

# The American Journal of Roentgenology

Edited by P.M. Hickey, M.D.  
Associate Editor, F.C. Zapffe, M.D.

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No. 1

## Memorial

To

Charles Lester Leonard, A.M., M.D.

Poetry . . . . . Esther Morton Smith

Resolutions

Portrait

Radiography of the Stomach and Intestines—A  
Report Prepared by Charles Lester Leonard  
for the Section on Radiology of the XVIIth  
International Congress of Medicine,  
London, 1913

Bibliography

Biography

Contributions to Medical Literature by Charles  
Lester Leonard, M. D.

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CHARLES LESTER LEONARD

When God's strong, tender angel came before him  
With his release,  
Then from the firing line we gently bore him  
Wrapped in deep peace.

His was an outpost where the fight was cruel  
Till his last breath,  
Yet with each day his courage found renewal;  
He served till death.

Courage of soul, too strong and high to fail him  
The hard fight through.  
Brother, and man, and hero—these we hail him—  
Sore tried, and true.

October 11th, 1913

*Esther Morton Smith*

**Whereas** The American Roentgen Ray Society as a body, and the individual members personally, have lost, through the death of Dr. Charles Lester Leonard, a member renowned for his scientific attainments in Roentgenology, beloved by his colleagues for the unfailing interest he displayed in establishing this society with high standards and mourned not only as the nestor of Roentgenology in America, but also as our personal friend and adviser,

**Be it resolved** that the American Roentgen Ray Society adjourn for a period as a token of respect to the memory of Dr. Leonard, and that we extend to his family our sincere and heartfelt sympathy in the loss of a husband and father.

Signed

P. M. HICKEY, M. D.

F. H. BAETJER, M. D.

E. H. SKINNER, M. D.



Charles Lester Leonard, M. D.

# THE AMERICAN JOURNAL OF ROENTGENOLOGY

*Editor, P. M. Hickey, M. D., Detroit*

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## THE RADIOGRAPHY OF THE STOMACH AND INTESTINES

Report by **CHARLES LESTER LEONARD, A.M., M.D.,** of Philadelphia

THE importance of röntgenography in the diagnosis of gastro-intestinal lesions has recently been emphasized by the prominence given to this subject in the programmes of national medical and surgical societies.

Special reports have been made and entire sessions given over to their discussion. The progress of the past five years has influenced medical and surgical opinion until a Röntgen examination is considered a *sine qua non* before operation.

The kindred sciences of anatomy, physiology, and pathology show the effect of their study in the living man by this method. Other methods of physical and chemical diagnosis are not displaced, but are amplified by the knowledge it affords. In fact, the Röntgen method yields its best results when the patient referred for examination is accompanied by all the data which the older methods can secure.

The importance of this particular adaptation of the radiographic method of diagnosis from the röntgenologist's standpoint is shown by the voluminous mass of literature accumulated in the past five years.

This literature is too extensive, even when viewed from the purely radiographic standpoint, to make a comprehensive analysis practical. Your reporter will therefore confine himself to a review of the most salient features gathered from the available literature and his own experience.

This will render them available for amplification, and those points not definitely settled can be discussed in the session the opening of which is the purpose of this paper.

The subject of technique will not include a discussion of apparatus or of the pros and cons of the relative merits of various methods employed. The more prominent and useful variations in technique will be stated, and their application discussed more fully under the examination for which they are best fitted.

### TECHNIQUE

The Rieder opaque meal is the point of departure from ordinary methods of radiography upon which is founded the entire structure of röntgenologic examination of the stomach and intestines.

It is due entirely to the introduction of the large quantities of bismuth in the food of the patient that these examinations can be made. The hollow viscera are practically invisible unless a contrast is produced by artificial means between them and the surrounding structures.

It must always be remembered that it is the silhouette of the opaque mass, more or less completely filling their lumen, that is being observed. The pathological changes to be studied are only expressed by their effects upon the contained ingesta.

The opaque chemical salts employed in forming the opaque meal have been the subnitrate, the subcarbonate, and the oxychloride of bismuth and the sulphate of barium.

Of these salts the oxychloride of bismuth is the most suitable. It possesses the advantage of insolubility and great pureness. Its only disadvantage is the relative high cost.

The subnitrate was much employed, but was found to possess toxic properties that were eliminated with difficulty.

The subcarbonate of bismuth was then employed, as it was free from toxic properties and was nearly as opaque. It has, however, been found that it combines with the free HCl in the stomach and thus produces abnormal conditions.

Barium sulphate has recently been much employed because of its low cost. Though less opaque than the bismuth salts, larger quantities can be employed at much less expense, an item of no inconsiderable importance in hospital work where large numbers of patients are examined. Great care must be taken to get a pure barium sulfuricum, since a number of serious accidents have been reported when the wrong salt was employed.

Pure barium sulphate for X-ray use is now placed upon the market by reliable chemical firms, such as Squibbs, or, as in Germany, under the name of Baradiol, used to signify a specifically pure barium salt for this purpose.

### THE OPAQUE MEAL

The vehicle in which the opaque salt is given is of much importance. In order to preserve, as nearly as possible, the true physiological condition the vehicle should be acceptable to the patient. It is well known that a good digestion is dependent upon a good appetite. Also that unless salivary digestion is stimulated, gastric digestion is abnormal. Nauseating, unappetizing media are therefore to be avoided if the physiological conditions are to be observed.

Media of varying consistencies must be employed according to the scope and quest of the examination. Bread and milk, wheat and rice puddings and various forms of porridge have been employed.

Oatmeal porridge is a universally used breakfast food, and forms one of the most suitable media for an opaque meal. Eaten with cream and sugar or fruit syrups it is a normal appetizing and readily digested food, and would seem to be an ideal vehicle for a uniform opaque meal, which could be used for universal comparison.

Watery suspensions with gum tragacanth or bolus alba have been frequently employed, and also cocoa.

The fermented milks apparently hold the opaque salt in suspension for long periods, but cannot be used with salts that combine with lactic acid. A watery decoction of potato flour has recently been suggested, which can be readily varied in its consistency.

A normal contrast meal has recently been suggested for use in determining the motor function, particularly of the intestinal tract. It consists of known quantities of a mixed food diet to which is added a definite amount of opaque salt with each meal during the first day. During the second day, when observations are commenced, the same diet is employed but without the opaque salt, and this routine is continued, while observations are made until the last trace of the opaque salt has passed the rectum.

The question of a uniform opaque meal upon which universal comparisons can be based is worthy of consideration.

The inflation of the stomach by means of the stomach tube, or by the separate administration of solutions of bicarbonate of soda and tartaric acid has been employed and discarded as a means of producing a contrast between the stomach and the surrounding viscera.

The author has recently employed this method with effect in combination with rapid stereo-röntgenography. The distension of the stomach with gas causes a cessation of peristalsis, and the stereoscopic picture reveals the inner surface of the distended stomach. In a case in which the Röntgen

findings were absolutely confirmed by the subsequent operation a malignant tumour was shown projecting into the lumen of the stomach from the posterior wall of the upper corpus and fornix, where its relation to the stomach tube could be exactly determined. If a method of coating the mucosa uniformly with an opaque salt can be combined with this method of radiography the lesser lesions of the mucosa might be revealed.

#### THE CAPSULES OF KASTLE

Gelatine capsules hardened in formalin to prevent their solution are made, one form containing bismuth alone, the other bismuth and air. The capsule containing air floats, while the other sinks to the bottom of the stomach. Their use will be referred to later in the appropriate place.

The capsule of *Schwartz* is made of gold-beaters' skin and contains bismuth and pepsin, and will be referred to in discussing the Röntgen method for the determination of the amount of free hydrochloric acid in the stomach.

A very valuable addition to the technique of gastro-intestinal Röntgen examinations is the *Haudek* double meal. The patient is given an opaque meal six hours before he presents himself for examination. The motor efficiency of the stomach can then be determined at once by the amount of residue remaining in the stomach.

A study of the amount, shape, and relative position of this residue with reference to the shadow in the bulbus duodeni and the umbilicus often enables the observer to make a diagnosis immediately. If it does not do this it suggests to him the line of further examination which is immediately entered upon by the administration of an opaque suspension or meal as the case demands.

Thus the examination can be completed at one sitting, with a saving of time both to the operators and patient.

The *Haenisch opaque enema* is a distinct advance in the study of lesions of the large intestine, and will be more fully considered in that connexion.

#### THE PREPARATION OF THE PATIENT

It is a point of great importance to have the patient properly prepared by thoroughly cleansing the intestinal tract before the administration of the opaque meal.

The omission of this preparation will lead to fallacious interpretations. Thus hardened faecal masses remaining in the large intestines may lead to the deduction of intestinal stasis. When with the bowel properly cleansed beforehand normal physiological conditions will be found to be present.

Likewise a patient should be allowed no food until the examination of the stomach is completed. The addition of food to the residue remaining in the stomach dilutes it and causes it to remain a longer time than it otherwise would. The same is true of the opaque chyme in the ileum.

#### THE POSITION OF THE PATIENT

Digestion normally occurs while the patient is in the erect or sitting posture. This is therefore the most utilized pose for examination. It is also the position in which ptoses and displacements of the stomach and intestines are most readily observed. The reclining, prone, and lateral position have their special applications. The placing of the patient in one or other of these positions and the study of the case in one position only is liable to lead to fallacious deductions.

Thus in the examination for *Lane* kinks and obstructions of the duodenum at its junction with the jejunum, the right lateral position would lead to unwarranted deductions. In this position the duodenum is most readily filled, and unless the patient is placed in the erect position an examination made in the lateral position alone would often lead to the deduction of obstruction. Kinks and obstructions at the duodenojejunal junction and in the ileum should be most marked with the patient erect. By employing the procedure of *Chiliaditi* with the patient erect the duodenojejunal angle can be readily shown.

