A manual of modern gastric methods : chemical, physical and therapeutical / by A. Lockhart Gillespie ; with a chapter upon the mechanical methods used in young children, by John Thomson.

A MANUAL OF MODERN GASTRIC METHODS

[*Photo by J. Hume Paterson.*

FIG. 1.—Auto-lavage. (See page 119.)

A MANUAL

OF

MODERN GASTRIC METHODS

CHEMICAL, PHYSICAL, AND THERAPEUTICAL

BY

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"The Natural History of Digestion" (Contemporary Science Series)

WITH A CHAPTER UPON

THE MECHANICAL METHODS USED IN YOUNG CHILDREN

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TO

CLAUD MUIRHEAD, M.D., F.R.C.P. Ed.

TO WHOSE

PRECEPTS AND PRACTICE

THE

AUTHOR IS DEEPLY INDEBTED.

PREFACE

In response to many requests the following notes have been put together in the hope that descriptions of the different modern schemes, which have been adumbrated for the purpose of helping a physician's diagnostic powers, and therapeutic facilities, in connection with gastric complaints, might serve a useful purpose when expressed succinctly, and based upon a personal acquaintance with the actual details of the processes. Practical performance of methods, carried out entirely at second hand from text-book directions (often transcribed by the authors without a personal trial), giving but bare details of the *modus operandi*, is apt to result in failure, or error, until the physician has found out by his own experience what precautions and additions are advisable. As many of the chemical methods of analysis are too complicated and lengthy for ordinary clinical work, the details of the more simple procedures have been emphasised, although at the same time the others are fully dealt with.

Scientific medicine progresses apace; in the diagnosis and treatment of gastric diseases quite as rapidly as in other departments; the aid she affords is of

great value, but liable to misuse. Science can aid clinical knowledge, but cannot take its place. Gastric modern methods often afford us invaluable evidence as to the true nature of the disease and its probable cause, but treatment founded upon them alone is apt to enter into conflict with the living personality of the victim.

Dr John Thomson has been good enough to supply a chapter upon the mechanical measures advisable for use on children, a subject on which, as is well known, he is an expert.

I have to express my thanks to my friends, Dr Max Einhorn of New York, and to Dr Fenton B. Turck of Chicago, for their kind permission to reproduce several figures; to record my deep sense of gratitude to the Royal College of Physicians of Edinburgh for the opportunities so freely given me of working in their Research Laboratory; and to thank Mr J. Hume Paterson of that Laboratory for his aid in the preparation of the figures.

A. L. G.

23 Walker Street,
June 1899.

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A MANUAL OF MODERN GASTRIC METHODS

CHAPTER I.

THE CONDITIONS PRESENT IN HEALTHY DIGESTION.

Normal Gastric Juice—Capacity of the Stomach—Measurements—The Gastric Contents—Three Stages of Gastric Digestion—Duration of the Stay of Food in the Stomach—The Fasting Stomach.

THE normal gastric juice of man has hardly ever been procured in a pure state. The one or two instances in which it has been examined have been cases of gastric fistulæ, such as the historic case of Alexis St Martin, and the case of a peasant woman, the subject of a gastric fistula, investigated by Schmidt. The composition of gastric juice as obtained from these patients has really little connection with that of the contents of the stomach after a meal, either in health or in disease. The contents in such cases have always been obtained by mechanical stimulation of the mucous membrane. The proper stimulation for the gastric glands is food of various kinds. The analyses of the gastric juice obtained from cases of fistula by mechanical stimulation bear very little relation to the characters of the secretion poured out by the cells of the gastric glands during digestion. Pure gastric

juice is a thin, colourless, or slightly yellow liquid, with a faintly acid, mawkish taste, and a peculiar, specific odour. When boiled it does not coagulate, but loses its activity. If it contains a normal amount of hydrochloric acid, it may be kept for a long time without decomposition occurring. The analysis of the secretion of the stomach during fasting may here be given.

Analysis of the Gastric Juice in Man, per mille (containing saliva).

Specific gravity, . . .	1002·00
Water, ...	994·40
Organic material, . . .	3·19 (Pepsin 3)
Free hydrochloric acid, .	0·20
Chloride of sodium, . .	1·46
„ potassium, . .	0·55
„ calcium, . .	0·06
Phosphate of calcium magnesium, and iron, . .	0·125

The analysis was made by Schmidt in a case of gastric fistula. It will be seen from the table that the solids of the gastric juice are below 1 per cent. Gamgee* says that the juice contains, as a rule, less than 1 per cent. of solids, $\frac{2}{3}$rds of which are organic, and about $\frac{1}{3}$rd inorganic. The amount of hydrochloric acid given in the table is only ·02 per cent., but it is not stated whether the hydrochloric acid present was in an absolutely free form or combined with the proteid material in the juice. The organic solids, which are chiefly composed of the ferment

* *Text-Book of Physiological Chemistry*, vol. ii. p. 79.

pepsin, amount to 319 grm. per cent., and the quantity of hydrochloric acid present is not sufficient to satisfy all the affinities of this organic matter, even if only part of it be proteid in nature.

Pure gastric juice reacts to litmus and to phenol-phthalein as an acid. We have, as yet, no accurate knowledge of the amount of juice secreted. The quantity secreted each hour, according to Schmidt, is 500 grm. in the dog, and if we reckon this as $\frac{1}{10}$th of the dog's weight, in man 6 litres each day should be formed. But Fremont found that the amount of pure gastric juice secreted by an isolated part of the dog's stomach only corresponded to 4 litres of gastric juice in man per diem.

The Capacity of the Stomach.

Different authorities give very varying estimates of the capacity of the human stomach. Beneke* gives it in the adult as 2980 c. cm., while Ewald (*Klinik der Verdauungskrankheiten*, part ii.) states that the average amount which the stomach can contain is little over a litre, although 1600 to 1700 c. cm. may often be held. He regards 3 pints (1700 cm.) as an abnormal quantity. In the new-born infant the stomach holds only 36 c. cm., or about $1\frac{1}{2}$ oz.; at six years of age it is able to contain 1090 c. cm.; while after twenty years of age it reaches its maximum capacity. Although these figures are the means of many observations, we must conclude that the capacity of the stomach varies immensely in different individuals, and that,

* *Constitution und Constitutions-Anomalien*, p. 112.

while there is no obvious relation between its size and the stature of the person, a capacity in the adult under 800 c. c., or over 2000 c. c., must be considered to be abnormal.

The Measurements of the Stomach.

Sappey gives the greatest diameter of the stomach from left to right as 24 to 26 cm., while Vierordt gives for the same measurement 27 to 32 cm. The diameter from the lesser to the greater curvature is 10 to 12 cm., while from the front to the back it is 8 to 9 cm. These figures apply to the stomach containing food; when empty, the walls are closely applied in the antero-posterior direction, and its greatest length diminishes to 18 to 20 cm., while the distance of the lesser curvature to the greater is only 7 to 8 cm. The pylorus is 1·8 cm. distant from the cardiac end in the empty stomach, but after food only 1·4 cm. from it.

Vierordt gives the surface of the gastric mucous membrane as 3000 cm.

The Gastric Contents.

In practice we have to deal with the contents of the stomach after the ingestion of food. These vary in composition with the food taken, the time after the meal, and the state of health of the individual. That the gastric juice secreted, after the stimulation of the glands by the constituents of the food swallowed, is quite different in composition from the pure juice obtained after mechanical irritation of the mucous membrane, is shown by the fact that the gastric contents generally possess a very much higher acidity than the

pure juice itself. If the gastric juice were secreted throughout digestion with the acidity indicated by analysis of the fluid obtained in the manner stated above, the acidity of the gastric contents could not rise above that figure. As, however, the acidity rises, and rises progressively after the ingestion of food, the amount of acid formed by the gastric glands must be in very much larger proportion to the total amount of fluid secreted. Samples of the stomach contents in health vary in composition to a wide extent, and the results obtained from their analyses yield little information, unless we note the nature of the meal which has been taken, and the time after it at which the sample has been removed.

The Three Stages of Gastric Digestion.

We may look upon gastric digestion as being divided into three stages. THE FIRST STAGE lasts from fifteen to forty minutes; in it the acidity of the contents is always rising, but, as the hydrochloric acid, which is being secreted, enters into combination with the salts and with the proteids of the food, no free hydrochloric acid can be detected. This stage is often marked by the presence of lactic acid in the contents. The lactic acid may be contained in the food itself, or arise from the action of micro-organisms on it. As the acidity is chiefly composed of hydrochloric acid combined with proteid bodies, it exerts only a weak antiseptic action, and lactic-acid-forming organisms can flourish unchecked. IN THE SECOND STAGE the hydrochloric acid is still being secreted, and the

total acidity of the contents continues to rise, while free hydrochloric acid can now be detected. That is to say, that more hydrochloric acid is being secreted than can combine at once with the proteids present. The antiseptic action of the free hydrochloric acid checks the lactic acid fermentation, and the lactic acid soon disappears. THE THIRD STAGE follows after the maximum acidity has been attained, and when much of the contents of the stomach have been propelled through the pyloric orifice. In this stage the hydrochloric acid, combined with proteids, is diminished in quantity; the total acidity also falls, while there is a much larger proportion of free hydrochloric acid present. The duration of these three stages varies with the kind of food taken. If the meal be largely carbohydrate in nature, the first stage is very short, because there is little proteid material with which the hydrochloric acid can combine. Free hydrochloric acid soon appears in the contents, though the total acidity does not rise so quickly. The second stage after carbohydrate food is characterised by a comparatively larger amount of free hydrochloric acid, a total acidity which is not very marked, and a small amount of acid combined with proteids. The first stage after this kind of food may only last fifteen minutes, while the third stage may commence as soon as the second or third hour. On the other hand, if the meal taken be composed largely of proteid bodies, free hydrochloric acid may not appear in the contents until an hour has elapsed. The acidity may rise to a high point, although the free acid present be slight in amount, the bulk of it being composed of acid in conjunction with proteid

bodies. The third stage after such a meal—*i.e.*, the stage in which the total acidity begins to fall again—may not be reached until the fourth or fifth hour. A mixed diet of carbohydrates and proteids leads to conditions midway between these two extremes.

Periods of Healthy Gastric Digestion.

1. Fifteen to forty minutes,—total acidity rising; *lactic acid often present; free hydrochloric acid absent;* hydrochloric acid combined with proteids the chief factor in acidity.
2. From fifteen or forty minutes to two or five hours,—after carbohydrates it usually begins early, and ends by the third hour. Acidity rising; *lactic acid absent, or only in traces; free hydrochloric acid present; hydrochloric acid combined with proteids still in the larger proportion;* some of the more fluid contents may be passed through the pylorus.
3. From two or five hours till emptying of stomach at the end of three to six or seven hours,—*total acidity falling; free hydrochloric acid present in greater proportion; the combined acid in less;* contents are being expelled through the pylorus more rapidly.

Of course we must remember that the reaction of the food taken may alter the characters of the stomach contents during the first period of digestion, but the acids in food-stuffs are generally organic, and these are rapidly absorbed or altered in healthy digestion, and have little influence on

its course, unless they are present in large quantities.

Bearing these facts in mind, we can easily make out, by analysis of the contents of the stomach in disease, what variation from the normal is present, if we remember that the sketch of the processes given above does not apply absolutely to all cases, but that considerable variations even in health may occur.

Duration of Stay of the Food in the Stomach.

The length of time during which the stomach contents remain in that organ varies with the nature of the food taken. Whatever be the nature of the food, it is probable that as early as from fifteen to twenty minutes after its arrival in the stomach the pyloric sphincter temporarily relaxes and allows a small portion of the more fluid contents to escape. This action is repeated rhythmically every five minutes or so, until the stomach is empty. The contents, however, may pass through the pylorus much more quickly, if fluids only have been taken.

The more solid the food the longer does it remain, and warmed foods pass through more quickly than cold.

Schüle found that 300 c. c. water at 18° C. passed through the stomach of the dog in ten minutes. At a temperature of 0° C., fifteen minutes elapsed before the first portion passed through the pylorus. At 28° C. and 40° C. its passage was quickened. Milk passed through almost as quickly as water. Solids mixed with fluids remained longer, the fluid portion passing downwards before the solids.

The flesh of animals remains from two and a half to five hours in the stomach; lamb about two hours and a half; beef, mutton, and fish three hours; veal and pork four to five hours. Soft boiled eggs remain about two hours and a half; if hard-boiled, five hours.

Vegetable foods remain about three hours in the stomach.

Fats may be passed on early, but generally remain to the last.

Breakfast may be said to take four hours and a half, a full lunch or dinner five to seven hours, and late dinner or supper seven to eight hours, before entirely leaving the stomach.

Ewald's test-breakfast should only remain about two hours in the stomach, Leube's test-dinner not longer than six to seven hours.

The Contents of the Fasting Stomach.

There is a considerable divergence of opinion with regard to the question whether the healthy stomach contains any fluid, further than the swallowed saliva, when more than seven hours have elapsed after the ingestion of food. Some authorities assert that the organ is absolutely empty, its walls covered with mucus possessing an acid reaction at the fundus, an alkaline at the pyloric region. Others report the presence of a small amount of fluid; the most reliable observations give only traces of hydrochloric acid, never more than 0·004 per cent.

