was placed on pasture. The pasture consisted of blue grass, and was not of very good quality due to the drouth conditions that prevailed. Some mixed legume hay was fed the animal. The Department of Anatomy purchased the cow about September 20, 1955, and it was killed and embalmed for use in the gross anatomy laboratory. The reticulum and the rumen were examined by the author on April 5, 1956. The magnet was located on the floor of the reticulum. The 3 nails were attached to the magnet with their long axis parallel with that of the magnet. No evidence of injury to the wall of the reticulum could be found.

Table 2. Location and disposition of magnet, and nails and/or wires

Number of cow	Starved prior	Administration of magnet	Administration of foreign object	Date of rumenotomy	Object in reticulum	Object in rumen
9	no	12-14-54		1-10-55	X	
20	no	12-9-54		1-13-55	X	
16	no	12-8-54	1-11-55	1-18-55	X	
15	no	12-8-54	4-1-55	4-12-55	X	
26	no[a]	1-13-55	1-13-55	1-29-55		X[b]
27	no[a]	12-23-54	12-23-54	1-13-55	X[c]	X[d]
24	yes	1-21-55	1-21-55	4-8-55	X	
17	yes	1-29-55	2-7-55	3-29-55	X	
19	yes	2-9-55	2-18-55	3-31-55	X	
25	yes	2-9-55	2-9-55	[e]	X	

[a]Denotes animal considered extremely full of hay at time the magnet was administered.

[b]Magnet and nails and wire recovered from posterior chamber of rumen.

[c]Magnet recovered from anterior dorsal sac of rumen.

[d]Nails and wire recovered from reticulum.

[e]Animal killed September 20, 1955.

IV. DISCUSSION

The purpose of this study was an attempt to develop a method of preventing traumatic gastritis by the oral administration of Alnico type V magnets. The author became interested in the prevention of traumatic gastritis while conducting a survey of the incidence of ferrous metallic foreign objects in the forestomachs of a herd of dairy cattle maintained under apparently good conditions. This survey was conducted for a period of six months on 104 cows and first calf heifers picked at random from a group of approximately 180 cows in the milking line. The selection was made without regard to age, breed, or stage of lactation. An electronic metal detector was used for the survey. The first examination of the herd showed that 18 of the cows were negative to the detector for the presence of ferrous material in the forestomachs, 67 were positive over the area of the reticulum, 13 were positive over the area of the rumen, and 6 were positive over both the rumen and the reticulum. The cows were checked at intervals of approximately one month for six months. At the end of the six month period, 7 cows were negative to the detector. Of these 7 cows, only 4 had remained negative for the entire period of the survey. Seventy-six cows were positive over the area of the reticulum. Ten cows were positive over the area of the rumen. Six cows were positive over both the reticulum

and rumen. Five cows had been lost from the group under survey due to traumatic gastritis. One of the five animals had died of traumatic gastritis and its complications. The other 4 animals that were lost from the herd due to traumatic gastritis were sold to slaughter because they were no longer profitable. This incidence agreed with that reported by Churchill (1950) who stated that the incidence of cattle positive to the metal detector is as high as 90% in certain herds. Maddy (1954) stated that the incidence of adhesions due to traumatic gastritis may reach 80.2% in certain herds, and that of 16,713 dairy cattle that he inspected at time of slaughter, 70.6% showed evidence of reticular adhesions, presumably from penetrations of foreign bodies. However, the clinical diagnosis of traumatic gastritis in the herd surveyed did not exceed 10% during the six months of the survey. In this connection, it must be understood that penetrations of the reticulum causing only a mild inflammatory reaction probably would not be brought to the author's attention by the herdsmen, if the cow involved did not go off feed or show other evidences of penetration. Also, no way to check the incidence of reticular adhesions could be devised. One other herd of 13 animals that the author had an opportunity to examine with the electronic metal detector showed an incidence of 100% positive, and in this herd, 4 animals required rumenotomies for the relief of traumatic

gastritis in a period of 4 months following the examination. One other herd of 19 animals was checked with the electronic metal detector, and 18 of the 19 animals were positive for the presence of ferrous metal in the forestomachs.

A preliminary report by Cooper (1954) proposing the use of magnets administered orally to control traumatic gastritis stimulated the author to investigate this method more thoroughly. Cooper (1954) reported on only 11 cattle, using no controls, and the magnet succeeded in reaching the reticulum in only 2 of the 11 animals, being recovered from the floor of the rumen in the other nine animals. No work had been done on the most efficient method of administration, of the effect of the magnet itself upon the animal, or upon the efficiency of the magnet in preventing the penetration of foreign bodies through the wall of the reticulum in a controlled study. In an attempt to determine these facts, studies were begun on a series of 44 animals in November, 1954.