Palpation of the abdomen with the hand of the observer during fluoroscopic examination is dangerous, and cannot be too strongly censured.

The procedure of *Chiliaditi* is a most ingenious and valuable addition to the technique of Röntgen examinations. The patient exhales deeply and then with glottis closed makes a forcible inspiratory effort, at the same time retracting the abdomen, but not allowing any air to enter the lungs. By this simple procedure the diaphragm is drawn high up, and with it the attached viscera, so that the movability of all the attached organs is readily demonstrated, and their attachment by or freedom from adhesions can be readily noted.

#### RONTGENOSCOPY AND RONTGENOGRAPHY

There is no question as to which of these methods should be employed in the study of the gastrointestinal tract. Both have their advantages and both their sphere of applicability, and the technique of their employment is without the scope of this paper.

The utility of röntgenography has been greatly enhanced by variations in the method of its application. Thus serial radiograms possess the great value of studying the varying phases of the passage of the bismuth meal out of the stomach and through the consecutive portions of the gastrointestinal tract. It has lately been used to scientifically depict the passage of the opaque meal through the entire gastrointestinal tract of healthy individuals. The further employment of this form of radiography in the study of pathological conditions will add greatly to the knowledge of their pathological physiology and form data for the comparison and explanation of the changes which occur in different diseases.

The *polygram*, or multiple exposures upon a single plate, is a simple and effective method of studying phases of motion occurring in organs possessing involuntary movements.

The sequence of movements both normal and pathological can undoubtedly be studied most perfectly by the *bioröntgenograms*. The apparatus and the large number of plates required is, however, such an item of expense, that unless a less expensive method can be devised of producing them their application will be limited.

Röntgenography already owes to this method knowledge which could be obtained in no other way. It is therefore to be hoped that means will be found to reduce the cost of its operation and thus extend its usefulness.

*Rapid stereoröntgenography* has already been applied with great benefit to the study of gastrointestinal conditions. Its value lies in resolving the composite shadows arising from the superposition of the shadows of various portions of the gastrointestinal tract, into discrete entities possessing not only length and breadth, but also depth, and in giving them their proper relations within the abdominal cavity. It is of great value in determining the angles which one portion of the intestinal tract makes with another. It also determines whether intimate adhesions exist between the various portions. It shows more clearly than any other method the topographical relations of the viscera to each other, and to the skeleton and parietes. It also reveals most clearly anomalies in form and position by adding a plasticity to the silhouette.

## THE STOMACH

### THE ANATOMY OF THE STOMACH

The recent work of Forssell in showing the relation of the muscular architecture of the stomach to the form as seen in the Röntgen picture is of great importance.

His investigations have shown that the form of the stomach is produced solely by degrees of contraction in its walls, but also that each portion of the stomach possesses an organized and constant anatomical structure; that is, a typical muscle architecture, which produces in the Röntgen picture characteristic forms and typical contractions.

Employing the anatomical structure as a basis, the following divisions are made. The pyloric canal or *canalis egestorius*, the sinus or *sinus ventriculi*, which gives the typical shape to the lower pole of the vertical stomach. The sinus is separated from the corpus by an oblique muscle bundle, which forms part of the perpendicular supporting structure. The main bundle of supporting fibres is attached to the œsophagus and passes downwards along the lesser curvature of the stomach, and then obliquely across to the greater curvature. It is not a true sphincter, but a thickened band of muscle fibres. The muscular structure of the pyloric canal, the sinus, the corpus and the fornix are all different in the relation of their muscle fibres to the supporting apparatus. It is thus that the anatomical architecture adapts each to its particular function, and produces typical forms by their varying contractions. The portion of the stomach that lies above the œsophagus, i. e., the fornix, contains air and has been termed the *Magenblase*, which acts as a pressure regulator and changes its shape with varying intragastric pressure.

### VARIATIONS IN THE POSITION AND SIZE

The normal stomach is variable in form and position according to certain types, all of which must be considered normal since each is capable of performing its normal function.

The later anatomical studies undoubtedly prove that the living stomach is correctly shown by the Röntgen picture.

Thus to röntgenology must be credited accurate knowledge of the shape and position of the living stomach. The identity of the anatomist's, the internist's, the surgeon's, and the röntgenologist's stomach must henceforth be accepted.

The normal stomach has been described as corresponding to various shapes. These divisions have been confusing, and a clearer understanding of what is meant will be secured if the division into groups according to muscular tone is adhered to in the future.

These groups are hyper-, ortho-, hypo-, and atonic forms. The emptying time, or normal period taken to empty these stomachs of the Rieder meal is an additional control in differentiating each type. The hypertonic requires from 2 to 3 hours to empty itself, the orthotonic 3 to 5 hours, the hypotonic 4 to 6 hours, and the atonic 6 to 8 hours.

The form of the normal stomach and its position depend largely upon the shape of the upper abdomen and the general anatomical characteristic of the individual. When the intercostal angle is wide and the upper abdomen broad the stomach assumes an oblique position. With a narrow upper abdomen and a more acute intercostal angle the stomach is perpendicular. Thus in some individuals an atonic type of stomach is normal, i. e., its function is not deranged, while the same type of stomach, in an individual of different build, but incapable of emptying itself, is the result of a ptosis.

Again, a hypertonic form of stomach may be found where the abdomen is broad and the intercostal angle wide, and yet it will be found to be orthotonic or even hypotonic.

### FUNCTIONAL DISTURBANCES OF THE STOMACH

#### TONICITY: FILLING PHENOMENA

The manner in which the opaque meal enters and fills the stomach is an indication of its muscular tone. It must, however, be remembered that an apparent change in tonicity may be the result of variation in intra-abdominal pressure or the result of external pressure exerted by neighbouring viscera or tumours springing from them.

The empty normal stomach lies in the form of a collapsed tube with its walls in contact except in the fornix which contains the *Magenblase*.

The opaque meal is first seen in the upper portion as a funnel-shaped shadow, which, while gradually increasing in size and depth, separates the walls and finally reaches the sinus and fills the pyloric canal. The length of the stomach remains fixed, while the corpus, sinus, and pyloric canal increase in girth and accommodate themselves to the amount of meal ingested. This type of filling phenomena is characteristic of the orthotonic stomach; in contrast to this the opaque meal, in entering an atonic stomach, seems to fall through the corpus directly into the sinus. The distension of the stomach commences in the sinus, the opaque meal collecting there in a half-moon form, while the walls of the corpus will remain in contact, and the fornix, filled with gas, preserves a more or less oval form. The length of the stomach is increased.

In neuropathic conditions the filling phenomena may be so altered as to suggest a pathological change in the walls of the stomach. They can be differentiated only after close study. Atropine hypodermically administered sometimes relaxes the spasm. Again, an additional amount of the opaque meal will often cause their relaxation and the appearance of the normal stomach form.

The diagnosis of a simple ulcer of the lesser curvature of the stomach may sometimes be made during the filling of the stomach. On the greater curvature of the stomach opposite to the situation of the ulcer, a small but deep and permanent contraction is seen like a commencing peristaltic wave. It differs, however, from a peristaltic wave in that it does not move onward, but remains as a spasm of the muscle for some time.

Gross changes in the contour of the stomach can be observed during the ingestion of the opaque meal. Thus the benign and malignant hour-glass stomach differ entirely in filling phenomena from the normal stomach. Malignant disease involving the œsophagus and upper end of the stomach can often be detected at this time.

The contracted stomach with patent pylorus gives a characteristic picture. The opaque meal is delayed in the œsophagus or fornix, and then rapidly passes through the contracted stomach into the duodenum.

It is possible at this time to study the relation of points of pain to the shadow of the stomach and duodenum. Too much importance should not, however, be placed upon these subjective symptoms, as they are often misleading.

### THE MOTOR FUNCTIONS OF THE STOMACH

The study of the varying intensity and form of the peristaltic waves and the time required for the opaque meal to pass affords definite data when combined with the shape, position, and form of the residue remaining in the stomach upon which to base conclusions regarding its motility.

The author called attention to the varying forms of peristaltic waves and their relation to the position of the patient in a paper read at the International Congress in Amsterdam in 1908.

He also called attention to the fact that marked changes in form take place during respiratory movement without any change in the position of the lower pole of the stomach.

In a paper before the College of Physicians of Philadelphia in December, 1908 (*Trans. of the Col.*, 1908; *Amer. Journ. of the Med. Sci.*, March, 1909), he showed that there was a constant relation between the form of the peristaltic wave and the function it was performing.

The study of the peristaltic waves of the stomach by the bioröntgenogram has elucidated the sequence of their movements, and has shown the variation in depth during their passage down the stomach.

Whether the function of the peristaltic movements is one purely for the purpose of passing the food through the stomach, or is also a churning

movement to facilitate digestion, has not been fully elucidated as yet. The function of the waves in the pyloric canal or the *canal egestorius* is undoubtedly for the most part to empty the stomach. However, peristaltic waves of great intensity are present, while the pylorus remains closed. Their effect upon the liquid contents must certainly be to drive part of the food back into the sinus.

As was shown by the author (loc. cit.), there is a constant change in the length and breadth of some stomachs during every cycle of respiration. It has been noted by surgeons, during operations under anaesthesia, while peristalsis is absent and the sphincters are relaxed, that the contents of the stomach is ejected into the duodenum in jets synchronous with the respiratory movements. Respiratory movements, therefore, must have a definite effect in expelling the food from the stomach. The bioröntgenographic study was made during suspended respiration. Respiratory movements occur much more frequently than peristaltic waves, and their effect upon the stomach and its contents should not be left out of consideration.

The form and depth of the peristaltic wave differs in the varying types of stomach, and in the same stomach with the patient in different positions. They also vary with the character of the ingesta. Thus the waves differ in the four normal types of stomach. In pathological cases, as in pyloric obstruction with compensation and muscle hypertrophy, the increased force is shown by their depth and volume.