If the fasting stomach be free from gases, it forms only a potential cavity, the walls being closely applied to any small quantity of fluid contained in it.

In this condition water and other bland fluids pass almost directly into the duodenum.

It may be stated here, that the healthy stomach, seven hours after a meal, contains little fluid, chiefly mucus and swallowed saliva, with a slightly acid reaction. No free hydrochloric acid is present.

The mere act of passing a stomach tube suffices to call forth a secretion of gastric juice, so that instances in which acid material has been obtained by its use from the fasting stomach are probably fallacious.

CHAPTER II.

THE METHODS FOR OBTAINING THE CONTENTS OF THE STOMACH.

Test-Meals—Methods used for the Withdrawal of the Contents—The Stomach-Tube—How to pass it—Stomach-Pumps—Expression—Einhorn's Stomach-Bucket.

IN dealing with this subject we must divide our description into two heads:—First, the test-meals; second, the use of the stomach-tube and other instruments.

1. Test-Meals.

So many have recommended the use of special test-meals before withdrawing the contents of the stomach for analysis, that it is necessary here to notice the principal forms suggested. The chief test-meals in use are as follows:—

(*a.*) *Ewald's and Boas' Test breakfast* (Probefrühstück). In this, ½ to 3 oz. of bread are given, and from 10 to 13 oz. of weak tea. The stomach contents are to be examined an hour afterwards. The ingredients of this meal are designed to include albuminoids, sugar, starches, non-nitrogenous extractives, and salts; while the tea belongs to a class of foods which, when weak, stimulate the gastric secretion.

(*b.*) *Klemperer* suggests that a pint of milk be given instead of the tea, along with the same amount of bread, and that the contents be examined two hours afterwards. The substitution of the milk is recommended in order to subject the stomach to a severer test.

(*c.*) *Germain-Sée's Test-meal.*—This consists of 3 to 5 oz. of bread, a small tumbler of water, and 2 to 2½ oz. of minced meat. The stomach contents are to be examined from one and a half to two hours after this meal.

(*d.*) *Bourget's Test-meal.** — Bourget gives 300 grains of toast and 3 oz. of weak tea without sugar, to which has been added a drachm of tincture of mint. The disadvantage of this meal is that it contains hardly any proteid, and it is only suitable for those cases in which the secretion is very slow.

(*e.*) *Herschell* recommends a lightly-boiled egg, 1 oz. of minced meat, 3 oz. of toast, and a quarter of a pint of very weak tea. The contents should be examined one and a half hours afterwards. This test-breakfast, it is evident, contains much more proteid matter than Ewald's.

(*f.*) *Leube and Riegel* have advocated a much larger test-meal, which they term the *test-dinner* (Probemittagsbrod). It consists of a plate of soup (about 13 fluid oz.), 60 grm. (2 oz.) of scraped beef, and 50 grm. (1¾ oz.) of wheaten bread. This meal contains very much more proteid material, and a longer time, therefore, must elapse before the contents of the stomach are removed. Indeed, they

* *La Médecine moderne*, August 4th, 1894.

should not be extracted after such a meal until four to six hours have elapsed.

For reasons stated above, I have, for my own part, found it quite sufficient to remove the stomach contents after any kind of meal, the nature of which is known and which approximates more nearly than special test-meals to the ordinary food each patient is accustomed to take.

Looking at these test-meals in a general way, Ewald's and Bourget's contain hardly any proteid bodies—that is to say, they give the stomach little of its special work—*i.e.*, the digestion of proteid bodies—to do. It appears to me that one can derive more useful information regarding the chemistry of gastric digestion if the stomach contents be removed after an ordinary meal containing a fair proportion of the proteids, than when a special and often unaccustomed form of food, consisting chiefly of carbohydrates and water, is given. In the latter case, free hydrochloric acid soon appears in the contents, owing to the small amount of albumin with which it can combine. A larger meal, such as Leube's or Herschell's, affords us evidence of how far gastric digestion is able to go in the digestion of proteid bodies.

In addition to the test-meals, Leube has recommended the washing-out of the fasting stomach with 400 c. c. of lukewarm water, until the last portions removed are neutral to litmus. He then injects 50 c. c. of a 3 per cent. solution of soda, which is allowed to remain in the organ for a space of about twelve minutes, and then is removed again by washing out the stomach with 400 c. c. of water. If

at the expiration of twelve minutes the soda solution has been neutralised, the secretion of hydrochloric acid is normal; if it still remains alkaline, the secretion is deficient.

Still another method has been used by Leube. He injects 100 c. c. of ice-cold water through the tube after the stomach has been thoroughly washed out. After ten minutes this liquid is removed by washing out the organ with 300 c. c. of water, and its acidity determined.

The last two methods, however, are of little practical value, as it has been shown that water rapidly passes through the stomach and excites little secretion of acid. In the first, of course, the soda may excite some secretion, but the knowledge gained is very small.

To sum up, any of the test-meals described above may be given, or the patient may simply take what he is accustomed to, and which, as a rule, experience has shown to be of such a nature as is most easily digested in his case, and to cause the least inconvenience. The contents should be removed some time after the meal. The lighter the meal the sooner can the stomach-tube be used. If unminced meat has been taken, three or four hours should be allowed to elapse. As a general rule, I select two hours after a light meal for the process. From practical experience, milk, I find, is one of the worst foods to give before trying to remove the contents of the stomach. The curdled masses clog the eyes of the tube more readily than other foods.

2. Methods of obtaining the Stomach Contents.

In many cases of dyspepsia, where the diagnosis is difficult and the proper treatment depends on the nature of the chemical processes in the stomach, it is often imperative to obtain some of the material for examination. In cases in which this is not allowed or is impossible, chemical analysis of the vomited matter, if there be any, may afford some clue to the abnormal processes present. But, as in the act of vomiting a large quantity of saliva is secreted and mixes with the stomach contents, the acidity values obtained are very erroneous.

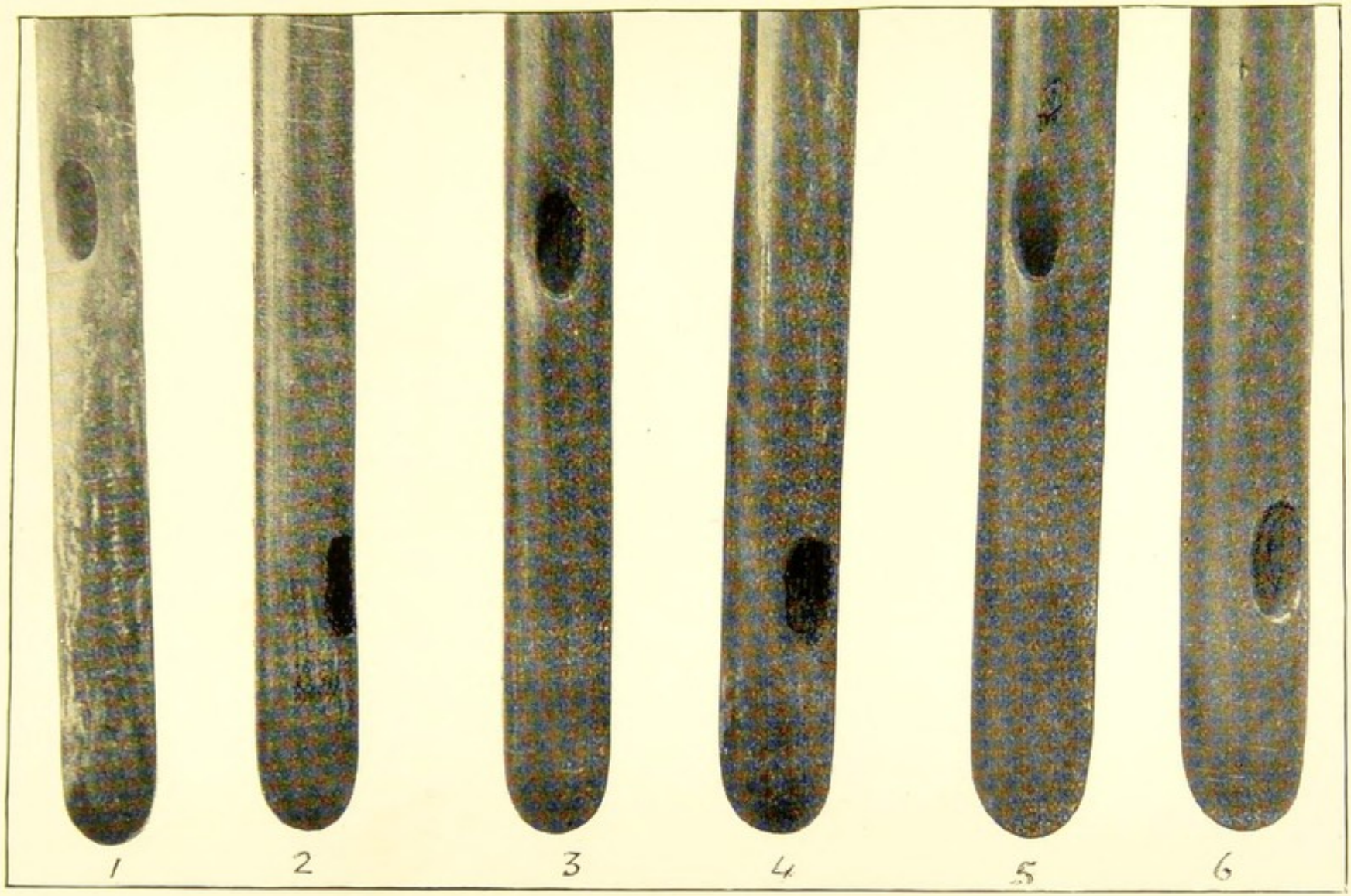
The easiest way to obtain the contents in a pure condition is by the use of the ordinary stomach-tube. Obtaining a small quantity of the gastric contents by means of the tube is a much less serious proceeding than that known as washing out the stomach. Usually a sufficient amount of the contents can be obtained immediately on passing the tube, and the proceeding may only occupy one or two minutes.

The Stomach-Tube.

The stomach-tube which is used at the present day is made of red rubber of a moderately soft consistence. Two forms are employed: one with a rounded blind extremity and two lateral eyes, one placed nearer the end than the other. The second variety has an open end, and, in addition, small lateral openings. The tube with the rounded blind end is to be preferred, as there is less danger in using it of damaging the mucous membrane of

the stomach by suction into the lumen of the tube through the terminal opening. The sizes generally employed are numbered 20 and 21 in the English scale (see Fig. II.). It is well to use large tubes rather than slender ones, as the muscles of the pharynx grasp a large tube very much better than they do a slender one, and thus facilitate its progress down the œsophagus. The tube should be from 32 to 36 inches long, and may be attached by means of a short glass tube to a further length of rubber tubing. Care must be taken that the piece of glass inserted between the two rubber portions of the tube is so made that the junctions between it and the stomach-tube are firm. There is just a chance that if the stomach-tube became detached it might slip down bodily into the stomach. At the other end of the upper rubber tube a funnel of moderate size is inserted. If the operation is to take place at the practitioner's house, a glass funnel is preferable, but when performed at the patient's house, a vulcanite or enamelled one is better.

The first thing that should be done is to give the patient a pledget of cotton wool soaked in a 5 per cent. cocaine solution, directing him to suck this and to keep the saliva and the cocaine as long as possible about the back of the mouth. Cocaine takes several minutes to act in many individuals, and it is better to wait for at least five minutes before attempting to introduce the tube. While the cocaine is acting the other necessary arrangements can be prepared. The patient is placed on a chair which may be put on the centre of a large square of waterproof sheeting. A piece of macintosh



[*Photo by J. Hume Paterson.*

FIG. 2.—Stomach Tubes. The terminal ends of soft rubber stomach tubes of various calibre. Natural size. (See page 16.)

is fastened over his clothes; while he is directed to sit with his knees wide apart, so that anything spilt on the macintosh runs into a pail, which should be placed on the floor between them. The tube is often directed to be moistened with glycerine or with oil, but patients often dislike the taste of the oil, while the glycerine may irritate the pharynx. I prefer simply to dip the tube in warm water. Then, asking him to throw his head slightly back, the point of the tube is introduced over the tongue into the pharynx. It is as well, especially on the first occasion, to allow it to remain there for a short time, while the patient is directed to breathe through his nose, and to swallow any saliva that may be present. The point of the tube is then gently pressed downwards and the patient requested to swallow. The muscles of the pharynx catch the tube, and no difficulty will then be experienced in passing it right down into the stomach. If the patient at any time expresses a fear of being suffocated, direct him to breathe freely through the nose, stopping at the same time the progress of the tube.