A. Most Efficient Method of Administration of Magnets

A series of 34 cattle were given magnets orally in an attempt to determine the most efficient method of administration. These animals were arbitrarily divided into groups according to whether or not they were deprived of hay prior to administration of the magnet, and the time elapsing

between the administration of the magnet and the rumenotomy performed to recover the magnet. Carroll (1955) reported on the field use of magnets in 42 animals, and he used 52 animals in the same age group in the same herd as controls. However, he did not indicate, except in the three instances in which he performed a rumenotomy and recovered the magnets, as to the final location of the magnet in the animal. In the three instances where he did recover the magnet, he stated that he found the magnet in the reticulum. He did not state that he made any attempt to determine a particular method of insuring that the magnet would enter the reticulum.

The first group of 12 animals were not deprived of hay prior to the administration of the magnet to each animal. Rumenotomies were performed upon these animals within 30 minutes of the administration of the magnet in an attempt to determine if the magnet would enter the reticulum directly, or first enter one of the chambers of the rumen. Eleven of the magnets were recovered from the anterior dorsal sac of the rumen, and 1 magnet was recovered from the reticulum. None of the animals were considered to have the rumen excessively filled with ingesta. However, some of the animals were considered to have rumen movements slightly weaker than would normally be expected, and in these animals the rumen movements were also considered to be slightly slower than normal. The results obtained in this group of animals do

not agree with Hutyra and Marek (1938, p. 87) who stated that heavy objects fall into the reticulum because of their weight. Runnells (1941, p. 324) stated that heavier objects lodge in the reticulum, but did not state if the objects go directly into it. Nusbaum (1955) stated that lead filled capsules that he administered orally were found in the reticulum immediately after the animals were slaughtered. However, he did not state the time elapsed between administration and recovery.

In the next series of animals studied, rumenotomies were performed on 4 animals that were considered to be on a full feed of hay, 24 hours after the administration of the magnet to each animal. The animals were in rather good physical condition, and the rumen movements were considered to be normal in rate and in force. In all of these animals the magnet was found in the anterior dorsal sac of the rumen. From the above total of 16 animals, it would seem that the magnet would tend to enter the anterior dorsal sac of the rumen if it was administered to an animal having a rumen normally full of ingesta.

One patient entering the clinic for a rumenotomy had a history of not eating a normal amount of hay or grain for the previous 2 days. The rumen movements were slightly slower and weaker than would be considered normal. The animal was given a magnet orally, and a rumenotomy was per-

formed upon the animal within 30 minutes after the administration of the magnet. The magnet was recovered from the anterior dorsal sac of the rumen. The rumen contents in this animal were about normal in consistency, though the quantity of hay in the rumen was sufficient in amount to fill the rumen to about only one-third of its capacity. The amount of fluid in the rumen and reticulum was considered to be about normal in quantity. Possibly the weakened rumen movements accounted for the failure of the magnet to enter the reticulum.

Since the magnets were not recovered from the reticulum in 24 hours after administration to animals with a full rumen, it was decided that the animals should be deprived of hay for a period of time prior to the administration of the magnets in an attempt to partially empty the rumen. It was felt that the entrance of the magnet into the reticulum might be interfered with by the purely mechanical factor of bulk of ingesta. Twelve animals were deprived of hay for a period of 24 hours prior to administration of a magnet to each animal. Rumenotomies were performed on these animals 24 hours after the administration of the magnets. The results obtained were much better than those obtained in animals that had not been deprived of hay. In 10 of the animals the magnet was recovered from the reticulum, and in 2 the magnet was recovered from the anterior dorsal sac of

the rumen. Cooper (1954) and Carroll (1955) did not mention any attempt to starve the animal prior to administration of the magnet. However, Muffly (1955) in discussing passing the same type of magnet through a stomach tube, stated that a 24 or 48 hour fast favored the entrance of the magnet and the end of the stomach tube into the reticulum. He also stated that he had 12 failures in 53 attempts to pass the magnet into the reticulum. Nusbaum (1955) did not mention starving the animals, and stated that he passed a 7 inch electromagnet successfully in 9 of 10 animals. He stated that he believed that in small animals the electromagnet he used might fall behind the ruminoreticular fold, and into the rumen. The observations made in this group studied by the author would tend to indicate that the entrance of the magnet into the reticulum is facilitated by depriving the animal of hay for 24 hours to empty the rumen prior to the administration of the magnet. Possibly a longer period of starvation would be indicated in animals in which the rumen was extremely full of ingesta. No conclusions were reached as to the exact time the magnet reached the reticulum, or if the magnet entered the anterior dorsal sac of the rumen in all instances before entering the reticulum.