#### THE EMPTYING TIME

The relation of the emptying time of a stomach to that of the normal type is probably the most accurate way of determining the motor efficiency. Thus it has been determined that the emptying time of the four types of stomach is as follows: That is, a standard Rieder meal of 350 grammes of food and 50 grammes of bismuth should pass through the hypertonic stomach in 2 to 3 hours, the orthotonic in 3 to 5 hours, the hypotonic in 4 to 6 hours, and the atonic is 6 to 8 hours.

The presence of a residue of bismuth in a stomach of any one of these types, after the normal time for that type, shows there is a deficient motility.

Differences in the time of evacuation have been shown to follow the placing of the patients in different position. The position of the patient must therefore be considered in estimating the time, and the patient should be kept as far as possible in the standing or sitting posture.

The relation of the shape and position of the residue in the stomach in connexion with the bulbus duodeni and the umbilicus will be discussed in connexion with the various pathological changes that take place in the stomach.

## PATHOLOGICAL CONDITIONS OF THE STOMACH

### DISTURBANCES OF SECRETION

By the employment of the Schwartz capsule the amount of free hydrochloric acid in the stomach can be determined by an examination not lasting over five hours.

The fibroderm capsule is made of gold-beaters' skin of known thickness, containing 4 grammes of chemically pure powdered metallic bismuth and 25 centigrammes of pure neutral pepsin. The pepsin is added to hasten the digestion of the capsule so that it will occur within five hours, and to make the time of digestion entirely dependent upon the amount of HCl by providing an excess of pepsin.

By experiments *in vitro* the time has been determined which is required to digest the capsule with fixed amounts of free hydrochloric acid. These results were found to conform to the time taken to digest these capsules in a large series of patients.

The patient is given a test meal in the morning while fasting, consisting of 200 grammes of slightly sweetened tea and a known amount of bread. The capsule is then taken, followed by a few mouthfuls of bread, and its passage watched with the fluoroscope through the oesophagus and into the stomach. During the entire examination the patient should lie upon the left side or sit reclining towards that side. This prevents the capsule from escaping through the pylorus. A fluoroscopic examination is made at the end of one and a half hours. If the capsule has been digested the bismuth will be seen as a small patch coating the inner surface of the stomach, and a high degree of hyperacidity is present. If the capsule is not digested until two hours after its exhibition a mild degree of hyperacidity is present. If after two hours and a half, a normal condition is present. Mild subacidity is present if the digestion takes three hours and a half. A high degree of subacidity is shown by its remaining undigested for from four to four and a half hours. An acidity is present if it is not digested after remaining five hours in the stomach.

PARASECRETION. During a fluoroscopic examination after the ingestion of the opaque meal a layer of less dense fluid can be seen separating the gas in the fornix from the meal below it. Upon its surface waves can be seen by careful observation and gentle shaking of the patient. This fluid is abnormal in a stomach after digestion is completed, and is termed parasecretion. In cases of hyperacidity thick layers constituting a succorhoea have been observed, while such a layer is seldom seen in an acidity.

The Kastle capsules described above are employed for determining the amount of fluid in a stomach and the time for it to pass out. They have been employed to show the time of passage of various kinds of food. Carbohydrates leave the stomach after digestion in two and a half to three and a half hours, albumins in from five to six hours, and fats in from six to eight hours. The amount of fluid present in the stomach can be estimated by measuring the distance between the capsule that floats and the one that sinks to the bottom of the stomach.

#### PATHOLOGICAL CHANGES IN THE FORM AND POSITION OF THE STOMACH

Changes in the form, position, and emptying time of the stomach, when studied together, are the most accurate method of determining the functional efficiency.

Before studying the changes in position and form of the stomach itself, those changes must be excluded that arise from pressure from without, due to other organs or tumours springing from them. Among these may be mentioned pregnancy, ascites, fibroma of the uterus, cysts of the ovaries, hypertrophies of the liver, spleen, kidneys, or tumours springing from them or other abdominal organs.

After the elimination of these extragastric causes the presence of peritoneal bands and adhesions must be considered. They can generally be eliminated during the observation of the filling phenomena, or may be excluded by employing the method of Chiliaditi.

The most obvious and frequent change noted in the stomach is that of ptosis. The form of the normal stomach in an individual of similar build must be considered in each case to exclude what has been termed a constitutional gastropptosis, although the determination of the time needed for evacuation will eliminate this factor. In the gastropptotic stomach the bismuth meal is seen to fall through the stomach, as it were. The lack of muscular tone allows the food to pass rapidly through the corpus and to collect in the sinus.

Since the pylorus and œsophagus with the fornix are firmly fixed by their ligaments, the gastropptotic stomach increases in vertical length. The lower point of the stomach descends far below the umbilicus and the crest of the ilium, and often reaches the symphysis pubis. The lower portion of the stomach is distended with the bismuth meal, while in the median portion of the corpus the walls are approximated.

The peristaltic waves are almost entirely absent in the erect position, and show then only in the pyloric canal. They are more frequent and deeper

when the patient is lying down, thus indicating the necessity of recumbency after meals in treating these conditions.

In ptosis with atony the stomach is incapable of emptying itself, and a residue of the bismuth meal is found six and eight hours and even longer after its ingestion.

In even severe forms of ptosis, through compensatory hypertrophy of the musculature, the stomach may become capable of evacuating its contents in normal time.

A more pronounced form of ptosis involves the pylorus, which is often found as low down as the fifth lumbar vertebra. This is known as a pyloroptosis, and is not generally accompanied by a prolongation of the time of evacuation. Where it results from extragastric causes, as from tumours involving the mid-epigastrium, which do not involve the stomach itself, the emptying time may be decreased, as in a case recently under observation in which the stomach emptied itself in less than three hours.

In considering the functional efficiency of the stomach, the four types of stomach alluded to above must always be taken into consideration, as the emptying time varies, as has been shown above, in each of these types.

When compensation has taken place in a gastropptotic stomach the lower pole is raised. The lower portion of the stomach is broadened and extends well over to the right, resembling a pyloric stenosis with compensation.

The efficiency of hammock operations and abdominal bandages applied to correct gastropptotic conditions can be readily determined by observations made after the opaque meal with the bandage or supporting appliance in place.

#### ULCER OF THE STOMACH

The diagnosis of gastric ulcer by the Röntgen method is one of its greatest advances. The accuracy and facility of this diagnosis varies inversely with the extent to which the stomach wall has been involved in the pathologic process. Simple ulcer involving only the gastric mucosa is the most difficult to diagnose. Diffuse callous ulcers of the florid type are almost as difficult. Penetrating ulcers that involve the muscular wall of the stomach can be recognized in a much larger percentage of cases. Perforating ulcers of the callous type can be detected in the majority of cases when proper technique is employed.

Callous ulcers with or without perforation that have produced contractions of the stomach wall present the picture of benign hour-glass contraction and are easily recognized. They must, however, be differentiated from

malignant hour-glass contraction and the intermittent and pseudo-hour-glass forms of the neurosis.

*Perforating ulcer of the stomach* which has not, through the contraction of scar tissue, changed the form of the stomach is the most readily diagnosed ulcerative condition except hour-glass contraction. That their apparent rarity is due to a lack of recognition rather than to the infrequency of their occurrence, has been shown by Haudek, who first established their radiographic diagnosis.

He has formulated their röntgenologic symptom-complex and signs as follows:

1. A diverticular-like projection from the stomach shadow usually on the lesser curvature.
2. Movability of the bismuth mass by palpation.
3. The persistence of a bismuth shadow at this point.
4. A hemispherical collection of gas above the bismuth shadow.
5. The constant and marked contraction of the greater curvature of the stomach at a point opposite to the shadow approximating in form an hour-glass contraction.
6. A displacement to the left of the pyloric portion of the stomach, especially noticeable in males, with a perpendicular outline on the right border of the greater curvature.
7. A retardation of motility so that six hours after the ingestion of the bismuth meal a large amount remains in the stomach. This residue is placed to the left of the median line when the ulcer lies high.
8. Antiperistalsis.
9. The presence of an acutely tender spot, with a sense of resistance on pressure, in the epigastrium in the region of the left rectus muscle. This is frequently seen in ulcer of the body of the stomach.

The characteristic picture of a perforating ulcer shows a distinct mass of bismuth in a diverticular process on the margin of the stomach silhouette. It is often distinctly separated from it. Above this shadow is clearly seen in the rapid röntgenogram a hemispherical area of lesser density. This is an air-bell occluded in the pocket by the bismuth and the callous overhanging edges of the ulcer.

It is of practical importance to remember that these ulcers, while occurring most frequently on the lesser curvature of the stomach, may be found in the anterior and posterior walls. During the examination, therefore, the patient must be rotated or the tube displaced from side to side, in order to

bring ulcers in these positions to the profile of the stomach shadow. Unless this is done they will be entirely hidden by the mass of bismuth in the stomach and escape detection.

It is sometimes necessary, in order to fill the ulcer with the bismuth, to place the patient on the back, the right side, or upon the abdomen. This is particularly true of the penetrating but not perforating ulcers, and is a point in technique not to be neglected.

The neighbouring organs most frequently involved in perforating ulcers are the liver and the spleen. When the liver is involved the shadow rises and falls with respiratory movements, and a dense induration can often be felt in the epigastrium to the left of the middle line. The movement with respiration is absent when the spleen is involved. A point of tenderness on pressure may be felt corresponding to the position of the ulcer when it is situated anteriorly.

The bismuth may remain in a perforating ulcer after the bismuth meal has sunk below it, or even after it has passed entirely into the intestines.

Although perforating ulcers are frequently found in connexion with an hour-glass contraction of the stomach due to scar tissue, they are as frequently found without any hour-glass contraction. There is also a pseudo-hour-glass form due to the contraction involving the greater curvature, which is found to be entirely absent at operation when the patient is under an anæsthetic.