When the point of the tube has entered the stomach cavity there is usually an escape of gas. As a rule, if the operation be performed two or three hours after a meal, no difficulty will be encountered in obtaining some of the contents through the tube for examination. If the patient be directed to retch, on almost all occasions some of the contents will pass up the tube and can be caught in a clean vessel. Whenever it is certain that the end of the tube has reached the stomach,

the funnel at the free end should be depressed, so that, if the action of retching be sufficiently strong to force some of the contents even a little beyond that part of the tube which projects out of the mouth, syphon-action may take place. If the patient's own exertions are not sufficient to force some of the contents through the tube, the operation of "expression" may be performed, as first suggested and performed by Ewald. This operation simply means the application of pressure over the region of the stomach, the patient bending forward at the time, by which means the contents may often be forced with great ease through the stomach-tube. The pressure may be applied by the operator or by the patient himself. If, before a sufficient quantity of the contents have been obtained, a blockage of the lumen occurs and no more will pass through the tube, it may be withdrawn for an inch or so and then passed back again. After this the obstruction generally disappears. If none, or too little, of the contents can be obtained in this way, a method which I have found very valuable may be tried,—*i.e.*, fill the funnel with warm water, pinching the india-rubber tube a short distance below with the left hand, so that no air can get down ; then relaxing the pressure, let the water fill the tube to some way beyond the piece of glass inserted in the middle of it. Then, when just enough water has been allowed to pass down to fill the tube, lower the funnel, let the water run into the pail, and the contents of the stomach are sucked up by the syphon-action thus induced, and may be caught, when they appear after the water, in a clean basin

held for the purpose. If it is done carefully, little or no water enters the stomach, and hence the contents are not diluted.

If all these operations are resultless, some warm water must be poured down the tube into the stomach, and, after a certain quantity has been administered—the amount should be measured beforehand—and before all the water has left the funnel, it should be rapidly depressed and the syphon-action started. The quantity of contents obtained will indicate, knowing as we do the amount of water added, what proportion the pure contents bear to the total fluid.

In withdrawing the tube care should be taken that it is not pulled up too quickly. There is a danger also, if the stomach has been emptied and if some fluid still remains in the tube, of the mucous membrane being injured by suction of a part of it into the openings at the end of the tube. It is as well to pour in a small quantity of water with the funnel raised before withdrawing the tube, and then, without depressing the funnel, to carefully pull it up, as the increased pressure forces the mucous membrane away from the eyelets.

After removing the tube it should be well washed in cold water, allowing a stream to pass through its lumen, to clear out the openings at its end; then it may be washed in warm water, in a solution of carbolic acid, and in warm water again, dried, and put away, lying as fully extended as possible. Before using it, it should again be washed in warm water, to clean it and render it more pliable.

Stomach-Pumps.

Boas has devised a useful form of the ordinary india-rubber ball-pump, in which a valve, placed between the stomach-tube and the cavity of the pump, allows the stomach contents to be readily withdrawn and emptied into a vessel (see Fig. III.). The ordinary medical aspirator, such as is generally used for tapping any of the body cavities, may be attached to a stomach-tube, the end of the stomach-tube being joined to the inlet of the vacuum bottle. It is better, however, if possible, to avoid the use in all cases of any force when withdrawing the contents.

Expression.

This method only requires incidental notice, as it has been mentioned above. Boas and Herschell recommend it, as a simpler and more useful way of obtaining some of the stomach contents than by syphonage or aspiration. Boas, indeed, prefers to express the contents of the stomach than to wash out the organ in the ordinary way. To express the contents of the stomach the tube is passed in, pressure applied over the gastric region, or the patient is directed to cough.

Einhorn's Stomach-Bucket.

Einhorn has invented an instrument which he terms the stomach-bucket (Fig. IV.). By means of this instrument a small quantity of the stomach contents can be easily removed and analysed.

A bucket of silver, with an opening at its upper extremity, is attached to a silk thread. The thread

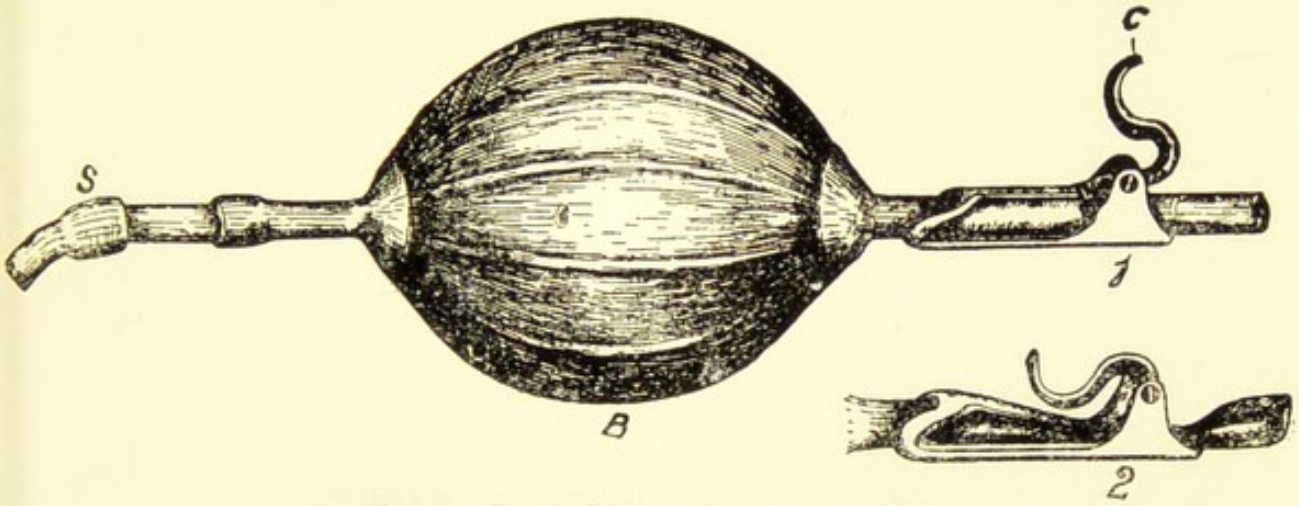


FIG. 3.—Boas's Ball-pump. (See page 20.)

FIG. 4.—Einhorn's Stomach Bucket. (See page 20.)

bears a knot or mark 16 inches from the bucket, serving as a guide as to the entrance of the bucket into the stomach. The bucket is placed far back on the tongue and the patient told to swallow it. In one or two minutes it reaches the stomach, and should be left there for five minutes. In withdrawing it, if any difficulty be felt as it passes the cardiac orifice, the patient is instructed to swallow, and the thread drawn up at the same time. If there be much mucus in the œsophagus, the bucket may become filled with it, and not with the gastric contents. To guard against this, a thin gelatinous covering may be stretched over the opening, as this covering rarely becomes dissolved before reaching the stomach cavity. The best time to use the bucket is one hour after Ewald's test-breakfast, or later if a larger meal has been taken. The quantity of stomach contents which can be obtained by the stomach-bucket is so small that its use is inadvisable unless in the case of a patient intolerant of the tube.

The stomach-tube or bucket should not be made use of in the examination of patients suffering from a thoracic aneurism, severe heart disease, or any debilitating disease tending to the occurrence of syncope ; in old people as a rule, or in advanced cancer of the stomach or gastric ulcer with recent hæmorrhage.

CHAPTER III.

THE EXAMINATION OF THE FLUID REMOVED FROM THE STOMACH, OR OF THE VOMIT.

Macroscopic Examination: Appearance—Amount—Specific Gravity—Smell—Undigested Food—Mucus—Blood—Pus. Microscopical Examination: Pus Cells—Blood-Corpuscles—Micro-organisms—Cancer Cells—Residual Remains.

Macroscopic Examination.

1. NAKED-EYE APPEARANCE.—The colour and the character of the solids in the fluid are first noted. It is as well to allow the unfiltered contents to stand for some time before noting the appearance. They usually separate into two layers, the lower containing the solids, the upper the fluid portion. If the digestive powers of the stomach are good, the solid matter is in small particles, the fluid portion almost clear. The contents removed from a dilated stomach often present a peculiar and easily recognised appearance. The solids separate into two layers, one at the bottom of the vessel, the other floating on the surface, with a dividing layer of fluid between. The upper layer of solid matter is like scum, and grey or brownish in colour, and consists chiefly of sarcinæ and yeasts. On other occasions the contents from such cases are porridgy and fermented. If the food taken consist of highly-coloured substances the

contents exhibit a corresponding tint. In general they are of a pale whitish-yellow, or darker yellow-grey hue.

2. AMOUNT.—The amount of food vomited or withdrawn varies with the size of the previous meal and the time after it has been taken in healthy persons, or in those who suffer only from a temporary acute attack of dyspepsia.

From one to two pints is not an abnormal quantity, unless obtained or vomited more than five hours after a light meal, or six or seven hours after a full one. In cases of dilated stomach enormous quantities are sometimes present. Thus Ewald refers to a case in which as much as 8 kilogrammes ($17\frac{3}{5}$ pounds) of material is said to have been vomited! In acute gastritis the quantity vomited is often moderate in degree, but is peculiar in that, however fluid the previous meal has been, the vomit is nearly always thick and porridgy.

When vomiting of large quantities of fluid occurs long after the taking of food, or when similar quantities can be removed by means of the tube before breakfast in the morning, stagnation of the stomach contents is present with delayed emptying. If the fluid obtained in the morning contain a normal or an increased amount of hydrochloric acid, often without more than traces of food, the condition of hypersecretion of the gastric juice is present. In this the amount removed before breakfast may be large. In cirrhosis of the stomach walls very little fluid may be obtainable; a total capacity of as little as 4 oz. has been observed.

It should be mentioned that many (Schreiber, Rosin, Leo, and Kinnicutt) maintain that from 2 to 50 c.c. ($\frac{1}{2}$ dr. to $1\frac{3}{4}$ oz.) can be obtained from the healthy fasting stomach, and that this fluid contains free hydrochloric acid. The investigations of Ewald, Boas, and Rosenheim discredit this observation, and support the previous results of Gmelin and Tiedemann (1826), who could find no trace of gastric juice when fasting. The former observers were probably misled by a secretion occasioned by the passage of the stomach-tube.

3. Specific Gravity of the Filtered Contents.—The normal specific gravity of pure gastric juice is from 1002 to 1005.

The contents removed six to seven hours after a meal have a specific gravity of 1004 to 1006, and of 1007 in any fluid removed before breakfast.*

After meals it rises to from 1010 to 1020; when the contents are hyperacid, or the seat of acid fermentation, it is 1010; in hypoacidity, 1020. Any figure above 1020 indicates hypoacidity.

The variations in the specific gravity depend chiefly on the amount of sugar present, and only slightly on the quantity of fluid taken at the previous meal, except for a short time after, owing to the rapidity with which any excess of fluid is got rid of through the pylorus, unless, indeed, motor activity be impaired. In hypoacidity, with no free hydrochloric acid during the early stages of digestion, conversion of starch into maltose can continue to

* Strauss, *Zeitschrift f. klin. Med.*, xxix., H. 3, 4.

take place in the stomach, thereby increasing the specific gravity of the filtered contents.

4. SMELL.—In healthy gastric digestion the stomach contents possess a peculiar "gastric" smell. In all cases with fermentation they are characterised by a disagreeable or sour odour. The odour of fluid from a dilated stomach with great stagnation is especially disagreeable. If the smell be like that of rancid fat, butyric acid fermentation has been in progress; if like sour milk, lactic acid formation; or if like vinegar, acetic acid has resulted from bacterial action. In rare instances there may be a smell of sulphuretted hydrogen or of putrefactive changes, due to decomposition of proteids.

5. UNDIGESTED FOOD.—The presence or absence of undigested portions of food should be noted. The character of the food taken, and sometimes the period of time which has elapsed without emptying of the stomach, may be ascertained by the nature of the fragments found, such as fruit skins, orange pips, coagula of milk, undigested muscle, etc.

The undigested muscle fibres may be recognised under the microscope, while the presence of lumps of still undigested meat in contents removed three or four hours after a meal shows that the digestive power of the stomach is diminished.

The diagnosis between regurgitation of food from an œsophageal diverticulum and vomiting from the stomach may depend to some extent on the state of the muscle fibres should they be present in the fluid ejected.

6. MUCUS.—An excess of mucus is easily recognised by the naked eye. The stringy and gelatinous nature of the stomach contents serves to indicate its presence in undue quantity. Normally it amounts to only half a teaspoonful. It is in larger quantity in vegetable eaters than in those who chiefly live on meat.*

Some of the gelatinous material may be placed in cold water and gently washed in it. The water is then poured off and a little liquor potassæ or baryta water added. The mucus dissolves in this, and can be precipitated from the solution by acetic acid, in which it is insoluble in excess.

The mucus is generally colourless, but may be slightly pigmented in long-standing cases of chronic gastric catarrh. As a rule pigmented mucus in the vomit comes from the lungs. The mucus contained in the gastric contents removed by the stomach-tube must come from the stomach itself, or from the saliva which has been swallowed.

When the gastric juice is of normal activity microscopical examination of some of the mucus shows that only the nuclei of the cells entangled in it remain (Jaworski). If digestion be weak the cells are entire. Jaworski's "spiral" bodies, formed from mucus by free hydrochloric acid, may also be discovered.

Mucus is increased in acute inflammatory affections of the gastric mucous membrane, and in cases of hyperchlorhydria and gastric ulcer. In cases such as the last two, where the hydrochloric acid is increased in amount, the mucus is often

* Schmidt, *Deutsch. Arch. f. klin. Med.*, lvii. 1, 2.

present in the form of balls or threads. In atrophy of the mucous membrane and in cancer of the pylorus and walls of the stomach, in which hydrochloric acid is diminished or absent, the secretion of mucus is increased.