It was felt that in some instances the entrance of the magnet into the reticulum might require a period of time longer than 24 hours after administration. In an attempt

to determine this, 5 animals were deprived of hay for 24 hours prior to the administration of the magnet to each animal. Rumenotomies were performed on the animals 48 hours after the administration of the magnets. In all 5 of the animals the magnet was recovered from the reticulum. This result would indicate that some time is required for the magnet to enter the reticulum. However, Cooper (1954) administered magnets of approximately the same size to 3 animals that were slaughtered 14 days later, and the magnet was found in each instance in the rumen. Possibly the combination of a rather empty rumen and the time factor would account for all of the magnets being recovered from the reticulum in the 5 animals the author studied.

More studies could have been made on the relationship between the degree of fullness of the rumen and the entrance of the magnet into the reticulum, and the time factor could also have been explored more thoroughly. However, the number of cattle that could be utilized in the study was limited, and for this reason this was not done.

B. Effect of the Magnet Itself, and the Efficiency of the Magnet to Prevent Penetration of the Reticulum

Various authors are in general agreement as to the most frequently observed symptoms noted in traumatic gastritis. Since the symptoms observed in a given individual are described as being variable, the most commonly noted symptoms were used

as a criterion in an attempt to determine if the magnet itself produced a gastritis, and if the magnet would prevent sharpened nails or wires from penetrating the reticulum. The clinical symptoms that were looked for in each animal were: a rise in the temperature, a rise in the rate of respirations, a rise in the heart rate, pain over the area of the xyphoid cartilage when pressure was applied, a change in the character and amount of feces voided, a slowing and weakening of the rumen movements, and a leucocytosis or a leucocytosis with a neutrophilia. It was decided that if clinical manifestations tended to indicate that traumatic gastritis had occurred, an immediate rumenotomy would be performed to attempt to determine if the magnet, or the nails and wire were causing the symptoms to develop. The symptoms mentioned above are the ones noted most frequently by Kingrey (1955), and were used as a guide because the type of nails and wires used in this study were the same as those that he used to produce traumatic gastritis in a series of ten cows.

Bosshart (1926), Bardwell (1927), Gibbons (1932), Udall (1939, p. 107), Jensen (1945) and Hansen (1953) all stated that pain over the area of the xyphoid cartilage was an important symptom of traumatic gastritis. Kingrey (1955) stated that pain over the area of the xyphoid cartilage was probably the most frequently observed clinical symptom of

the disease. The author has also noted this to be a frequent manifestation of traumatic gastritis in cases that he has observed. Ryan (1947) stated that pain over the xyphoid was not always present, and that it was of questionable value in nervous animals. Milne (1953) stated that this symptom was of questionable value. None of the animals in this study showed any evidence of pain upon pressure over the region of the xyphoid cartilage, with the exception of cow # 15. This animal showed some discomfort both prior to and after administration of the magnet, and also of the nails. However, the animal did not show the forced expiratory noise or grunt that is usually noted, and it was felt that possibly the discomfort could have been due to the animal being of a nervous disposition.

A loss of appetite for grain was mentioned by Bosshart (1926), Gibbons (1932), Ryan (1947), and Kingrey (1955). However, since the animals were kept on a ration of hay only, the diminished appetite for grain could not be used to check for evidence of penetration or of gastritis. Kingrey (1955) stated that a diminished appetite for hay was not as apparent as that for grain. None of the animals under study were observed to have a diminished appetite for hay during the course of the study.

None of the ten animals studied showed any evidence of a leucocytosis, or of a leucocytosis with a neutrophilia.