Since the favourite seat of callous ulcers is upon the lesser curvature of the stomach, the contraction of their scar tissue gives rise to a shortening in the length of the lesser curvature. Haudek has pointed out that this gives rise to a dragging of the pylorus to the left, and has shown that a difference can be noted in the shape and position of the residue in the sinus and its relation to the bulbus duodeni. In perforating callous ulcer and in florid ulcers with or without penetration the residue in the sinus has a sharp, straight, almost perpendicular outline on the right side, with the shadow in the bulbus duodeni to the left of the umbilicus and nearly above the sinus. In carcinoma of the pylorus the residue has a poorly-defined jagged right border, while the bulbus duodeni is well to the right of the umbilicus. In uncompensated stenosis of the pylorus the residue is broader and drawn out in the form of a crescent, and extends to the right and left of the median line, while the shadow of the bulbus duodeni is far to the right. A residue due to spasm or slight stenosis of the pylorus is small in amount on the left side, while the bulbus is on the right.

**PENETRATING ULCER OF THE STOMACH.** When an ulcer has only penetrated the muscular coat of the stomach it does not show the depth or form of the perforating ulcer, and has no thickened edge overhanging its depth. It does not extend so far from the lumen of the stomach, and hence its bismuth shadow is not separated from that of the stomach; nor is there any bell of gas, since no cavity is present in which it can become occluded.

The characteristic Röntgen picture therefore varies markedly from that of perforating ulcer. Instead of the rounded diverticulum filled with bismuth and gas there is only a slight bud or spur-like projection from the profile of the stomach shadow. To detect the small projections the patient should be rotated, bringing various points on the stomach shadow in the profile. The right lateral position is of practical value in these cases, as it makes the lesser curvature the dependent portion of the stomach, and it is here these ulcers are most frequently situated.

A variation in the technique is described by Schwartz, in which he employs a watery solution of bismuth in small quantity. It is exhibited with the patient on the back. The patient is then turned gently on one side and then the other, and finally on the abdomen. This is to coat the mucosa so that the shallow ulcers will retain a small amount of bismuth when the patient stands erect. He has succeeded in this manner in locating small ulcers on the posterior wall of the stomach.

The symptom-complex of penetrating ulcer is the same as for perforating ulcers, except that the symptoms are less pronounced.

**THE SIMPLE ULCER** is probably the least readily recognized form, since there is no adherence of the bismuth to its surface and no retention after the onward passage of the bismuth meal. It, however, is characterized by a sharp and for a time permanent indentation of the greater curvature opposite to it. This resembles a commencing peristaltic wave, but is differentiated by its persistence in the same spot for a very long period.

The florid, flat, or indurated ulcer, either with or without erosion, is also very difficult to recognize. If there is much erosion and a ragged defect of the mucosa it can possibly be recognized when brought into the profile line of the stomach.

All of these ulcers, especially those of the callous type in which larger areas of the lesser curvature are involved, give rise to a displacement of the pylorus, and, according to some authors, to a reflex spasm of the pylorus with an increase in the time of evacuation of the stomach.

In considering the diagnosis of these ulcers, the symptoms and the röntgenologic findings have been given in relation to ulcers situated in the median and upper portion of the stomach. Ulcers that lie in the pyloric canal or in that neighbourhood are more difficult to diagnose. Except in rare cases of perforating ulcer the röntgenologic picture is wanting. The diagnosis must here be based upon the obstructive signs. The spasm of the pylorus is more marked. There is a decrease in motility and a large residue of the bismuth meal is left in the stomach after six hours. This is the result of the intermittent opening of the pylorus in the presence of spasms. The peristaltic waves are more frequent, deeper, and more powerful in appearance. Antiperistalsis is generally present.

A further consideration of the symptoms of ulcer of the pylorus and the differentiation of various forms of pyloric obstruction will be deferred until after the consideration of malignant disease of the stomach.

#### BENIGN HOUR-GLASS CONTRACTION

The pathologic sequel of callous ulceration of the lesser curvature of the stomach, resulting from the extension of the disease and the contraction of the scar tissue formed, is the benign hour-glass contraction of the stomach.

Before considering it, however, it will be well to study those rarer conditions of pseudo- and intermittent hour-glass contraction.

**THE PSEUDO-CONTRACTIONS**, as noted above, are the result apparently of various neuroses that produce a spasmodic contraction of the greater curvature. They cause a deep infolding of the greater curvature of the stomach in the middle of the corpus, or near its upper limit. They are produced by spasms of the musculature, which, although often persisting for some time, pass away spontaneously, or can be made to relax sometimes by the hypodermic injection of atropine, and sometimes by massage.

This type of hour-glass contraction must be differentiated, not only from the benign and malignant hour-glass stomach, which are both due to structural changes in the wall of the stomach, but also from the intermittent hour-glass contractions that are caused by extra-gastric conditions.

**INTERMITTENT HOUR-GLASS CONTRACTION** of the stomach has been the cause of much study to a number of observers.

The picture seen on the fluoroscope and in the röntgenogram immediately after the bismuth meal varies greatly from any normal type. The stomach may be seen in the normal position with a distinct and broad deficiency in the shadow separating the fornix and upper corpus from the

sinus and pylorus. There may be no pyloric portion of the stomach visible; an extremely short but rounded opaque shadow, with the *Magenblase* above it, occupies the position of the upper half of the stomach. Or there may be a stomach shadow extending sharply over to the right in a diagonal line far beyond and above the umbilicus. The greater curvature of this stomach shows a marked depression and makes it approximate an hour-glass form. These altered forms of the stomach cannot be changed by varying the position of the patient, by massage, or by the injection of atropine. They do, however, vary from one examination to another if they are made on different days. There is no retardation of motility. There is sometimes a greater rapidity in the emptying time, even as rapid as is noted with an open pylorus. There is never any residue in the stomach after six hours. These are not conditions similar to the defective stomach shadow, seen formerly when patients were radiographed in the recumbent or prone position, and due to pressure of the vertebræ.

These cases demand a careful study of the other hollow abdominal viscera to determine their causation. The intermittent hour-glass stomach is seen repeatedly in the same patient, but the normal stomach is found during other observations. Its cause must therefore be variable and intermittent in its operation.

The study of the large bowel and its anomalies of position has been the method of its solution. The colon, either distended with gas or fæces, or bound by intimate adhesions to the greater curvature of the stomach, forms the rational explanation of the cases that so far have been observed. It is frequently possible, by increasing the amount of the bismuth meal, to induce a complete filling of the stomach, so that its normal outline is visible.

#### HOURLASS CONTRACTION OF THE STOMACH

A biloculation of the stomach may result from organic changes in its musculature, or, as has been noted above, from spasms.

Organic changes, either benign or malignant, are the most frequent cause of hour-glass contraction.

The benign hour-glass stomach is the sequel of callous ulceration of the lesser curvature of the stomach. The contracting scar tissue draws the greater curvature of the stomach, that lies opposite to the ulceration, over toward the thickened lesser curvature. It is because the ulcer is generally on the lesser curvature and the contracting tissue is drawn toward it, that the connecting canal is typically found near the lesser curvature. In contrast to this the canal is situated centrally in malignant hour-glass contraction.

The filling phenomena are also very characteristic. The opaque meal collects in the upper sac and only gradually passes through the tortuous canal into the pyloric portion of the stomach. Sometimes it requires hours for its passage.

The emptying time is necessarily increased by the delay in passing from one portion of the stomach to the other. As scar tissue in the lesser curvature draws the pylorus upwards and to the left and also induces spasmodic contractions of the pylorus, thus a further delay results in the emptying time.

Benign hour-glass contraction may also be combined with ulcerative pyloric stenosis. The symptom-complex is then combined.

Spasm of the pylorus is differentiated from organic obstruction by the presence of marked antiperistalsis, where spasm is present combined with the intermittent passage of the food from the stomach.

In organic obstruction the emptying time is increased. Where the obstruction is of long standing there may be a continuous flow of bismuth through a tortuous and contracted canal. A marked variation in this phenomenon is of course dependent upon the age and extent of the obstruction.

To bring out more clearly the differences between benign and malignant hour-glass contraction, the latter will be considered next, before studying the other forms of malignant disease of the stomach.

#### MALIGNANT HOURLASS CONTRACTION

The concentric invasion of the entire circumference of the corpus by malignant disease results in an hour-glass form of stomach. It is the result of the invasion of the lumen of the stomach from all sides and is not due to a circular contraction of the walls of the corpus. It spreads not only concentrically inwards, but also upwards and downwards along the wall of the stomach.

The Röntgen picture is not only one of lacunar biloculation, but also of a ragged deficiency in the stomach shadow.

The spreading of the disease concentrically inwards from the entire circumference places the connecting canal in the centre of the stomach. This canal is larger, more ragged in outline, and as the result of the upward and downward invasion of the stomach wall has a funnel-shaped entrance and exit. The food on entering the stomach passes almost directly through the canal into the lower pole of the stomach. Some remains in the upper sac, but not so much as in benign hour-glass contraction. Thus the true form of the stomach cavity may not show itself until the lower pole is entirely filled.

Unless the pylorus is involved in the disease the emptying time may not be delayed. In fact, in some reported cases the opaque meal or watery suspension passed almost immediately through the pylorus as if it were patent.

The form of the stomach and the relation of the two sacs is different in the two kinds of hour-glass stomach. In the benign form the contracting scar tissue pulls the greater towards the lesser curvature. The lower sac is therefore often displaced to the left. In malignant disease the normal relations are more nearly maintained, with a subtraction from the normal stomach shadow on both sides of the corpus.

The length of the connecting canal is greater in carcinoma, since more of the stomach wall is involved. The length of the stomach is shorter in ulcer because it is the result of contracting scar tissue. These differences in the Röntgen symptom-complex are characteristic of disease confined to the corpus.