7. BLOOD.—If the bleeding is profuse and from an artery, the blood may be bright, and either clotted or capable of clotting. When it has remained in the stomach for a short time it comes up in dark clots, while if it has remained for a long time the blood is altered to a dark brown or black material, like "coffee-grounds," which is not in the form of clots, nor does it clot outside the body.

When the hæmorrhage has been slight, it is often difficult to determine whether the lungs or the stomach are at fault. As a general rule blood which has come from the lungs or air passages is bright in colour, while blood from the stomach is darker.

When present in small quantity, the discovery of blood-corpuscles under the microscope decides the question. Indeed, microscopical examination sometimes reveals its presence when no naked-eye evidence is obtainable. The well-known guaiacum and ozonic ether test is not of much use in testing for blood in the stomach contents, as many of the common vegetable constituents of the food, as well as saliva and bile, respond to it.

When the blood has been vomited in the form of "coffee-grounds," the microscope affords us no assistance. As the same appearance may be presented by the entrance of bile into the stomach, or by an

admixture of tea or coffee taken shortly before, it is often necessary to determine the nature of the "grounds."

Bile can be identified by the play of colours with fuming nitric acid (Gmelin's test).

If the deposit be formed of altered blood, in which the hæmoglobin is changed into insoluble hæmatin, two tests will reveal the fact :—

(*a.*) The formation of hæmin crystals, by placing a small drop of the deposit on a microscope slide, adding a crystal of chloride of sodium and a drop of glacial acetic acid, then covering with a cover-glass, and heating over a spirit lamp until bubbles commence to form. Under the microscope, small reddish-brown oblique rhombic crystals of the hydrochlorate of hæmin can be seen if blood pigment is present.

(*b.*) By the formation of Prussian blue, signifying the presence of iron. For this test to be of moment the patient must not be taking any preparation of iron.

A small quantity of the black deposit is mixed with a little chlorate of potassium in a capsule, and a drop or two of hydrochloric acid added. The mixture is heated over a spirit lamp, and a few drops of a 5 per cent. solution of potassium ferrocyanide added. If blood is present, Prussian blue is formed.

The presence of blood in large amount indicates gastric ulcer or carcinoma, the former especially if it be bright in colour. Lesser quantities may come from the stomach in similar conditions, and also in erosions of the mucous membrane, congestion of the l ver, and acute gastritis. In the latter, and in some

cases of chronic catarrh, the presence of blood can only be discovered by the identification of the red corpuscles under the microscope. Blood also may be contained in the contents voided in cases of phlegmonous gastritis, and when congestion of the stomach is caused by backward pressure from heart disease or cirrhosis of the liver.

8. PUS.—Pus may be present in the gastric contents, and is usually due to muco-pus brought up from the air passages and mixed with the vomit. It may, however, be due to phlegmonous gastritis, with localised abscesses of diffuse suppuration. It is easily recognised under the microscope.

Microscopical Examination.

The identification of pus cells and blood corpuscles by means of the microscope has already been referred to, and mention made of the value of this method in the detection of undigested muscle fibres, and in deciding, from the appearances presented by detached epithelial and other cells, upon the activity of the contents before removal. If they are entire, the digestive power is weak; if nuclei alone remain, it is active.

It will aid in the diagnosis of the nature of any fermentative process present if the form of organism contained in the fluid can be identified. Cover-glass preparations can be made directly from the specimen and mounted unstained, or after staining with methylene blue.

Sarcina ventriculi and yeasts take up aniline dyes

very readily, and the excess must be removed by washing before examination.

With iodine and weak sulphuric acid, the sarcina ventriculi gives a red-violet colour, the cellulose reaction.

In addition to these forms, various moulds may be present, and several species of bacteria, bacilli, and micrococci.

The bacterial forms may be divided into two classes :—(1), Those which form acids by their growth, and which, as a rule, do not liquefy gelatine ; and (2), those giving the medium in which they grow an alkaline reaction, and which generally liquefy gelatine.

To the first class belong Bacillus Coli Communis, Bacillus Acidi Lactici, Bacterium Lactis Aerogenes, which do not liquefy gelatine, and Bacillus Butyricus and Bacillus Amylobacter, which do.

In the second class are found Bacillus Subtilis, Proteus Vulgaris, and Bacillus Fluorescens Liquefaciens.

In addition, several micrococci and leptothrix forms have been identified.

The presence of cells from malignant growths, and of small detached portions of the gastric mucous membrane, can also be determined by use of the microscope.

An examination of the precipitate from a specimen of stomach contents, which has been removed from the paper used for its filtration or obtained from the deposit present on standing, often throws considerable light on the nature of the processes present.

As already mentioned, the digested or undigested state of the muscle fibres, and the presence of entire

epithelial cells, or of their nuclei only, may afford a means for the determination of the peptic activity of the fluid examined. Connective tissue fibres and elastic fibres may be recognised, and fat globules, starch granules, and vegetable cells found in the deposit.

CHAPTER IV.

THE EXAMINATION OF THE FLUID REMOVED FROM THE STOMACH, OR OF THE VOMIT—(Continued).

THE CHEMICAL EXAMINATION.

The Total Acidity—Deci-normal Solutions—Qualitative Tests for Free Acids—Free Acids of any Kind—Congo Red—Tropaeolin—Benzo-purpurin—Leo's Test—Free Hydrochloric Acid—Vanillin-Phloroglucin (Günzburg's)—Resorcin (Boas')—Sulphocyanide of Potassium (Mohr's) for Free Organic Acids—Uffelman's Reagent—Perchloride of Iron—Boas' Aldehyde Test—Formation of Ethers—Cacodyl—Strauss' Method of applying the Perchloride of Iron Test.

1. Total Acidity.

IN every case the first of the more minute analyses should be the estimation of the total acidity of the contents. This total acidity comprises the acidity due to acid salts, and to mineral, and organic acids, in a free state or combined with proteids, which are present. The contents may be tested before or after filtration. The acidity values obtained before and after the contents have been filtered very often vary greatly. If the proteids are in undigested masses, some of the acid present combines with them; after filtering, this combined acid remains behind on the filter paper with the proteid, and the

acidity of the filtrate is below that of the original specimen. If there is little free acid the acidity of the filtrate may be much lower than that of the unfiltered contents. On the other hand, if the contents are largely composed of insoluble vegetable bodies, the filtrate may have a higher acidity than before filtration. As noted above, the total acidity varies with the time after food has been taken, with the nature of that food, and with the individual from whom it has been obtained. The total acidity rarely reaches 0·3 per cent. Schüle gives it as 0·11 to 0·26 per cent., while Hayem and Winter give the normal limits as 0·18 to 0·2 per cent. Shortly after food the amount may be very much less than this, while three or four hours after a meal largely consisting of proteids, it may rise to 0·4 per cent. without indicating the presence of any diseased condition.

The question whether the contents are acid or not may be at once answered by the use of blue litmus paper, which reacts both to acid salts and to acids themselves. But a qualitative estimation of the reaction is seldom of much service. To arrive at a knowledge of the exact acidity present we must use another test. For this a deci-normal solution of caustic soda is necessary. A normal solution is one of which a litre contains the exact weight in grammes of the chemical body used which corresponds to its molecular weight. That is to say, a normal solution of sodium hydrate contains 40 grm. Na. in the litre of distilled water (NaHO = 23, H = 1, O = 16). A deci-normal solution is a normal solution diluted ten times, while a centi-normal solution, which may be used when great accuracy is desired, is a normal solution diluted

a hundred times. A given quantity of a normal solution of any alkali will exactly neutralise the same amount of a normal solution of an acid. Thus, 100 c. c. of normal soda solution will neutralise 100 c. c. of a normal solution of hydrochloric acid; and as hydrochloric acid has a molecular weight of 36·5, 100 c. c. of normal soda corresponds to 3·65 grm. of this acid. When the acid is dibasic, as, for instance, in the case of sulphuric acid, only half of the sum of the molecular weight is used in making up the normal solution. Sulphuric acid has a molecular weight of 98, and, therefore, 49 grm. of the acid are added to each litre to make up a normal solution. In the same way, oxalic acid with a molecular weight of 126 only requires 63 grm. to the litre to form a normal solution. A litre, then, of a deci-normal solution of caustic soda corresponds to 4 grm. of soda, to 3·65 grm. of hydrochloric acid, 4·9 grm. of sulphuric acid, and 6·3 grm. of oxalic acid. Each cubic centimetre of deci-normal solutions represents one-thousandth part of these amounts.

The method for ascertaining the total acidity of the stomach contents is based upon the quantity of a deci-normal solution of an alkali required to be added to a known quantity of the contents before the reaction becomes neutral or slightly alkaline. Many indicators have been used; the majority of them are vegetable bodies, such as litmus or cochineal, which do not change their colour with sufficient distinctness when the neutral point is reached to allow of very accurate observations to be made by their aid. An aniline body, phenol-phthalein, is of greater service. It forms a slightly yellow solution in alcohol, remains almost

colourless if added in small quantity to an acid liquid, but becomes of a pink colour in an alkaline one. If, therefore, a solution of deci-normal sodium hydrate be dropped into 10 or 100 c. c. of the stomach contents, to which a drop or two of an alcoholic solution of phenol-phthalein has been added, until a pink colour appears and remains permanent, the quantity of soda used will correspond to the quantity of acid neutralised, and, therefore, to the amount of acid contained in the 10 or 100 c. c. of the stomach contents. It is generally recommended that the soda be added until a pinkish tinge appears and does not vanish on shaking. Toepfer, however, says that more accurate results are obtained if the soda be added until the contents become of a dark red colour, which does not increase on the further addition of the alkali. The depth of the colour reaction in such a case should be controlled by adding an excess of alkali to a similar amount of the contents in another beaker, and by comparing the colour of the two (*v.* p. 68.)

If the gastric contents are so highly coloured that all reactions with colour indicators are rendered obscure, some animal charcoal may be added to a known amount of the fluid, the mixture well shaken, filtered, and the filtrate tested in the usual way. Before using the charcoal, however, it is well to ascertain whether it is absolutely neutral, or whether it contains any matters soluble in water. To do this, some may be agitated with distilled water, filtered, and the reaction of the filtrate tested ; while another portion of the filtrate may be evaporated to dryness. In the first case, there should be no acid or alkali present; in the second, no solid residue remaining after evaporation.

The apparatus required for the estimation of the total acidity comprises a Mohr's burette, either simple or with a Shellbach's band. (The presence of this band is of advantage, as it obviates any difficulty, such as may be caused by the meniscus, in reading the figure on the burette corresponding to the level of the fluid.) The burette should be graduated to fifths of a cubic centimetre, and should be furnished with a stop-cock, or with a short india-rubber tube controlled by a clamp; a burette stand, preferably double, and two or three porcelain evaporating-basins to hold 50 c. c. and one to hold 100 c. c. are also necessary. White porcelain basins are preferable to glass beakers, as the pink colour of the end reaction shows up more clearly against the white ground than against the colourless glass. If beakers are preferred, a similar number of the same capacity should be provided, and when used, should be placed upon a sheet of white paper. In addition, an iron tripod covered with copper gauze and a spirit lamp, or, if possible, a Bunsen gas burner, are requisite.

When the ordinary burette is not in daily use, the soda solution is apt to leak out at the stop-cock, and to dry, in the form of carbonate of sodium, on that part of the burette, or at the extreme lower end. In such cases Kleinert's burette will be found to be very convenient. In this form of burette the stop-cock is at the upper end, while the lower end is more drawn out. To fill the burette the stop-cock is opened, the solution sucked up as far as necessary, and then the stop-cock is closed. The pressure of the air keeps the fluid in the burette, and the solution can be run out as usual by turning the stop-cock at the upper

end. After titration a well-greased glass plate is placed in contact with the lower opening, and supported in that position.

Practical Examples of the Estimation of Total Acidity.

Reagents required.—A deci-normal solution of caustic soda, of which 1 c.c. contains ·004 grm. of sodium hydrate; an alcoholic solution of phenol-phthalein—either two or four per cent.; a known quantity of the stomach contents which it is desired to test. 100, or 10, or 5 c.c. may be used. 10 c.c. will usually be found to be the most convenient quantity. The contents may be filtered or unfiltered.

As an example, the estimation of the total acidity of a specimen of stomach contents removed three hours after a meal, which consisted largely of proteids, will be instructive. 10 c.c. were tested before and after filtration. To each a few drops of phenol-phthalein were added, and the deci-normal solution of soda carefully dropped in. In the unfiltered specimen, 9·4 c.c. of the soda were added before the solution became permanently pink in colour, and 10·6 c.c. in the case of the filtered specimen. That is to say, the total acidity in the unfiltered was equal to 0·34 per cent. of hydrochloric acid, and in the unfiltered contents to 0·38 per cent.