The total leucocyte count remained within normal limits generally ascribed to the bovine species, with the exception of cow # 9, and cow # 16. Cow # 9 had a total leucocyte count varying between 16,160 per cmm and 17,640 per cmm prior to the administration of the magnet, and varying between 14,660 per cmm and 16,640 per cmm after administration of the magnet. No cause, other than a chronic mastitis, could definitely be determined for the relatively high count. Cow # 16 had a total leucocyte count of 13,600 per cmm on one occasion prior to the administration of the magnet. The Schilling Index showed a shift to the left at this time. This high count was probably due to the lacerations produced in the rectal mucosa during the laboratory exercises in obstetrics. Jensen (1945) stated that the total leucocyte count would exceed 15,000 per cmm in traumatic gastritis. Arthur (1946), Ryan (1947), and Churchill (1950) stated that a leucocytosis with a neutrophilia was an important diagnostic feature in differentiating between traumatic gastritis and other digestive disorders in the bovine species. Kingrey (1955) stated that the total leucocyte count might remain within normal limits, but that the rise in the percentage of stab neutrophiles could be relied upon to indicate the presence of infection resulting from penetration. None of the ten cows studied showed any marked shift of the Schilling Index.

A marked rise in the temperature was not noticed in any of the ten cows under study. Some slight variations in the temperature were noted on certain occasions when the external temperature to which the animals were exposed changed suddenly, but in none of the animals did this exceed 1°F. Bosshart (1926), Bardwell (1927), Gibbons (1932), Hutyra and Marek (1938, p. 92), Udall (1939, p. 107), Ryan (1947), and Kingrey (1955) all mentioned rise in the temperature as occurring in traumatic gastritis.

The rise in the respiratory rate mentioned by Bosshart (1926), Hutyra and Marek (1938, p. 92), Udall (1939, p. 107), and Arthur (1946) did not occur in any of the animals. Some difficulty was experienced in obtaining an accurate and consistent respiratory rate for the individual animal. The respiratory rate seemed to be the most variable of the clinical data obtained. The shallow respirations noted by Hutyra and Marek (1938, p. 92), Udall (1939, p. 107), and Arthur (1946) did not occur in any of the animals studied.

In all ten of the animals studied the character and the amount of feces voided did not change during the course of the study, with certain exceptions. The exceptions were that the feces voided were noted to be more fluid and more voluminous on several occasions. In each instance where this occurred, the animal was found to have been palpated during the obstetrics laboratory exercises for an exceedingly long

time the preceding day. The feces would generally revert to the normal consistency and volume for the particular animal within 48 hours. Bosshart (1926) stated that the bowel action tended to become retarded in traumatic gastritis. Ryan (1947) stated that he regarded a reduced amount of feces voided, but of normal consistency, as a regular symptom of traumatic gastritis. Kingrey (1955) stated that of the ten animals in which he experimentally produced traumatic gastritis, each animal showed some suppression of fecal evacuation.

None of the cows studied showed any significant change in either the force or the rate of the rumen movements. However, the rate of the rumen movements was taken in all instances after several other clinical observations had been made upon the animals, and it is possible that some error could have been made in recording the rate in some individuals. This might be true if the previous clinical examinations had startled the animal being examined. The rate and the force of the rumen movements were constant, or nearly so, in each animal for the entire period the animal was studied. The rate averaged about two movements per minute for all of the cows. The force was considered to be moderately forceful in all of the animals. Cow # 16 averaged $2\frac{1}{2}$ movements per minute during part of the study, and 2 per minute for the rest of the period. Cow # 9 averaged $1\frac{1}{2}$

movements per minute during the entire period of the study. Cow # 26 averaged 2 rumen movements per minute, but on two occasions dropped to 1½ movements per minute. These rates agree closely with those given by Dukes (1942, p. 286) who stated that the rumen contractions averaged 2.8 per minute while eating, 2.3 per minute during rumination, and 1.8 per minute while resting. Gibbons (1932) and Clay (1946) stated that loss or dimunition of rumen movements was one of the principal symptoms of traumatic gastritis. Kingrey (1955) stated that the reduction in the rate of the rumen movements was of less diagnostic significance than the reduced force of the contractions. He further stated that the force of the contractions tended to remain reduced during the entire course of the disease as he produced it experimentally.

None of the cattle studied showed any marked rise in the rate of the pulse during the entire period of the study. A rise in the pulse rate had been reported to be a rather constant symptom of traumatic gastritis by Bosshart (1926), Bardwell (1927), Gibbons (1932), Hutyra and Marek (1938, p. 92) and Udall (1939, p. 107). Kingrey (1955) stated that an increase in the pulse rate was always noted in the animals in which he produced traumatic gastritis experimentally, but that he found the rate to be variable in normal cows, and that the increase in the rate in traumatic gastritis was small. The heart rate in the animals under study was

thought to be rather high in several instances, but since the rates recorded were fairly consistent for the individual animal both prior and after the administration of the magnet and nails and wire, it was decided to accept these rates as being normal for the individual animal.