The well-known tendency of callous ulcer to take on carcinomatous degeneration must always be remembered. It makes an absolute differentiation impossible in all cases.

The combination with pyloric involvement will be taken up in the study of pyloric obstruction.

### CANCER OF THE STOMACH

The röntgenologic picture of the stomach is a silhouette of the contained opaque meal. Deficiencies correspond to overgrowths of tissue invading its lumen, or abnormal contractions that cause an infolding of its muscular walls.

Cancer of the stomach is a pathological hyperplasia which produces defects or subtractions from the normal silhouette. The röntgenologic recognition of medullary carcinoma is therefore primarily dependent upon the recognition of persistent defects or subtractions from the normal stomach shadow. They must, however, be differentiated from contractions in its walls and pressure effects due to adhesions or to abnormalities in other viscera.

This does not apply to infiltrations of the stomach wall by sarcoma and other malignant disease. The Röntgen picture and symptoms of these conditions will be studied later.

In carcinoma of the cardia or fornix defects in the shadow are not so readily recognized with the patient in the erect position. Disease in this locality is generally suspected by the picture resulting from the stenosis of

the lower end of the œsophagus. The passage of the opaque meal is retarded. The œsophagus becomes filled and is often dilated. When there is extensive involvement the opaque meal is seen passing through a tortuous canal and emerging at a point some distance from the normal opening of the œsophagus into the stomach.

With the patient in the prone or recumbent position a ragged defect may be shown in the stomach shadow. If the tumour lies entirely on the anterior or posterior walls the only sign of it will be a lacunar defect of irregular outline visible only when the anterior and posterior walls are approximated by pressure. These lacunar defects are due to masses of the growth that project into the lumen of the stomach and thus displace the bismuth.

The author has shown, in a case subsequently operated upon when the diagnosis was confirmed, that malignant tumours of the cardia can be shown by stereoscopic röntgenography when the stomach is inflated with air.

Defects in the stomach shadow at different points along the greater and lesser curvatures have led to the detection of carcinomata that did not give rise to obstructive symptoms.

Leaving for a time the consideration of obstructive malignant disease, in order to study all pyloric obstructions together, the infiltrating and perigastric forms of malignant disease will be considered.

*Infiltrating malignant disease* results in a thickening and hardening of the stomach walls. This produces a form of stomach like the hypertonic. As in other forms of malignant disease peristalsis is wanting in the portion of the stomach wall invaded by the disease. In extensive involvement the whole stomach may be converted into a rigid canal with an open pylorus through which the bismuth suspension, and even the more solid meal, flows unobstructedly into the duodenum. In such cases there is often a distended œsophagus that acts as a reservoir, and in all cases some of the meal is usually retained in the œsophagus.

In other cases where the upper pole of the stomach is not involved it is the reservoir, and appears as a small contracted, or sometimes a dilated, cardiac portion of the stomach; while some of the bismuth meal is found in the lower part of the œsophagus. These tumours are often palpable, but it is of practical importance to determine whether the palpable tumour is of the stomach or not, and the extent to which it is involved. The mobility of a palpable tumour, in relation to a normal stomach shadow, will determine whether it involves the stomach or not.

*In carcinoma of the pylorus* the defects in the stomach silhouette vary in form with the extent and position of the tumour. The projection of the

tumour mass into the pyloric canal and sinus gives rise to defects in the shadow of varying size depending upon the extent to which the stomach is involved. The shadow has a ragged edge with often an irregular linear shadow extending from it to the pylorus. This may indicate the compressed and narrowed pyloric canal or an irregular channel through the ulcerated surface of the tumour. In contrast to the open pylorus of infiltration there is a stenosis which by its long-standing opposition to the passage of food has resulted in the typical dilatation of the lower pole of the stomach, and a compensatory hypertrophy of its musculature.

In carcinoma of the pylorus of lesser extent, the defects in the stomach shadow may assume an entirely different type. The profile defects with its typical ragged edge may be entirely wanting, and the pylorus may have an almost entirely normal appearance. Pressure with the fluorescent screen upon the lower pole of the stomach may here reveal the round lacunar shadows, which correspond to the tumour masses springing from the anterior or posterior walls and only made visible by their approximation through the pressure exerted.

Pyloric obstruction of organic origin is the result of callous ulceration or malignant disease involving the pyloric canal and extending in a greater or lesser degree to the sinus.

The differential diagnosis between these conditions, although not absolute, is in a great measure possible by the Röntgen method. The fact that callous ulcers are often the seat of malignant degeneration must, however, always be remembered.

In both conditions where compensation is absent the lower pole of the stomach is dilated and extends well over to the right. In fact it may extend so far to the right as to hide the pylorus. In carcinoma the patient is seldom seen before the tumour has attained sufficient size to produce defects in the stomach shadow. When the disease is less advanced it is nearly impossible to differentiate it from callous ulcer and its contractions, since in this situation penetrating and perforating ulcers are seldom present.

In infiltrating malignant disease the differentiation from the ulcerative form is easier. The shape of the stomach is entirely different. In ulcer of the pylorus there is a shortening of the lesser curvature, the pylorus is raised while the lower pole is dilated, and there is present a tortuous condition of the caudal pole, the axis of the stomach becomes more or less a spiral. In infiltrating sarcoma or malignant infiltration that is fibrous in character, the lower pole of the stomach is narrowed, the axis is straight or slightly curved with the pylorus above the umbilicus, and the stomach extends upwards, backwards, and to the left. The stomach is shortened

as well as narrowed. The emptying time in ulcer and carcinoma is delayed in uncompensated cases, but may be nearly normal where compensation has taken place. In infiltrating sarcoma the emptying time is shortened in ratio with the insufficiency of the pylorus.

#### THE EARLY DIAGNOSIS OF CANCER OF THE STOMACH

The symptom-complex of cancer of the stomach is not one that leads to a suspicion of the disease in its incipency. Where cachexia is present with chronic gastric disturbance, a suspicion of the cause should lead the clinician to refer the patient for a Röntgen examination. It is impossible to establish a diagnosis with certainty before the disease has attained some growth. The probability of cancer in connexion with the clinical symptoms can be increased or its possibility excluded by the examination.

The early recognition of cancer is always dependent upon the early presentation of the patient, no matter where the disease is situated. To increase the number of early diagnoses the patient must be referred by the physician for Röntgen examination whenever a suspicion is present. Where carcinoma is suspected the presence of normal peristalsis in the pyloric canal and along the entire wall of the stomach is of very great value in excluding the disease. If, however, there is a point where peristalsis is interrupted, especially if it is in the pyloric canal, the suspicion of cancer is strengthened.

#### INDICATIONS FOR OPERATION

The determination of the exact location, size, and nature of a gastric lesion is a basis upon which the possibility of an operation and its character can be founded.

Since in malignant disease the question of metastases cannot be determined by the Röntgen examination, it can only be said that operation is possible. The maintenance of an orthotonic form by the stomach is claimed to be an indication that operation is possible. On the other hand, the horn form or hypertonic type of stomach, where no peristalsis is present, is held to be a contra-indication to operation.

A tumour of the pylorus, however, may be present in a stomach of this type which can be completely removed.

Again, it is held that if a hand-breadth of the upper pole of the stomach remains uninvolved in the disease, resection can be successfully performed. Even a small tumour of the corpus is inoperable if the condition is complicated by pyloric obstruction. In spite of the impossibility of rendering

exact indications for operation the Röntgen method is capable of determining when the disease is too extensive to permit a successful operation.

The surgeon today does not attempt an operation upon the stomach before he has before him all the data which this method is capable of rendering, while the physician does not refer his patient for operation before the knowledge it affords shows him that operation is necessary. In many instances as complete knowledge of the condition of the stomach can be obtained by this method of examination as by an exploratory laparotomy, while the definite knowledge it affords localizes operative intervention and determines its extent and nature before it is commenced.

### THE SMALL INTESTINE

The passage of the bismuth meal through the small intestine is so rapid that the determination of its normal peristaltic action is attended with great difficulty. With the exception of a small mass in the bulbus duodeni and the collection of masses in the convoluted portion of the ileum, little is seen in normal cases. The rapid röntgenogram shows in addition small flecks of bismuth scattered throughout the duodenum, the jejunum, and the upper portion of the ileum.

The first portion of the duodenum, or the bulbus duodeni, retains the bismuth because of its different anatomical structure. Instead of the Kerk-ring valves, or *valvulae conniventes*, such as are found in other portions of the duodenum, it is perfectly smooth inside with many secretory glands distributed over its surface. It differs also in its external support, being held in place by a separate fold of the gastro-hepatic ligament. The second or descending portion is bound tightly down by the parietal peritoneum and thus has no mesenteric attachment. Physiologically the bulbus duodeni, which has been called the second stomach, is of great importance, as it receives the acid chyme from the stomach and neutralizes it before it passes through the rest of the intestine. It also acts as a buffer to receive the food ejected from the stomach. Because of the acid chyme it receives it is more liable to be the seat of ulceration.

The study of pathological cases has shown that the duodenum possesses in its peristalsis both mixing and progressive movement. The third or ascending limb of the duodenum passes upward and back of the stomach to form an acute angle where it unites with the jejunum. The bismuth meal passes through the entire duodenum in from twenty-five to sixty seconds.

The pathological changes shown by the Röntgen examination are displacements, ptoses, constrictions by bands or adhesions, spasms, and stenoses, the latter either from contracting scar tissue or neoplasms—displacements

and ptoses may accompany ptoses of the stomach and other viscera. Their pathological effect is seen in the delayed passage of the chyme and is the result of a more acute angle produced between the duodenum and jejunum, since this angle is more securely fixed and does not usually participate in the ptosis. These ptoses can only be demonstrated with the patient in the erect position, with the entire duodenum, as well as the rest of the ptosed small intestine, dragging downwards upon the duodenojejunal angle.