Unfiltered—$(9{\cdot}4 \times {\cdot}00365) \times 10 = 0{\cdot}3431$
Filtered—$(10{\cdot}6 \times {\cdot}00365) \times 10 = 0{\cdot}3869$

The results may be expressed in terms of hydrochloric acid per cent. as above, or in the same terms of oxalic acid; or may be given, as Ewald has suggested, simply by the number of c.c. of the deci-normal solution of caustic soda required to neutralise 100 c.c. of the stomach contents. If expressed in Ewald's notation, the acidity of the unfiltered specimen would be represented by 94, of the filtered by 106. The acidity per cent. is calculated from the number of the c.c. of the soda solution used by multiplying it by the quantity of acid represented in each c.c. If 10 c.c. of the contents be originally used, the figure obtained represents the amount of acid in that quantity, and multiplying by 10 gives the percentage acidity.

The total acidity simply expresses the acidity value of the contents, and does not indicate in any way the component parts to which it is due.

Example II.

9 A.M. Breakfast, consisting of Benger's Food only.

11.15 A.M. Contents withdrawn. 10 c.c. tested unfiltered. 4·8 c.c. of the deci-normal soda solution used.

$(4{\cdot}8 \times {\cdot}00365) \times 10 = {\cdot}1752$ per cent. as HCl per cent.

Total acidity of specimen = ·1752 per cent. as HCl per cent.

Recorded by Ewald's notation = 48.

Example III.

From the same case as II., after treatment.

9 A.M. Breakfast—boiled fish, milk and water.

11 A.M. Contents withdrawn. 10 c.c. tested unfiltered.

9·3 c.c. $\frac{N}{10}$ NaHO used.

$(9{\cdot}3 \times {\cdot}00365) \times 10 = {\cdot}33945$.

Total acidity of specimen = ·339 per cent. as HCl.

Ewald's notation = 93.

If it is wished to record the acidity in terms of oxalic acid, the calculation in Example III. would be as follows :—

$(9{\cdot}3 \times {\cdot}0063) \times 10 = {\cdot}5859$ per cent. as oxalic acid.

Similarly in terms of sulphuric acid :—

$(9{\cdot}3 \times {\cdot}0049) \times 10 = {\cdot}4557$ per cent. as H_2SO_4.

2. Estimation of Free Acidity.

It is often of great importance to ascertain whether part of the total acidity is formed of free acids, volatile or non-volatile, mineral or organic. Numerous tests have been suggested for the qualitative detection of these free acids, and for their quantitative estimation.

Qualitative Tests for the Presence of Free Acids.

1. FREE ACID OF ANY KIND.—Three reagents are used to show the presence or absence of free acid of

any kind. The first, *Congo red*, is a bright red powder, which is changed to an equally bright blue in the presence of free acids, especially of free mineral acids, even in a dilution of 0·002 per cent. As, however, it is affected to some extent by free organic acids, it cannot be used satisfactorily for the accurate determination of the amount of free mineral acid present. The blue coloration caused by the presence of free hydrochloric acid differs slightly from that brought about by free organic acids, the latter causing a slightly more violet tinge. Acid salts do not affect it. The most convenient way to use Congo red is by means of Congo red papers, which are strips of filter paper dipped in a saturated watery solution of the dye and then dried. *Tropæolin*, OO, is an orange aniline dye (the *l'orange Poirier* of the French), which is only slightly soluble in water, but more soluble in a mixture of alcohol and water. Free mineral acids, as dilute as 0·025 per cent., give its solution a bright red-brown tinge, while organic acids turn it slightly red. Acid salts give it a straw yellow. If used by the simple addition of the stomach contents to its solution, no reliance can be placed upon its reaction as a means of detecting the presence of free hydrochloric acid. If, however, a small quantity of the tropæolin solution be evaporated at or below the body temperature, and, when dry, a drop of the stomach contents be added, should free hydrochloric acid be present a violet or purple tint will develop. It is said that free organic acids do not give this last reaction.

Benzo-purpurin, 6 *β*.—This aniline dye has been suggested by van Jaksch for the detection of free acids. Test papers made in the ordinary way may

be used. If free hydrochloric acid be present, the purple colour of the dye is turned dark blue and is not removed by ether. With organic acids the colour becomes much darker,—in fact, a brownish black, but it is removable by means of ether. A mixture of the mineral and organic acids gives a dark brown tint, only partly decolorised by ether.

Leo's Method.—Leo's method is performed in the following way :—A strip of blue litmus paper is dipped into the gastric contents and kept as a standard. Some of the contents are then put into the watch-glass, and a small quantity of absolutely pure calcium carbonate added. After stirring the solution with a glass rod, the reaction is tested with blue litmus paper and compared with the standard. If the litmus paper is no longer reddened the acidity is entirely due to free acids and not to acid salts. If the red colour is not so pronounced, both free and acid salts are present. If there is no change, free acids are absent, and the acidity is due to acid salts alone. If this procedure be undertaken after removal of the organic acids with ether, any free acid shown to be present must be hydrochloric acid. This, however, is by no means a trustworthy method, nor is it quantitative.

Methyl violet was long recommended as a trustworthy test, but it has been often shown that the reaction, which was looked upon as sure evidence of the presence of free hydrochloric acid, occurs with organic acids also. The addition of 0·024 per cent. of hydrochloric acid to a dilute solution of this dye changes the red-violet tint to a sky-blue.

The colouring matter of *Bordeaux Wine* and of

Bilberries has been similarly recommended by Uffelmann for free hydrochloric acid, but it is subject to the same fallacy as the last reagent.

Emerald, smaragd, or malachite green, probably the *vert brilliant* of Lêpine, changes from dark green to light green in the presence of free hydrochloric acid. It is not a very delicate reagent. The same may be said of fuchsin.

2. FREE HYDROCHLORIC ACID ALONE. — A second class of reagents are used for the detection of free hydrochloric acid.

Günzburg's Vanillin-Phloroglucin Test.—This test is one of the most accurate and delicate of those used at the present time for the detection of free mineral acid. It is made up as follows :—

Phloroglucin,	2 grm.	xxx grs.
Vanillin,	1 grm.	xv grs.
Alcohol,	30 c. c.	1 fl. ℥.

The solution has a slight yellowish colour. If a few drops of this reagent and an equal quantity of the stomach contents be evaporated to dryness in a capsule over a water-bath, or by cautious heating with a spirit-lamp, care being taken to avoid burning the contents, the presence of free mineral acid is shown by the development of a bright rose-red colour, caused by the formation of minute red crystals.

Organic acids, even in strong solution, do not give this reaction except in the case of tartaric acid, while hydrochloric acid combined with proteids causes no red coloration. The solution is capable of revealing the presence of free hydrochloric acid in a single drop of the stomach contents, even when as little as 0·01 per

cent. is present. It is quite sufficient to obtain a faint streak of red at the edge of the drying solution to be sure that free hydrochloric acid is present.

The Resorcin Test.—The solution used for this test contains 5 grm. of resorcin and 3 grm. of cane sugar in 100 c. c. of weak alcohol; recommended by Boas, it reacts in a similar way to Günzburg's, and has the advantage of being much cheaper, but is not quite so delicate. The colour struck by it is not so scarlet as in Günzburg's test, but is rather more of a pink tint.

Mohr's Sulpho-cyanide of Potassium Test. — For this test 2 c. c. of a 10 per cent. solution of sulpho-cyanide of potassium are added to 0·5 c. c. of a neutral solution of ferric acetate, which should be of a strength of from 4 to 5 per cent.; water is then added up to 20 c. c. If a solution containing free hydrochloric acid be brought in contact with Mohr's reagent, a peach-red colour appears at the point of junction of the two liquids, which soon becomes brown if the free hydrochloric acid present be concentrated. The response to this test is not so delicate as to either Günzburg's or Boas' reagents.

3. For Free Organic Acids.—The three reagents just mentioned are used to indicate the presence of free hydrochloric acid. To detect the organic acids which may be present in a free state:—

(1.) *Uffelmann's Reagent* may be made use of. The test solution, as recommended by him, is composed of—

Carbolic acid solution (1 in 20),	10 c. c.	℥ijss.
Distilled water,	20 c. c.	℥v.
Liquoris ferri perchloridi,	1 or 2 drops.	

On addition of the iron solution to the carbolic acid, a clear violet, or, as it has been termed, amethyst-blue colour is produced. The mixture should be diluted with water, if it is so dark that one cannot see through it when some of it is poured into a test-tube. A good rule is to dilute the mixture until it is about the colour of claret.

The proportions given above are not essential. In practice it is quite sufficient to add a drop or two of the perchloride of iron solution to a solution of carbolic acid of any strength, and to dilute the mixture with *distilled* water until the colour is as deep as that of claret. If the solution be kept made up for any length of time, it will soon be found to lose its characteristic colour and to react abnormally.

If a solution containing lactic acid be added to some of this reagent, the violet colour is changed to a canary-yellow when the acid is present in moderate quantity, or into a greenish-yellow if the amount be small. As little as 0·01 per cent. of lactic acid will serve to produce the reaction. Unfortunately lactic acid is seldom present alone in the stomach, and as other acids change the colour of the fluid in a different way, the result of the reaction may be very indefinite. Thus, free hydrochloric acid simply discharges the colour of the solution; when combined with proteid bodies it gives it a yellow-brown tint, which is very similar to that produced by acetic acid. Butyric acid discharges the colour from the solution, but generally gives it a greyish opalescent look. Both tartaric and citric acid give the same reaction as lactic. Free hydrochloric acid, therefore, simply discharges the

colour, lactic acid causes it to become a bright canary yellow, acetic and combined hydrochloric acid give a yellowish brown, and butyric acid a greyish opalescent appearance to the solution.

(2.) Another reaction which may be used to identify lactic acid, and which is rather more delicate than Uffelmann's, is brought about by adding one or two drops of a dilute solution of perchloride of iron to 50 c. c. of distilled water. When lactic acid is added to this, even in very dilute proportions, the solution, which is almost colourless, develops a light yellow tint. The three acids mentioned above do not give this reaction. A few drops of the stomach contents dropped into the iron solution cause the same change of colour, should lactic acid be present.

In the two last tests the presence of alcohol, sugar, or phosphates may cause a similar yellow colour to that produced by lactic acid.

(3.) Boas has introduced a more complicated test for the presence of lactic acid, in which a certain quantity of the stomach contents is shaken up with a large excess of sulphuric ether. The ether used should be five times the amount of the stomach contents. The ether extract is decanted off, and contains the most of the lactic acid dissolved in it; after evaporating the ether, the residue is dissolved in water, and heated in a porcelain basin with sulphuric acid and peroxide of manganese. Any lactic acid which may be present is decomposed into formic and acetic aldehyde. If a drop of a solution of iodine be added to this, iodoform forms, and can be easily recognised by its peculiar smell. Such an ethereal extract will contain both butyric and acetic acids if these acids

are present in the stomach contents, and they may be identified by their characteristic odours; or, in the case of acetic acid, if after neutralising the ether extract with carbonate of soda a few drops of a neutral solution of ferric perchloride be added, by the bright red colour produced.

If the stomach contents have a pronounced yellow colour, which would obscure the reaction obtained with Uffelmann's reagent, or if the three organic acids are present together, an easy method of detecting the presence of lactic acid is to evaporate a large quantity of the stomach contents, say 50 or 100 c. c., down to 10 c. c., in an evaporating basin over a water-bath. Allow the residue to cool, and add 50 c. c. of ether. As acetic and butyric acids are volatile, they are driven off during concentration on the bath; the ether dissolves out the lactic acid and leaves the hydrochloric acid in the residue. The ether extract is then evaporated to dryness as before, and the same tests applied.

(4.) To ascertain more particularly the presence of the two volatile organic acids the filtered stomach contents are distilled. Three-fourths of the liquid should be driven off, and, as lactic acid is not volatile, and as free hydrochloric acid only volatilises when there is little or no water left, the two volatile organic acids are obtained in a pure state in the receiver. Butyric acid can be recognised by its peculiar smell, like that of rancid butter, or, by heating it with a small quantity of alcohol and a drop or two of strong sulphuric acid, by the formation of butyric ether, which gives off an odour resembling that of pine-apple rum. Similarly, acetic ether may be

formed from acetic acid, affording a peculiar but agreeable odour. Or it can be recognised by the reaction which follows the addition of a few drops of the perchloride of iron. Acetates also can be identified in the contents by means of the cacodyl reaction; that is, if caustic potash and a little arsenious acid be added to the solution and the mixture evaporated, a nauseous, penetrating odour develops. The amounts present of the two volatile organic acids may be calculated by titration of the distillate in the usual way, and knowing the total acidity of the stomach contents beforehand, subtraction of the figure thus obtained will give the acidity due to lactic and hydrochloric acid in the remainder.

Strauss* suggests that the test for lactic acid with dilute perchloride of iron should be performed as follows:—Exactly the same amount of the gastric contents should be taken, and the same amount of ether used on each occasion. The residue left on evaporating the ether is diluted with water to the same degree at each examination, and two drops of a solution of one part of liquor ferri perchloridi to nine of water added. The test performed in this way is very delicate, and the depth of tint developed may serve as an indication of the quantity of acid originally present.

* *Berliner klin. Wochenschrift*, 1895, No. 37.

CHAPTER V.

THE EXAMINATION OF THE FLUID REMOVED FROM THE STOMACH, OR OF THE VOMIT—(Continued).