The animals were all subjected to a rumenotomy to recover the magnet, or the magnet and nails and wire that had been administered, with the exception of one animal. This one animal was examined after dissection in the Department of Anatomy. In the animals in which a rumenotomy was performed the magnets were all recovered, as were all of the nails and wires that had been administered. At the time the rumenotomy was performed, the serous surface of the reticulum was palpated, and also the adjoining tissues. In the nine animals so examined, no adhesions between the reticulum and the adjacent structures could be detected. However, it was possible that small or fragile adhesions might have been overlooked by this method. After the rumen was incised, the hand was inserted into the opening and the reticulum and the compartments of the rumen were searched for the magnets and/or nails and wires that had been administered. The wall of the reticulum was palpated for any evidence of thickening. No evidence of a thickened area of the wall of the reticulum was noted except in cow # 27. In this animal the magnet plus 3 nails was administered on

12-23-54. The animal was subjected to a rumenotomy on 1-13-55, and the magnet was recovered from the anterior dorsal sac of the rumen. The 3 nails, plus 2 pieces of baling wire that had not been administered to the animal, were recovered from the reticulum. The nails and the wires were not penetrating the wall of the reticulum nor laced through the folds of the mucosa at the time of the rumenotomy. A thickened area of the wall of the reticulum approximately 25 mm in diameter was noted on the ventral floor. No symptoms had been observed in the animal during the course of the study that would tend to indicate any penetration of the reticulum, except possibly the rise in the total leucocyte count to 9,360 per cmm on December 30, 1954. However, the differential leucocyte count on this date revealed 10% stabs, 16% segmented neutrophiles, 62% lymphocytes, and 12% eosinophiles. The differential leucocyte count immediately preceding this one showed stabs 10%, segmented leucocytes 17%, lymphocytes 56%, and eosinophiles 17%. From this it can be seen that the neutrophiles did not increase in percentage, but that the lymphocytes increased at the expense of the eosinophiles. Since no other symptoms of traumatic gastritis occurred during the period of study, it was assumed that the thickened area could have been a result of a previous penetration of the wall of the reticulum, possibly from the 2 pieces of baling wire that were found in the reticulum. This sup-

position would agree with the report of Hansen (1953) who stated that many cows would recover from one or more attacks of traumatic gastritis if expectant treatment was employed. Hutyra and Marek (1938, p. 98) and Udall (1939, p. 106) also stated that expectant treatment was often successful. In the case of this animal it is difficult to understand why the sharpened nails did not penetrate the wall of the reticulum. However, Kingrey (1955) stated that wires have a greater tendency to penetrate the wall of the reticulum than do nails.

In cow # 26 the magnet and the 3 nails and 1 wire that had been administered on 1-13-55, were recovered from the posterior chamber of the rumen on 1-29-55. The wire and the 3 nails were attached to the magnet. This result compares with the report of Cooper (1954) who found that the magnet would hold and attract a reasonable amount of ferrous material regardless of the location of the magnet.

A larger group of animals to study in this group would have been desirable. This would have allowed a better indication of the feasibility of the use of magnets to prevent penetration of the wall of the reticulum by foreign objects of ferrous nature. It would also have been desirable to study the animals for a longer period of time before performing a rumenotomy upon the animals to recover the magnets. A period of one year would possibly have been of

more value in an attempt to determine if the magnet would prevent penetration of the reticulum, and if the magnet itself would cause any harm by acting as a blunt foreign object in the digestive tract.

V. CONCLUSIONS

1. The most efficient method of insuring that a magnet of the type used in this study will enter the reticulum after oral administration, is to partially empty the rumen of the animal by depriving it of food for a period of at least 24 hours before administration of the magnet.

2. Heavy foreign objects tend to enter the anterior dorsal sac of the rumen, and within 48 hours after ingestion most will migrate into the reticulum.

3. Magnets administered orally to cattle did not in the period during which the animals were observed produce any symptoms of traumatic gastritis.

4. Magnets administered prior to the administration of sharp foreign objects will prevent these objects from penetrating the wall of the reticulum.

5. The use of orally administered magnets of the type used in this study might be a feasible method of prevention of traumatic gastritis in certain herds.

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