The procedure of Chiliaditi, i. e., the retraction of the abdominal muscles during forced expiration, by raising the stomach renders this angle visible with the patient in the erect position.

ULCERS OF THE DUODENUM vary in their character from simple ulcer to perforating. Their determination by clinical surgical methods, as by symptomatology and palpation, has been very difficult and the source of much discussion among surgeons—English and American surgeons holding that a typical symptom is the hunger pain. This has been explained as the result of the passage of hypersecretion from the stomach after it is empty of food, the renewal of food and normal digestion relieving the irritability of the ulcer. The diagnosis of duodenal ulcer is therefore of great importance, and the perfection of its Röntgen diagnosis most important. It has been found possible, by the use of a watery suspension of bismuth, given on a fasting stomach, to fill the duodenum, and thus more readily observe its condition.

In superficial ulcer of the duodenum the emptying time of the stomach is normal or decreased, in contrast to the delayed emptying in cases of gastric or pyloric ulcer, which produces a spasm of the pylorus. The stomach generally has the hypertonic form, the pylorus and greater curvature lying above the umbilicus. The stomach is not dilated in its lower pole as in gastric or pyloric ulcer. The peristalsis of the sinus is more marked, and the pylorus opens more frequently. A point of tenderness upon pressure is located over the bulbus duodeni, and the patient, if asked to locate the point of pain, usually places the finger over this spot.

A number of cases have been reported in which gastric and duodenal ulcers have been found to coexist. Here a conflict in symptoms has been noted, the duodenal ulcer counteracting the spasm of the pylorus provoked by the gastric ulcer, resulting in a more rapid evacuation of the stomach than normal.

Penetrating ulcer of the duodenum is less frequent, and has in addition to the symptoms of superficial ulcer the characteristic diverticulum outside the normal shadow of the duodenum, which persists as a small bismuth fleck after the duodenum is empty.

A condition characteristic of all ulcers of the duodenum is the retention of the opaque chyme in it for a longer period than normal, as the result of a mild stenosis possibly, spasmodic at the duodenojejunal juncture. It is probable that many of the so-called Lane's kinks situated at this juncture are in reality spasmodic stenoses due to duodenal ulcer rather than to actual kinks due to ptoses. This is more likely because of the defective mode of examining these patients, which errs in making the examination in the right lateral position rather than in the upright, in which position in the nature of the kink it would be most marked and more easily observed. In addition, after the administration of the opaque meal, the patient was placed upon the right side, thus causing the filling of the duodenum and aiding the retention of the bismuth in that organ.

Spasms of the duodenum due to neuroses produce transient symptoms that are characteristic of ulcer or mild stenosis, but can be differentiated by their amenability to appropriate medical treatment.

Stenosis of the duodenum is characterized by an abnormal repletion and the presence of visible peristalsis and antiperistalsis. The dilatation of the duodenum is greater the narrower the stenosis, and the extent involved longer according to the situation of the stenosis. The peristalsis is uninterrupted so long as the opaque chyme is retained. The character of the stenosis, whether it is spasmodic, cicatricial, due to pressure of bands from without, or the result of new growths, cannot in the majority of cases be determined by the Röntgen method.

#### DISPLACEMENT OF THE DUODENUM DUE TO PERITONITIS IN NEIGHBOURING ORGANS

The presence of strong cicatricial bands connecting the liver and gall bladder with the duodenum have been frequently observed by surgeons in operations in this region of the abdomen.

It has been demonstrated that the presence of such adhesions involving the duodenum and the stomach can be demonstrated by the Röntgen examination. The interference with motility and peristalsis can be observed upon the screen with the patient in the upright position, or may be shown in röntgenograms either in the erect position or when the patient lies upon the left side.

The jejunum and ileum form the remaining portion of the small intestine. The movements of these portions are very rapid and can only be shown by extremely rapid röntgenograms. It has been found that both mixing and onward peristaltic waves are present in this portion of the intestine, although they are very slight in the lower portion of the ileum where the chyme collects before entering the cæcum.

The opaque meal is seen within a half-hour after its ingestion in the duodenum and collects in the lower ileum after four hours, while some has already entered the cæcum. After six hours a part still remains in the ileum, while more is in the cæcum, and after eight hours it has entirely passed from the ileum.

There is apparently a tonic contraction of the ileocæcal valve which gives rise to this delay in the passage of the chyme into the cæcum.

The pathological conditions that involve the jejunum and ileum are due to external causes, as from bands due to adhesions after localized inflammation, tumours either within its wall or external to it, and to displacements or ptoses. In studying the emptying time of the ileum the condition of the stomach must be taken into consideration, since any delay in the evacuation of the stomach must hinder the chyme from reaching the lower ileum.

#### PTOSES OF THE ILEUM AND JEJUNUM

The jejunum seldom undergoes any ptoses even when a general visceroptosis is present. In the ileum, however, ptoses are more frequent and the entire lower ileum may lie in the true pelvis, where it has been mistaken for a distended rectum. Such ptoses are not of grave significance, and are not an ætiological factor in the production of chronic constipation. They may cause a delay of from two to four hours in the emptying of the ileum, that is ten to twelve hours after the bismuth meal, but are not due to stenoses of the ileocæcal valve. By pressure upon these masses in the ileum the separate folds of the intestine may be discovered.

Dilatation of the ileum with an increase in its length, when due to obstruction of the ileum, is a condition demanding surgical intervention in which the surgeon wishes to know the exact seat of the obstruction. In these cases the passage of the chyme into the cæcum may be delayed for 24.48 or even 72 hours post cæcum.

The picture of these conditions is striking, and not to be confused with other intraabdominal conditions. Besides the delay of the chyme in the ileum, this portion of the intestine is enormously dilated. Thus the ileum, normally the size of the thumb, attains a diameter as large as the colon, and maybe even larger. The convolutions of the intestine are ranged side by side, like the pipes of an organ. They are filled with liquid and gaseous contents, the bismuth chyme filling the lower portion with a level line separating it from the gas above, which renders that portion brilliantly translucent.

The obstruction producing such changes is chronic in its nature, and is the result of malignant disease, tuberculous disease, or adhesions and contractions due to chronic appendicitis or other inflammations of the cæcum and colon.

Iliac kinks have been reported in many cases where less-marked symptoms were present. The apparent stoppage of the flow of chyme into the cæcum may result from the eating of more food before the opaque meal has had time to pass. This second meal dilutes the chyme and the bismuth remains a longer time in the ileum, often ten or twelve hours. An iliac kink should be demonstrable with the patient in the erect position, as displacement of the viscera by the assumption of other positions causes a twisting and pulling that may be erroneously interpreted as an iliac kink.

In a true kink the intestines should be distended on the oral side of the kink, and empty, or nearly so, on the anal side.

### THE LARGE INTESTINE

This portion of the gastrointestinal tract is divided into the cæcum, ascending colon, transverse colon, descending colon, sigmoid flexure, and rectum.

The anatomical relations of these various portions should be clearly understood in order to appreciate the pathological variations. The cæcum is that portion of the large intestine that lies below the ileocæcal valve. It is almost entirely surrounded by peritoneum and is freely movable, often normally to a great extent because of its mesenteric attachment. It may descend into the true pelvis or be capable of lateral displacement to a very great degree without producing any pathological condition or symptoms.

The ascending colon extends upwards and, as should be carefully noted, backwards into the iliac fossa, and reaches nearly to the liver, where it forms a more or less acute angle, which is called the hepatic flexure, with the transverse colon. It is not covered with peritoneum entirely, but lies in a measure back of it. Resting as it does obliquely backward in the right iliac fossa, it is not displaced downwards very readily, although it is the largest portion of the colon in its diameter, and often remains filled for a long time. The hepatic flexure, together with the first portion of the transverse colon, is frequently ptosed, i. e., drawn forward downward, but without giving rise to obstructive symptoms in the majority of cases.

The transverse colon extends from the hepatic to the splenic flexure, but not in the horseshoe-shaped form as was formerly described. It follows an oblique direction, from below upwards, along the greater curvature

of the stomach, and often forms a deep loop down even into the true pelvis without giving rise to abnormal conditions. The latter third of this portion of the colon rises almost perpendicularly to the splenic flexure, where it forms an acute angle with the descending colon. In fact in the non-stereoscopic picture its shadow often overlies that of the descending colon. The splenic flexure, unlike the hepatic, is firmly held up to the diaphragm by a strong ileocolic ligament. It is usually seen distended with gas, and the acute angle which it forms with the descending colon is a natural hindrance to the passage of the fæces. The descending colon lies retroperitoneal and, like the ascending colon, is supported by its oblique direction forward and downward in the left iliac fossa. It extends from the splenic flexure to the brim of the true pelvis.

The sigmoid flexure is very variable in shape, length, and position, as it is attached to a mesentery which is variable in length. In all its parts the colon is characterized by haustral segmentation, though it is less marked in the descending colon and sigmoid flexure.

The rectum or ampulla recti is the most distensible portion of the colon, and forms a reservoir for the fæces. It seldom exhibits movements except during defæcation.

### THE MOTOR PHENOMENA OF THE COLON

As a result of the distribution of the musculature of the large intestines there are produced various forms of motion which can be studied by their effect upon the bismuth containing chyme. These movements have recently been studied most completely in normal individuals by series of röntgenograms extending over a period of twenty-four hours.

They consist in regular peristaltic movements, greater peristaltic movements, antiperistaltic movements, and storm-like movements occurring infrequently, but producing marked displacement of the intestinal content toward the rectum. The lesser peristaltic movements take place as the result of the contraction and relaxation of the circular musculature in a given area, and produce only a slight effect in the passage of the fæces analwards. They may pass in either direction, either forward or backward, and have been described as mixing and segmenting movements.