3. The Quantitative Estimation of the different Factors which go to make up the Total Acidity.

For Free Hydrochloric Acid only—Mintz's Method—Hydrochloric Acid, free and combined with Proteids—Sjöqvist's Method—For all the Acids Present—Cahn and von Mering—Mintz-Boas—Hayem and Winter—Toepfer—Martius and Lüttke—The Author's Modification of Hayem and Winter's Method—For the Organic Acids—Methods used less frequently—Contejean—Hoffmann—Braun—Mierzynski—Table of Methods.

IN the preceding chapters the methods described apply only to the individual conditions under which the different acids are found. To obtain the greatest amount of information concerning the chemistry of the stomach contents, we must make use of methods which will indicate both the acids present and the chemical forms in which they exist. Unfortunately, owing to the complexity of the subject, most of these methods are so complicated, and, as a rule, so difficult, that they are out of the reach of any one unskilled in chemical analysis, or unprovided with the somewhat large amount of apparatus necessary. As the practitioner, as a rule, has little time on his hands, and as most of the methods involve lengthy pro-

cesses, if they are to be conscientiously and accurately performed, the majority of them are impossible in general practice.

The different acid factors which require quantitative investigation are — 1, The total acidity; 2, the constituents of that acidity; 3, the presence of free hydrochloric acid; 4, the portion of hydrochloric acid combined with proteid bodies; 5, the presence of volatile and non-volatile organic acids; and, 6, the acidity due to acid salts.

The estimation of the total acidity and the consideration of the tests for the individual acids have already been dealt with.

1. The Quantitative Estimation of Free Hydrochloric Acid.

Mintz's Method.—Mintz has recommended the use of Günzburg's reagent (*cf.* p. 41) for the quantitative estimation of free hydrochloric acid.

A deci-normal solution of caustic soda is added from a burette to 10 c.c. of the stomach contents, either filtered or unfiltered, until the red coloration disappears which forms on evaporating a drop of the solution with vanillin-phloroglucin.

The quantity of soda added is regarded as equivalent to the amount of free hydrochloric acid present. Mintz has demonstrated that when hydrochloric acid is present both in a free state and combined with proteids, the alkali combines first with the free acid. The exact point at which the red coloration with Günzburg's reagent disappears is noted, and the amount of the soda solution used represents the quantity of free hydrochloric acid in the solution.

Example :—

1. Tested by Evaporation Method (*cf.* p. 74).

Stomach contents removed four hours after food—meat and jelly, with a tumbler of milk. Contents yellowish white, full of small débris, slight gastric odour.

Total acidity (tested unfiltered, with deci-normal soda and phenol-phthalein), ...	0·3723 per cent., or 102.
Acidity combined with proteids and in acid salts (after evaporation at 100° C.), ...	0·3358 per cent., or 92.
Leaving as free acidity . . .	0·0365 per cent., or 10.

The free acid present consisted entirely of hydrochloric acid; no organic acids were present.

2. The Same Tested with the Vanillin-Phloroglucin Reagent.

Deci-normal solution of soda was added to 10 c. c. of the contents, and after every two drops the fluid was tested with Günzburg's reagent. A negative reaction occurred when 1 c. c. had been added. The free hydrochloric acid, therefore, was ·0365 per cent., corresponding exactly to the figure obtained by the evaporation method.

In performing this test I have found it very convenient to dry several c. c. of Günzburg's solution on the surface of a flat-bottomed evaporating basin, and, after the addition of every two or three drops of the soda, to place a drop of the contents in sequence on the surface of the basin by means of a glass rod. The basin is then warmed over a flame or kept on a water bath. After the addition of each drop or two drops of the soda to the mixture the amount run from the burette is noted, and a drop of the mixture placed in regular order on the dried reagent in the basin.

The exact point at which the free hydrochloric acid has been completely neutralised can then be easily determined, and by reference to the amount of soda used corresponding to the first absence of the red reaction in the basin, the equivalent amount of free acid present can be estimated.

This method is very easy and does not take up much time. It appears to be accurate when the contents contain only hydrochloric acid, either free or combined with proteids. The presence of free organic acid vitiates the result. Thus, if a solution is made of hydrochloric acid and water, and the amount of free hydrochloric acid present estimated by this method in one portion, and then if a small quantity of acetic or lactic acid is added to a similar quantity of the same solution, the amount of free hydrochloric acid registered exceeds that known to be present in the original watery solution. Some of the alkali added combines with the organic acids, although, as it has a greater affinity for free hydrochloric acid, the amount is not great.

The soda does not appear to act on the hydrochloric acid combined with proteids until all the free acid has been neutralised.

This process can be reversed in cases in which there is no free hydrochloric acid present, and used for the estimation of the amount of hydrochloric acid which it is necessary to add before the affinities of all the proteids, still incompletely combined with the acid, and of the organic salts present, are fully satisfied. For this purpose a deci-normal solution of hydrochloric acid is run into 10 c. c. of the contents, drop by drop, until the reaction with vanillin-phloroglucin

is positive. The amount of the deci-normal solution added represents the quantity necessary to satisfy the requirements of the proteids and organic salts of the fluid, so as to allow of the presence of a trace of free hydrochloric acid. As the combination of the acid with proteids is not an instantaneous process, it is as well to allow the solution to stand for half an hour or so, after the first positive result has been obtained, and then again to test it. Usually a further small addition of the acid will be found to be required.

Example.

Gastric Contents; unfiltered; removed two hours after a light breakfast—little odour; watery; digestion weak; no fermentation.

Total acidity—10 c.c. = 4 c.c. NaHO $\frac{N}{10}$ = 0·146 per cent. (or 40).

Free hydrochloric acid absent.

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10 c.c. taken, and deci-normal hydrochloric acid added.

Günzburg's reagent gave a positive reaction after 1·5 c.c. were added, or 0·05475 per cent. (15). That is to say, that before free hydrochloric acid could appear in this sample of stomach contents, 0·0547 per cent. of hydrochloric acid required to be added to it, making a total acidity of 0·2007 per cent. The positive reaction first appeared after 1·3 c.c., but on allowing the solution to stand for fifteen minutes, it could not be obtained until 0·2 c.c. additional was run in.

2. The Estimation of Hydrochloric Acid, free and combined with Proteids.

The Method of Sjöqvist.—Sjöqvist's * method con-

* *Zeitschrift für Phys. Chemie*, vol. xiv., p. 1.

sists in evaporating a certain quantity of the stomach contents to dryness after the addition of barium carbonate, care being taken not to add an excess of this salt. It is then incinerated. In the ash the chlorine is present as chloride of barium, while any organic barium salts, which may have been formed, are converted by incineration into carbonate of barium. As carbonate of barium is insoluble in hot water, while chloride of barium, on the other hand, is soluble in it, the two salts can be separated from one another by washing the ash with hot water. Thus 10 c. c. of the stomach contents, filtered or unfiltered, are mixed with about 0·05 grm. of carbonate of barium in a platinum, or nickel, capsule, evaporated to dryness, and then reduced to ash. After cooling, the soluble salts are dissolved in 50 to 75 c. c. of boiling water, the insoluble remainder being separated by filtration. The solution which has passed through the filter paper contains all the barium chloride formed from the hydrochloric acid in the 10 c. c. of the stomach contents. As first described by Sjöqvist, the barium chloride is converted into the carbonate by the addition of caustic soda, and as the carbonate is insoluble in water it is thrown down as a flocculent precipitate. The mixture is again filtered. The precipitate of barium carbonate on the filter paper is collected and washed, dissolved in hydrochloric acid, and evaporated to dryness.

A modification of the method has been proposed by van Jaksch,* in which the chloride of barium in the first filtrate from 10 c. c. of the stomach contents is converted into sulphate of barium by the addition

* *Monatshefte für Chemie*, vol. x., 1889, p. 211.

of pure sulphuric acid; the sulphate is then caught on an ash-free filter paper, dried, ashed, and weighed. The amount of sulphate of barium obtained multiplied by 0·3132 gives the amount of HCl present in 10 c.c. of the contents. In the original method, after dissolving the barium carbonate in hydrochloric acid and evaporating it to dryness, the ultimate residue obtained is again dissolved in water and titrated with a silver nitrate solution. As the residue consists solely of chloride of barium, the quantity of standard silver solution used before the end reaction with chromate of potash is reached, corresponds to the chlorine present. 1 c.c. of the silver solution represents 0·001 grm. chloride of sodium, and the amount of hydrochloric acid present may be calculated by multiplying the number of cubic centimetres of the silver solution used by 36·5 (HCl) and dividing by 58·5 (NaCl). The figure obtained represents the quantity of hydrochloric acid in 10 c.c. of the stomach contents. Sjöqvist has, however, modified* his method during the last year or so. He changes the barium chloride extracted from the ash into barium chromate by adding ammonium chromate. The barium chromate thus formed is insoluble in acetic acid, and can readily be freed from the ammonium chloride which is formed. The chromic acid present is estimated by the addition of hydrochloric acid and iodide of potassium.

$$2\ BaCrO_4 + 16\ HCl + 6\ KI = 2\ BaCl_2 + Cr_2Cl_6 + 8\ H_2O + 6\ KCl + 3\ I_2.$$

These reagents form chloride of barium, chloride of

* *Skand. Arch. f. Phys.* v., 4/6, s. 277.

potassium, chloride of chromium, and free iodine from the chromate of barium. The free iodine is titrated with standard hyposulphite of sodium solution.

Still another modification of the process has been suggested by Salkowski,* who converts the sulphate of barium formed in van Jaksch's method into chloride of barium by the addition of hydrochloric acid, and titrates this, as in the original method, with nitrate of silver and chromate of potash.

This method, either in its original form or any of its modifications, is theoretically a very perfect one, but requires experience and facilities which are seldom within the reach of the ordinary practitioner. It takes no note, moreover, of the quantity of hydrochloric acid combined with albuminous bodies, and Martius and Lüttke have found that, when free hydrochloric acid is present in small quantity and the combined acid in a greater proportion, the results obtained by the method are frequently much below the truth. The results simply indicate the total chlorine present in the stomach contents in the form of hydrochloric acid, free or combined with proteids. No indication is given of the amount of acidity due to organic acids or acid salts.

During the process of incineration of the residue after evaporation of the fluid mixed with barium carbonate, some of the barium salt may be reduced to the hydrate, which is partly soluble in hot water.

To ascertain its presence a drop of phenol-phthalein is added. If a pink colour develops, the filtrate is alkaline, owing to the presence of barium hydrate. Air should be blown through the fluid through a glass

* *Virch. Arch*, Bd. 73, s. 292.

tube, or a stream of carbonic acid gas passed through it, until it is colourless again. It is then refiltered.

Example of Sjöqvist's Method, as modified by van Jaksch.

STOMACH CONTENTS, *Filtered and Unfiltered.*

Two hours after a light meal of proteids and bread, from a case of Hyperchlorhydria.

Contents have no smell, save slightly "gastric." Unfiltered, are full of small brown-grey débris; filtered, are clear and almost colourless.

Total acidity—Unfiltered, 0·3942 per cent., or 108.
Filtered, 0·365 per cent., or 100.
Total Chlorine—Unfiltered, 0·4469 per cent.
($AgNO_3$ and K_2CrO_4)
Filtered, 0·4742 per cent.
No organic acids were present.

Some carbonate of barium, previously found to be chlorine-free, was added to 10 c.c. both of the unfiltered and filtered contents in two crucibles, dried over a water bath, and incinerated over a naked flame.

After cooling, the ash was washed out of the crucibles with hot distilled water on to filter papers, and further washed until the filtrate reached an amount of about 100 c.c. Excess of dilute pure sulphuric acid was then added to each filtrate, and the resulting precipitate caught on ash-free filter papers, washed with distilled water, and dried. The papers were then incinerated in porcelain crucibles of known weight, and the weight of the ash determined.

	Weight of Barium Sulphate in 10 c.c.	Hydrochloric acid per cent.
Unfiltered,	0·121 × 0·3132 = 0·03789 grm. HCl.	0·3789
Filtered,	0·130 × 0·3132 = 0·04071 grm. HCl.	0·4071

That is to say, of the total chlorine in the unfiltered contents, 0·4469 per cent., Sjöqvist's method gives 0·3789 per cent. as in

the form of hydrochloric acid, leaving 0·068 per cent. as inorganic salt; and in the filtered, of the 0·4742 per cent. total, 0·4071 per cent. consists of hydrochloric acid, and 0·0671 per cent. of chlorine in an inorganic form.

Estimation of the inorganic chlorine after simple incineration at a dull red heat gave 0·1368 per cent. for the unfiltered, and 0·173 per cent. in the filtered contents. The results of Sjöqvist's method gave, therefore, what appears to be too high values for the hydrochloric acid present.