The greater peristaltic or wave movements extend over a much larger area and produce more displacement of the fæces. They can, however, act in either direction, and hence do not result in much onward movement of the intestinal contents.

Antiperistaltic movements have been shown to exist in the normal intestine, and result in marked displacement backward of the fæces.

Gross longitudinal peristalsis or storm-like movements occur about five or six times only during the passage of the ingesta through the colon, and have been noted particularly just before or during defæcation. They result in the sudden displacement, by a movement not lasting more than two or three seconds, of larger masses of the fæces analwards. The result of their action is seen in the disappearance of the haustral segmentation over an extended area, sometimes a third of the transverse colon, so that there remains in the evacuated segment only a small amount of the bismuth shadow almost linear in breadth. This shadow increases in breadth, and becomes more marked by haustral segmentation the nearer it approaches the mass which has been displaced.

There are undoubtedly in some more or less pathological cases even more frequent and rapid movements, since the entire bismuth meal has been found in the splenic flexure and descending colon in periods very much shorter than the normal.

In studying the pathological colon two methods of procedure have been adopted, both of which are of value, as each is better adapted to the study of certain forms of pathological disturbance.

The first, which until lately has been most used, is the watching of the bismuth meal as it passes downwards through the intestine. This, the oral method, is particularly adapted to the study of the functional derangements, as various forms of constipation, that are found in the large intestine. For this purpose the ordinary opaque meal is employed. It has been recently suggested that a normal diet contrast meal should be employed in these examinations consisting of a known amount of ordinary food containing a definite amount of opaque substance in the first twenty-four hours, and followed by a similarly regulated diet, but without the addition of bismuth, until the observation is completed.

The second is the employment of opaque rectal enemata with the fluoroscopic observation of its passage upwards through the intestine, and the subsequent making of röntgenograms to record the pathological condition found.

The knowledge of the position and relation of the different parts of the large intestine, and the relation of varying abnormal conditions either within or external to it, will be always greatly facilitated by the making of rapid stereoröntgenograms. The situation of the large intestine within the dense abdomen practically makes it impossible to obtain views of the gastrointestinal tract that are of value except in the antero-posterior or postero-anterior directions. These shadows necessarily overlies each other

in the simple röntgenogram. In the rapid stereoröntgenogram, on the other hand, their relation in transverse planes can be readily recognized, and the angles formed can be estimated more accurately.

#### DILATATIONS AND PTOSES OF THE LARGE INTESTINE

The cæcum and the ascending colon, as the reservoir in which the cellulose undergoes bacterial action, retains the chyme much longer than other portions of the large intestine, and hence becomes, in cases of constipation, much dilated. This dilatation is often visible as an excess, although this portion of the intestines is always variable in size and position.

The cæcum mobile is a pathological condition upon which much stress has recently been laid. It is based upon the excessive mobility of the cæcum. As has, however, been said above, the cæcum in normal individuals is often excessively mobile, so that it is difficult to determine when a pathological condition exists. It has, under the name of typhlocolitis, been studied for fifteen years by French surgeons, and today forms no indication for surgical intervention.

The varying position of the hepatic flexure and transverse colon in perfectly healthy individuals with no symptoms referable to this portion of the intestine makes it difficult to determine what should be considered pathological ptoses. Thus it is impossible to say whether the ptoses seen in some forms of chronic constipation are the result of the constipation or a contributing factor in its production. Ptoses of the large intestine most frequently accompany general ptoses and those of the stomach.

Tuberculosis of the large intestine and ileocæcal tuberculosis are of much more frequent occurrence than tumours as the cause of intestinal stenosis. They are to be suspected when the bismuth meal does not reach the cæcum and ascending colon in from four to five hours. Tuberculous ulcerations that do not produce stenosis are detected by defects in the shadow of the intestine. These defects in the intestinal shadow must be identical in repeated observations at varying intervals of time, as the normal intestine often shows a disconnected shadow as the result of exaggerated tonicity or spasms.

The study of constipation and its causes has been carried out by various investigators by the Röntgen method.

Constipation or obstipation has been divided into hypokinetic and dyskinetic forms and dyschesia.

In the hypokinetic form of obstipation there is a lack of muscular tone and motor stimuli. This deficiency in motor stimulus may occur in any

part of the colon, and will be seen as a mass of fæces persisting for a long time in the given area without the peristaltic movements of haustral segmentation. There may be present a ptosis with an elongation of the colon, but this is not an essential characteristic.

In the dyskinetic form there is an excess of motility with antiperistalsis in a marked degree. The lower colon and rectum may be filled in the normal time, but through an abnormal segmentation and retrograde movement of the fæces their evacuation is delayed beyond the normal time. The fæces may be seen as small discrete masses scattered throughout the colon.

In dyschesia the colon is found to be normally active, the food passing through it and reaching the rectum in the normal time. The delay is entirely in the evacuation of the rectum. This is the result of an abnormally distended ampulla recti, so that an excessive amount of fæces is necessary before the requisite stimulus to defæcation is present. In extreme cases there may be a blunting of the muscle sense.

There may also be a congenital dyschesia, principally seen in infants, but often persisting in later life, which is dependent upon a defect in the muscle sense of the organ that did not develop with the individual. These forms react to local stimuli, as enemas or slight irritants, as glycerine suppositories, but are not in severe or mild cases influenced by internal medication.

Very interesting studies upon the action of various forms of laxatives and purgatives have been made showing that the Röntgen method is available in studying the physiological action of drugs in these cases. Purgative enemata following a bismuth meal or opaque enema have also made it possible to study the action of the musculature of the intestine which follows their employment.

The employment of the opaque enemata have their greatest value in determining anomalies in the position and form of the large intestines, and changes in its calibre the result of constrictions or stenoses of either benign or malignant character, and the presence of adhesions, bands and kinks which produce a hindrance to the passage of the fæces.

These enemata are made by adding 90 grammes of the bismuth salt or a proportionate amount of pure barium sulphate to 1½ litres of warm water.

The employment of the bismuth enema loses all its value if not properly given and watched fluoroscopically during its progress upwards through the intestines.

The patient's bowels must be thoroughly cleansed by the use of castor oil, followed by a cleansing enema two hours before the time of observation.

The patient is placed upon his back on a viewing table with the tube properly encased beneath. The opaque enema is placed in an irrigating bag with a glass rectal tube attached. After the air has been expelled this tube is passed a little way into the rectum and the fluoroscopic observation begins at once. To reduce the danger of dermatitis only the progressing end of the bismuth shadow should be watched through a narrowed diaphragm.

The progress of the bismuth is then followed throughout the entire intestines and any deviation from the normal shadow is easily noted. The entire intestine is filled in a very few minutes, and any deviation from the normal calibre is easily noted. Any time during the examination if a deviation from the normal is seen the diaphragm can be opened and a röntgenogram taken showing the condition. The return flow of the opaque enema should also be watched. Its removal saves the patient annoyance, and at the same time affords the operator a second chance to view its passage through the intestine.

No diagnosis should, however, be rendered from one examination. The findings of the first examination must be confirmed by a second examination several days later. During all these examinations it is wise to have the tube repeatedly disconnected for a moment or two, and then again placed in circuit. This can be done by a foot switch, or by an assistant who controls the apparatus.

Through this method of examination, as well as by the bismuth meal, great progress has been made in locating the seat of stenoses and anomalies in the position and shape of the various portions of the intestines. The connexion or freedom from the invasion of palpable abdominal tumours can be determined, and in some cases affords an early diagnosis, which could not otherwise be made, and leads to a successful operation. In many instances it is, however, only a localizing process for an exploratory laparotomy.

The Röntgen diagnosis of conditions involving the large intestine is of undisputed value, as it affords definite knowledge in a field which has been uniformly dark, and where even exploratory laparotomy had often failed to determine the exact condition present.

In addition to the determination of the pathological variations in the intestine noted above, the Röntgen method shows the presence of pathological and surgical anastomoses between various portions of the hollow viscera.

Thus gastrocolonic fistulæ, ileocolonic fistulæ and the results of surgical gastroenterostomies and ileocolostomies have been studied by this method. Then, too, diaphragmatic and other obscure forms of hernia, as

well as diverticulæ and anomalies in the size and position of various portions of the intestinal tract, have been shown, as well as their relation to other organs.

This report on the Radiography of the Stomach and Intestines could not be briefer because the progress of röntgenology has made it cover a very wide field. It could not be comprehensive, since the literature of the subject could not come within the reach of any one author. It could not treat fully of the subject from the röntgenologic standpoint without becoming too voluminous. The reporter's excuse for shortcomings must be, that such great and revolutionary progress has been made in adapting this method to the medical and surgical diagnosis of gastrointestinal conditions that the entire subject must be rewritten.

The *living* anatomy, physiology, pathology, and symptomatology has yet to be written, and this can only be done, as the results are determined, by the study of the living patient by the Röntgen method.

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## BIOGRAPHY

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Röntgenology in America owes much to Dr. Leonard. He was a pioneer in every sense of the word, and began his studies in this specialty at a time when the Röntgen Ray was thought to be only useful in demonstrating foreign bodies and bone lesions. He was the first in America, if not in the world, to demonstrate renal calculi, and the outline of the kidneys, and very soon following this brilliant work, the Röntgen method was definitely established as the only reliable one in the diagnosis of renal calculi.

He has always remained a leader in the newer development of Röntgenology, yet always conservative, dignified and broad enough to accept other people's opinion. Even though he began his work at a time when Röntgenology was in its infancy, he kept close to the subject until his death. He at no time allowed himself to become the subject of newspaper notoriety, and has constantly avoided everything of that nature. He has always taken an active and dignified part in the scientific sessions of the Medical Organizations to which he belonged, particularly the American Medical Association, the American Röntgen Ray Society, the County Medical and the College of Physicians. He has preserved always the most cordial relations with his colleagues, both local and national, and steadfastly held their confidence.