3. The Estimation of all the Acids present in the Stomach Contents.

(*a.*) *The Method of Cahn and von Mering.*—This method aims at the exact determination of the total hydrochloric acid, the volatile acids, and the lactic acid of the stomach contents. Fifty c. c. of the contents after filtration are distilled over a naked flame until three-fourths of the liquid have gone over. The residue in the retort is again made up with distilled water to 50 c. c., and re-distilled until three-fourths have a second time passed over into the receiver. The distillate contains all the volatile organic acids, and, if it be titrated with a deci-normal solution of soda, their proportion in the 50 c. c. can be determined. The residue in the retort or flask is shaken up with 500 c. c. of pure ether, and the ether decanted off. This procedure is repeated six times. The total ether decanted off on the six occasions is mixed together, evaporated, and the residue titrated with soda in the usual way. The figure obtained represents the quantity of lactic acid originally present in 50 c. c. of the filtered stomach contents. To the concentrated remainder in the retort after the removal of the ether, a quantity of freshly precipitated cinchonin is added to

excess, until the reaction becomes neutral. The mixture is then washed into a separating funnel with chloroform, and shaken four or five times with fresh quantities of chloroform. The chloroform solutions, separated from the stomach contents, are distilled, the chloroform driven off, and the residue remaining is dissolved in water acidified with pure nitric acid. The chlorine present in it is then precipitated with an excess of silver nitrate. The chloride of silver which forms is weighed in the usual way, the amount of the silver salt obtained being reduced to terms of hydrochloric acid by multiplying its weight by 0·25427.

This method is costly, complex, and difficult, while the large amounts of ether used to take up the lactic acid remove a considerable proportion of the hydrochloric acid present. No notice is taken in the method of the hydrochloric acid combined with proteids. For these reasons the method cannot be recommended.

(*b.*) *The Mintz-Boas' Method.*—Boas has modified the method as recommended by Mintz by removing the organic acids present in the contents with ether, decanting the ether, and estimating the presence of free hydrochloric acid in the residue by adding a deci-normal soda solution until Congo red paper no longer responds to its action—that is, until it is no longer blued. It is by no means certain that ether removes all the organic acids present, while Congo red is not a satisfactory indicator. The usual quantity of ether which is recommended to be used is 100 c. c. to 10 c. c. of the stomach contents. As much more ether is necessary to extract all the organic acids,

the process is rendered very expensive, while the large quantity of ether required allows some of the mineral acid to be removed in it.

Example of the Mintz-Boas' Method.

Contents from a dilated stomach. Large amount—1950 c. c. Sour smell; fermenting scum on surface on standing; deposit of grey-brown débris at the foot; gas bubbles forming.

Filtered. Filtrate slow in passing through paper, greyish opalescent in colour.

Total acidity, 10 c. c., 10·6 c. c. $\frac{N}{10}$ soda added = 0·3869 per cent., or 106.

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10 c. c. shaken up with 100 c. c. of ether, placed in a separating funnel, and the lower watery layer removed.

To this deci-normal soda solution was added, and the fluid tested with Congo red paper. 3 c. c. were required to be added before the paper failed to respond, though the colour shown by it was violet-blue throughout. (Phloroglucin-vanillin gave no reaction from the commencement.) The 10 c. c. were again shaken up with 100 c. c. of fresh ether, the ether removed, and the process repeated three times in all.

The watery remainder still changed the colour of Congo red slightly—*i.e.*, to a light violet.

The acidity of this remainder, tested with phenol-phthalein, was equal to 6·5 c. c. of $\frac{N}{10}$ soda solution, 0·237 per cent., or 65, giving 0·1499 per cent. removed by the ether.

From other analyses, this specimen was found to contain no free hydrochloric acid, 0·2319 per cent. of hydrochloric acid combined with proteids, 0·0219 per cent. of free acid, due to acetic acid, and 0·1331 per cent. of lactic acid. The sum, therefore, of the organic acids—0·155 per cent.—exceeded the quantity removed by the 300 c. c. of ether by 0·0051 per cent.

(*c.*) *The Process of Hayem and Winter.* — The method of Hayem and Winter* is based upon an altogether different foundation. It depends chiefly upon the fact that a solution of hydrochloric acid in water, or added to a solution of carbohydrate or extractive bodies, volatilises completely when the mixture is dried at the boiling point. On the other hand, if the solution to which the hydrochloric acid has been added contains any proteid bodies, evaporation to dryness at 100° C. does not suffice to drive off all the hydrochloric acid, as that part of it which has entered into loose chemical combination with the proteid remains behind. They also state that the only factor capable of accurate determination, among those to which the acid reaction of the stomach contents is due, is the chlorine. If the total acidity be known, and the exact amount of chlorine present be estimated both as hydrochloric acid, free or combined with proteids, and as inorganic salt, the proportion of the chlorine in the form of hydrochloric acid subtracted from the total acidity will indicate the proportion of acidity unconnected with this acid. Thus, they proceed to investigate the forms in which the chlorine in the stomach contents is present as follows :—

Measure out 5 c.c. of the filtered contents into three crucibles, which we may term A, B, and C. To A an excess of pure carbonate of sodium is added, so as to convert all the chlorine present into chloride of sodium. The three crucibles are then dried on a water-bath at 100° C., and are allowed to remain there for at least one hour after their contents have been rendered thoroughly dry. (If there is much proteid

* *Du Chimisme Stomacale*, Paris, 1891.

matter in the contents and an excess of free hydrochloric acid, the contents of capsule B should be re-dissolved, after drying, in distilled water, again dried, and the manœuvre repeated as long as a drop of the contents, after adding water, causes a red coloration when tested with vanillin-phloroglucin.)

The dried contents of capsule B are then dissolved in a small quantity of distilled water, an excess of the carbonate of soda added, and the mixture again dried. In the first capsule, capsule A, the total chlorine is in the form of inorganic salts; in capsule B we have the chlorine, which has been left after evaporation to dryness at 100° C. in an inorganic form; while capsule C contains simply the dried contents. Each of the three capsules is now heated over a naked flame until all the organic matter in their contents has been burned off. The heat employed should not be too great; a dull red heat is all that is required, for chlorides are easily driven off at a higher temperature. After incineration, when the crucibles have cooled down, a slight excess of pure nitric acid is added, along with some distilled water. The crucibles are then heated again until their contents reach the boiling point, to drive off carbonic acid. To each solution carbonate of calcium or of sodium is now added up to the neutral point, or to a point slightly beyond it. The contents of the crucibles are then thrown on filter papers and the residue washed with boiling water. The filtrates are tested with a deci-normal solution of nitrate of silver (17 grm. to the litre), in the presence of neutral chromate of potassium. The number of cubic centimetres of the silver solution used in capsule A indicates the total quantity of

chlorine originally present in 5 c. c. of the stomach contents. Similarly, the number of cubic centimetres used in capsule B represents the amount of chlorine remaining after evaporation to dryness—*i.e.*, in the inorganic chlorides and the hydrochloric acid combined with proteids. Capsule C, which has been ignited without the addition of any soda, gives the amount of the inorganic chlorides in 5 c. c. of the stomach contents. The chlorine is rendered in terms of HCl per cent.

The authors also estimate the total acidity in the usual way with phenol-phthalein and soda, and thus obtain a fourth factor. In this way the value for the total chlorine may be obtained, and if the figure pertaining to the capsule B be subtracted from that of the total chlorine—*i.e.*, that in capsule A—the amount of free hydrochloric acid may be calculated. Similarly, by subtracting the result of the titration in capsule C from that of capsule B, the hydrochloric acid combined with proteids, the value for the combined hydrochloric acid, may be ascertained. The values of the free and the combined acid can then be compared with the total acidity previously estimated; if their sum is equal to or above it, no organic acid can be present. But if the total acidity exceeds the figure obtained by the sum of the chlorine, free and combined, organic acid or acid salts must also be present in the contents. The figure obtained in capsule B may often include bodies such as chloride of ammonium, which are driven off by incineration, but not altogether driven off at 100° C., and thus increase the figure obtained for the combined chlorine.

The method is, unfortunately, long, and the manipulations required difficult of accomplishment save by a trained chemist. It has been adversely criticised by many, while others have recommended it warmly. Biernacki * remarks that it gives correct results when used in artificial digestion experiments, but that the figures obtained in the case of the stomach contents are not to be absolutely relied on, especially because of the presence of acid phosphates. Rosenheim † and Langermann ‡ find that the free hydrochloric acid in the stomach contents is represented as too small in amount by it. Hoffmann § condemns all methods for the estimation of free hydrochloric acid by evaporation as liable to fallacy.

Three facts, however, can be absolutely determined by the figures obtained from the method of Hayem and Winter. First, the total quantity of hydrochloric acid, both free and combined, can be accurately deduced from the chlorine determinations in the first and third capsules. That is to say, that the chlorine originally present in an inorganic form subtracted from the total chlorine will give the exact figure for the chlorine which is not present in an inorganic form. Again, the figure for the total hydrochloric acid subtracted from the total acidity will represent without error, unless ammonium chloride be present, the proportion of the acidity which is or is not due to it. The two doubtful values are, that of the free hydrochloric acid $(a - b)$ and that of the com-

* *Centralblatt für Klinische Medizin*, No. 20.

† *Deutsche Medizinische Wochenschrift*, Nos. 13, 14, 1891.

‡ Virchow's *Archiv*, Bd. 128.

§ Schmidt's *Jahrbuch*, Bd. 233, s. 268.

bined hydrochloric acid ($b - c$), although the sum of the two may be correct.

A combination of this method and the method recommended by Mintz yields good results. By means of the process of Hayem and Winter the absolute amount of chlorine, which is not in the form of inorganic compounds, is determined, and then, by the use of Mintz's method, the amount of free hydrochloric acid is ascertained. The difference between the two values will give the figure for the free acid.

Hayem and Winter designate the result of titration with soda solution, that is the total acidity, by the letter A ; the total chlorine, "chlore total," by T ; the difference between the chlorine in crucibles A and B, the free chlorine, "chlore libre," by H ; the chlorine remaining in crucible C after simple incineration, the inorganic chlorine, "chlore fixe," by F ; and the excess of chlorine in crucible B over that in C the chlorine combined with proteids, "chlore combiné organique," by C. Another symbol which they make use of is a,

$$a = \left(\frac{A - H}{C}\right).$$

The symbol a, therefore, represents the quotient obtained by dividing the figure for the total acidity, minus that for free hydrochloric acid, by the amount of combined chlorine. If no organic acids are present, or acid salts, a should have a value of 1. Normally it varies between 0·8 and 0·92.

The presence of the organic acids of fermentation and of an excess of acid salts raises the value of A, and thus a may correspond to a value above the figure 1.

Example of Hayem and Winter's Method.

Sample of stomach contents removed two hours after Benger's Food, in a case of gastrostomy for occlusion of the œsophagus.

Contents (slight gastric smell) were in a well-digested form.

After filtering, 5 c. c. were placed in three crucibles—*a*, *b*, and *c*. To *a* sodium carbonate was added in excess. The three crucibles were then heated on a water-bath until an hour had elapsed after their apparent thorough drying.

Deci-normal sodium hydrate solution and a drop of phenolphthalein was added to another 5 c. c.

Total acidity = 6·5 c. c. $NaHO\frac{N}{10}$, or 0·4745 per cent. or 130.

The dried contents of crucible *b* were dissolved in a little distilled water, carbonate of soda added, and the solution dried again as before.

The contents of *a*, *b*, and *c* were now ignited over a naked flame at a dull red heat, the resulting ash dissolved in water, rendered slightly acid with nitric acid, heated to expel carbonic acid, and filtered.

The filtrates were titrated with deci-normal nitrate of silver solution, and chromate of potassium.

a. Total chlorine,	. 6·6 c. c.	$AgNO_3\frac{N}{10}$,	or 0·4818	per cent.
b. Chlorine after evaporation,	. 6·0 c. c.	,,	or 0·4380	,,
c. Inorganic chlorine,	. 1·6 c. c.	,,	or 0·1168	,,

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1. Total acidity,	0·4745 per cent. or 130	= A
2. Total chlorine (*a*),	0·4818 ,,	= T
3. Free chlorine (*a*—*b*)	0·0438 ,,	= H
4. Fixed chlorine (*c*)	0·1168 ,,	= F
5. Combined chlorine (*b*—*c*)	0·3212 ,,	= C
6. Acidity not due to chlorine (1 − 3 + 5),	0·1095 or 30.	

$$a = \left(\frac{A-H}{C}\right) = \frac{0{\cdot}4745-0{\cdot}0438}{0{\cdot}3212} = 1{\cdot}34.$$

The figures obtained show practically normal amounts of chlorine, and a high total acidity, much of it not due to hydrochloric acid. This circumstance is explained by the fact that the patient at the time was taking dilute phosphoric acid after her food.

(*d.*) *Toepfer's Method.*—A method has been described by Toepfer* which is easily performed, and is said to be fairly accurate. Toepfer first estimates the total acidity by means of phenol-phthalein and a deci-normal solution of soda in the usual way.† He then uses a 1 per cent. solution of sodium-alizarin-sulphonate in water. This body is stated to be unaffected by hydrochloric acid in combination with proteid. A third indicator is also used, 0·5 per cent. solution of dimethyl-amido-azo-benzol in alcohol, which reacts to free mineral acids, and is not affected by organic acids, unless present in greater proportion than 0·5 per cent. The second reagent is termed for brevity alizarin, and is used in a similar manner to phenol-phthalein, deci-normal soda being added until a permanent pure violet colour results. This tint should be compared with that formed on the addition of 3 or 4 drops of the alizarin solution to 5 c. c. of a 1 per cent. solution of sodium carbonate. The third indicator, or dimethyl, has a yellow colour if no free hydrochloric acid be present, red if there be some in the contents. The deci-normal solution is added until this red colour disappears. By this method we obtain, first, the total acidity; second, with the alizarin, the acidity minus the combined hydrochloric acid. No. 2 subtracted from No. 1 gives the amount of combined hydrochloric acid present.