In 1904 and 1905 he served as president of the American Röntgen Ray Society, and has always been a moving spirit in raising the standard of this Society to its present high level.

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Röntgenology in America owes much to Dr. Leonard. He was a pioneer in every sense of the word, and began his studies in this specialty at a time when the Röntgen Ray was thought to be only useful in demonstrating foreign bodies and bone lesions. He was the first in America, if not in the world, to demonstrate renal calculi, and the outline of the kidneys, and very soon following this brilliant work, the Röntgen method was definitely established as the only reliable one in the diagnosis of renal calculi.

He has always remained a leader in the newer development of Röntgenology, yet always conservative, dignified and broad enough to accept other people's opinion. Even though he began his work at a time when Röntgenology was in its infancy, he kept close to the subject until his death. He at no time allowed himself to become the subject of newspaper notoriety, and has constantly avoided everything of that nature. He has always taken an active and dignified part in the scientific sessions of the Medical Organizations to which he belonged, particularly the American Medical Association, the American Röntgen Ray Society, the County Medical and the College of Physicians. He has preserved always the most cordial relations with his colleagues, both local and national, and steadfastly held their confidence.

In 1904 and 1905 he served as president of the American Röntgen Ray Society, and has always been a moving spirit in raising the standard of this Society to its present high level.

Locally he organized the Philadelphia Röntgen Ray Society in 1906, and has always been its secretary. This organization meets at regular intervals in the offices and laboratories of its members in Philadelphia, and by mutual helpfulness has done much to raise the standard of Röntgenological work in Philadelphia. It has done much to preserve the most cordial relations between the various members, and has enabled them to act with dignity in their relations to each other and the general profession.

He was the official delegate of the American Medical Association to the Röntgen Decennial in Berlin in '05.

In 1908 he was invited to attend the British Medical Association as a guest, where he read a scientific paper.

He was also a delegate from the American Medical Association to the Fourth International Congress of Radiology and Medical Electricity in Amsterdam, where he read the report for this country, and served as honorary president of the Congress.

In 1910 he was the delegate from the American Medical Association and from the American Röntgen Ray Society, to the Fifth International Congress on Radiology and Medical Electrolgy at Barcelona, and served as honorary president.

He served as associate editor of the "Archives of the Röntgen Ray," of London; the "Zeitschrift für Röntgenkunde," of Leipsic; and the "Journal de Radiologie," of Brussels.

He was a member of Harvard Club of Philadelphia, University Club, Order of Founders and Patriots of American National Club, British Röntgen Society of London, German Röntgen Society, American Röntgen Ray Society, American Medical Association, College of Physicians of Philadelphia.

For many years he was secretary of the Pennsylvania Society, Order of Founders and Patriots of America. He was universally beloved by the associates of the order, but quiet and unassuming as became a great scientist of international reputation.

He was probably the last of the pioneers in the development of Röntgenology as a specialty of medicine, and his untimely end was largely due to the fact that as a pioneer he was necessarily ignorant of precautions to be observed by those employing the ray. Fingers were amputated to arrest the disease resulting from frequent exposure. Later his hand was taken off and finally his arm as ineffectual efforts to stop the deadly X-Ray cancer. The disease remained unchecked through ten years during which the doctor did not give up his work until actually bedfast. He was taken to Atlantic City during the summer, but his disease progressed to a rapidly fatal termination in spite of the efforts of his physicians.

His absence was keenly felt at the section on Radiology of the International Congress of Medicine in London, in August, 1913, for the thought of establishing a section on Radiology originated with Doctor Leonard. The deepest sympathy was expressed at this time, and the most glowing tributes paid to him as a scientist.

Dr. Leonard, together with Dr. Holzknecht of Vienna, was selected to prepare reports on the present status of Röntgen diagnosis in gastro-intestinal conditions. This report, which was very comprehensive and very elaborate, was prepared by Dr. Leonard during the last year while suffering severely from the disease which caused his death. It entailed a great amount of reading of English, French and German literature, and the fact that he accomplished all this work in the midst of great suffering, and without a murmur or a complaint, is a clear demonstration of his sense of duty, his high ambitions and his fortitude: in fact, one of Dr. Leonard's greatest characteristics was his strenuous avoidance of any expression of sympathy, or personal comment, with regard to his disease. He bore his troubles in secret, and without complaining at any time to those who were nearest and dearest to him.

At the Annual Meeting of the American Röntgen Ray Society, in October, 1913, the Society adjourned for a half hour in his honor, and it was voted that some means should be provided to commemorate his memory at each of our Annual Meetings, and also to provide some means of definitely establishing a memorial to the martyrs of this science.

So highly esteemed was the work of Doctor Leonard by the medical world that the Pennsylvania State Medical Society in session in Philadelphia adjourned for thirty minutes as a mark of respect. Dr. Lawrence Litchfield, who presented the resolution to adjourn, characterized the dead martyr to science as the most prominent member of the State Society.

The Evening Telegraph, a Philadelphia newspaper, in an editorial referring to Dr. Leonard states:

"The X-Ray has played a remarkable and beneficent role in medical and especially surgical science. It has saved many lives and relieved many more from pain and life-long suffering. But like every gift to humanity, its giving has cost the lives of its pioneers.

"Medical science is honored by such noble sacrifices as this, inspired by no mercenary aims, but by the purest motives on behalf of suffering humanity, Charles Lester Leonard has shed lustre upon Philadelphia, and upon the profession he adorned and whose work he advanced, at the cost of his life."

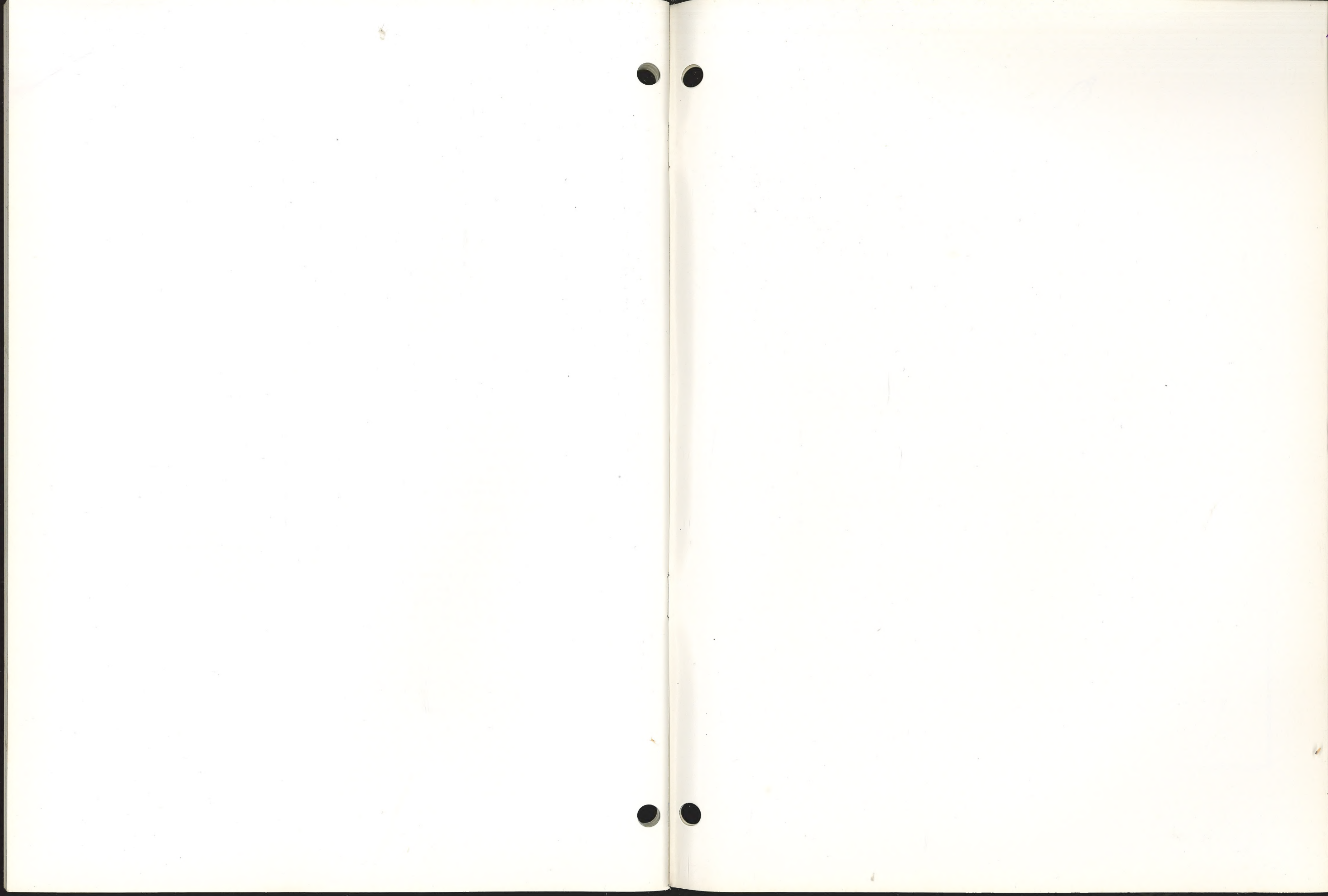
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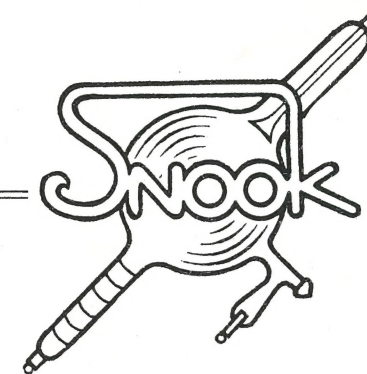
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