* *Zeitschr. f. Phys. Chemie*, Bd. xix., pp. 104-222.

† But see p. 68.

The amount of soda used in titrating No. 3 gives the free hydrochloric acid. Adding the figures obtained for the combined and the free hydrochloric acid will give the total proportion of that acid present; and subtracting that from the total acidity will give the acidity due to organic acids and acid salts.

The advantages of this method are, that it takes up a short time and requires no complicated apparatus, the addition of the soda solution to equal parts of the contents after the addition of the three indicators being all that is necessary. With regard to Toepfer's method, Mohr * states that good results may be obtained after the operator has had some practice with it, but that at first it is difficult to decide the exact point at which the end reactions occur. There is a danger, to his mind, of the quantity of free hydrochloric acid found being too high.

Hoppe-Seyler † recommends it, while Strauss ‡ remarks that the end reaction with the dimethyl is determined with difficulty.

Hari, § discussing it, is not quite sure if the alizarin is to be absolutely depended upon for the estimation of the combined hydrochloric acid, while he recommends the portion to which this indicator has been added to be shaken thoroughly until the violet colour produced by the alkali has disappeared, when a thin layer of the fluid is looked through. Dimethyl-amido-azo-benzol appears to be ten times more delicate than Günzburg's reagent and than Congo red, in the

* *Zeitschrift f. Phys. Chemie*, Bd. xix., No. 6, p. 647.
† *Münchener Med. Wochenschrift*, l., 1895.
‡ *Deutsche Arch. f. klin. Med.*, lvi., p. 1, 287.
§ *Archiv f. Verdauungskrankheiten*, Bd. ii., Heft 2.

detection of free hydrochloric acid, and twenty times more delicate than Congo red with regard to organic acids.

The experience of this method which the writer has had does not lead him to recommend it as being very accurate. The presence of free organic acids along with free hydrochloric acid causes the dimethyl to record too high a figure, in the same way as Günzburg's reagent; while he cannot accept it as proved that it is entirely uninfluenced by hydrochloric acid in proteid combinations. Artificial mixtures of albumin with a very small portion of hydrochloric acid, which did not lose acidity on drying, and in which both Günzburg's and Liebermann's tests were negative, coloured the dimethyl solution pink or orange, and, if this reagent be accurate, contained some free mineral acid. It is so delicate, as regards free hydrochloric acid, that it is almost certain that it must react in some degree to that acid in its combined form.

Its end reaction is also difficult to determine with certainty. If a drop be added to 5 c. c. of deci-normal hydrochloric acid solution, and an exactly corresponding amount of deci-normal solution of soda added, before the acid has been neutralised, the bright red colour changes to orange, then to brownish yellow, becoming light yellow on exact neutralisation. This light yellow tint must, therefore, be reached in titrating specimens of stomach contents before the absence of free hydrochloric acid is certain. But the orange colour mentioned above seems to be given to the dye by dilute organic acids, and by combined hydrochloric acid.

Sodium-alizarin-sulphonate is supposed to be un-

affected by this combined hydrochloric acid, while reacting to all other acid bodies. When tested in the same way as dimethyl, its colour, greenish yellow in the presence of acids, became violet at the point of neutralisation, using deci-normal solutions of hydrochloric acid and soda. With excess of proteid, the violet colour did not appear until a considerable quantity of alkali was added, more than was represented by any acid salts in the albumin solution, or free acid as shown by dimethyl.

Toepfer recommends that the titration with phenol-phthalein and deci-normal soda should be carried on until the colour produced is not deepened by further addition, instead of regarding the first permanent pink tinge as the end reaction. Equal quantities of acid and alkaline deci-normal solutions when mixed together produce no coloration of phenol-phthalein, a trace of the soda in excess causes a permanent pink, the depth of which varies greatly with the quantity added. A dark red only appears when the fluid is of considerable alkalinity,while excess of the indicator yields a permanent degree of redness where the usual smaller quantity only gives a pink, capable of further intensification.

Example of Toepfer's Method.

Contents removed from a case of slight excess of hydrochloric acid, two hours after a light meal. Have no smell, fluid clear, food well digested. Used unfiltered.

1. *Total acidity.*

10 c. c. titrated with deci-normal soda and phenol-phthalein.

8·1 c. c. used until solution became pink—

$8{\cdot}1 \times 0{\cdot}00365 = 0{\cdot}295$ per cent., or 81.

8·5 c. c. used until solution became red—

$8{\cdot}5 \times 0{\cdot}00365 = 0{\cdot}310$ per cent., or 85.

2. *Free hydrochloric acid.*

10 c. c. titrated with deci-normal soda and 2 drops of 0·5 per cent. alcoholic solution of dimethyl-amido-azo-benzol.

4·6 c. c. added when solution became orange—
=0·1679 per cent., or 46.

5·1 c. c. added when solution became light yellow—
=0·1861 per cent., or 51.

3. *Acidity* minus *that due to combined hydrochloric acid.*

10 c. c. and 3 drops of the watery solution of alizarin-sodium-sulphonate : titrated as above.

7·8 c. c. used before solution became violet and corresponded to tint of the indicator in a 3 per cent. solution of sodium carbonate—

7·3 c. c. × 0·00365 = 0·2847 per cent., or 78.

Result.

Total acidity	0·295 per cent., or 81 0·310 ,, ,, 85	(1)	
Free HCl	0·1679 ,, ,, 46 0·1861 ,, ,, 51	(2)	
Combined HCl	0·0103 ,, ,, 3 0·0255 ,, ,, 7	(1–3)	
Organic acids and acid salts	0·1168 ,, ,, 32 0·0985 ,, ,, 27	1–[2+(1–3)]	
Total hydrochloric acid, free and combined	0·1782 per cent., or 49 0·2116 ,, ,, 58	[2—(1–3)]	

Phloroglucin-vanillin gave the free HCl as only 0·09 per cent.

(*e.*) *Martius and Lüttke's Method.*—This method is based upon the theory that, when the gastric contents are ignited at a low heat, below the point at which chlorides volatilise, the hydrochloric acid present is driven off, leaving the chlorine which is in combination with bases. It, in fact, rests upon the same proposi-

tion which Hayem and Winter have advanced for part of their process. The only difference lies in the fact that the dried contents are not subjected to so high a temperature. Indeed, the method has been elaborated for the purpose of estimating the chlorine present without destroying the organic substances which are contained in the fluid tested.

Reagents required (Volhard's Method).

1. A deci-normal silver solution, containing nitric acid and persulphate of iron.

This solution is made by dissolving 16·997 grm. of dried and pure nitrate of silver in about 900 c. c. of dilute nitric acid, containing 25 per cent. of the acid, adding 50 c. c. of the liquor ferri persulphatis, and diluting the mixture with distilled water to the volume of 1000 c. c. 10 c. c. of this solution represents 0·0365 grm. HCl.

2. A deci-normal solution of ammonium sulphocyanide.

7·6 grm. of this salt is dissolved in distilled water and the solution made up to 1000 c. c. The solution must be standardised against the foregoing solution of nitrate of silver.

To do this 10 c. c. of the silver solution are measured out into a beaker and about 200 c. c. of water added. The sulphocyanide solution is then added from a burette until a permanent reddish colour appears. If the solutions are exactly correct, 10 c. c. of the sulphocyanide solution will be necessary. If, say, 9·6 c. c. are required, 960 c. c. of the sulphocyanide solution must be diluted up to 1000 c. c. This diluted solution should again be tested against the deci-normal silver.

The Process of Analysis.

10 c. c. of the unfiltered stomach contents are poured into a graduated flask of 100 c. c. capacity. The contents should be well shaken before being measured. Then 20 c. c. of the deci-normal acid silver solution are added to this, the whole well shaken and set

aside for ten minutes. If the contents are strongly coloured, they may be decolorised by the addition of 5 to 10 drops of a solution containing 1 part of potassium permanganate in 15 parts of water. This is rarely necessary, and the addition should only be made after all the chlorine has combined with the silver, as permanganate of potash decomposes free hydrochloric acid and liberates chlorine. After chlorine has combined with silver this action does not occur. The contents of the flask are then diluted with distilled water to the 100 c.c. mark, and filtered through a dry filter paper into a dry vessel. 50 c.c. of the filtrate are placed in a beaker, and the quantity of silver is determined by the use of the sulphocyanide solution. The number of c.c. of this solution used is multiplied by 2, and the figure obtained is subtracted from the 20 c.c. of silver solution originally employed, and gives the amount of silver required to combine with the total chlorine, and, therefore, the amount of total chlorine in 10 c.c. of the gastric contents. The sulphocyanide solution is acted on by the nitrate of silver uncombined with chlorine, and is unaffected by the chloride of silver formed from the chlorine in the stomach contents. This part of the process gives the total quantity of chlorine present in the contents.

Other 10 c.c. of the gastric contents are evaporated to dryness in a platinum capsule either on a water-bath or an asbestos slab. They are then ignited over a naked flame until the residue no longer burns with a luminous flame, care being taken not to heat the capsule too strongly and to thereby drive off some of the chlorine. After the incineration the residue is mois-

tened with distilled water and thoroughly rubbed up with it by means of a glass rod. It is then treated with hot distilled water and filtered, the precipitate on the filter being washed once or twice with hot water to make sure that all the chlorides have been removed from the carbon and insoluble ash of the residue. The whole filtrate is then mixed with 10 c. c. of the deci-normal silver solution, and the excess of silver nitrate remaining determined, as before, by means of the sulphocyanide solution. The figure obtained, subtracted from the 10 c. c. of the silver solution originally added, gives the amount of silver required to combine with the chlorine in the inorganic chlorides of 10 c. c. of the gastric contents.

From the first analysis we have found the total chlorine present, in the second the chlorine which is in the form of inorganic salts. If the second figure be subtracted from the first, we obtain the exact amount of chlorine present in the form of hydrochloric acid in 10 c. c. of the gastric contents.

Example of Martius and Lüttke's Method.

Stomach contents from a case of chronic fermentative dyspepsia with intestinal putrefaction; sour smell; food ill-digested; a number of organisms under the microscope; removed two and a half hours after a light breakfast.

Total Acidity = 0·25 per cent., or 70 (unfiltered).

No free hydrochloric acid present with vanillin-phloroglucin.

Acetic and lactic acids present with Uffelmann's reagent.

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10 c. c. of unfiltered contents were placed in a 100 c. c. flask, and 20 c. c. of the deci-normal and silver solution added. After diluting to 100 c. c. and filtering, 50 c. c. were titrated with the deci-normal ammonium sulphocyanide solution.

6·2 c. c. were added before a permanent reddish colour appeared.

That is, 12·4 c. c. of the silver solution were contained in the filtrate of 100 c. c., but 20 c. c. were added, 7·6 c. c. therefore remained on the filter paper.

7·6 c. c. = (1 c. c. = 0·00365 grm. HCl) 0·02774 grm. HCl in 10 c. c., or 0·02774 per cent.

The total chlorine present was 0·2774 per cent.

Other 10 c. c. were dried in a crucible and carbonised over a naked flame. The residue was well washed with distilled water and filtered. 10 c. c. of the acid silver solution were added, and the amount made up to 100 c. c. After filtration, 50 c. c. were taken and titrated as above.

2·5 c. c. of the sulphocyanide solution were required, or 5 c. c. in the 100 c. c. 5 c. c. subtracted from the original 10 c. c. of the silver solution left 5 c. c. remaining on the filter as chloride of silver, or 0·1825 per cent. as hydrochloric acid.

The inorganic chlorine present was 0·1825 per cent.

Result—

Total acidity, . . .	0·25 per cent.
Total chlorine, . . .	0·2774 „
(Free chlorine, 0·00 per cent.)	
Inorganic chlorine, . .	0·1825 per cent.
Chlorine combined with proteids,	0·0949 „

Therefore,

Acidity due to other factors, .	0·1551 „

The results from this analysis were checked by using 25 c. c. of the two filtrates which remained, adding to them dilute hydrochloric acid in excess, and throwing the chloride of silver formed on ash-free filter papers. The precipitates were then washed with water and alcohol, dried, incinerated in weighed capsules, and the amount of chloride of silver present determined by weighing. The precipitate of chloride of silver was so finely divided that some sodium chloride had to be added in addition to the acid, and the precipitate on the filter could not be thoroughly washed. After incineration, therefore, when the silver chloride remained in a more compact state, any soluble

chlorides present were washed away with distilled water, before finally drying and weighing.

Thus in the estimation of the total chlorine the 20 c. c. of the silver solution added represents 0·34 grm. $AgNO_3$ or 0·287 grm. AgCl (170 : 143·5). In 25 c. c. of the filtrate ·0438 grm. of silver chloride was found, or 0·1752 grm. in the 100 c. c. Subtracting this from 0·287 grm. we get 0·1118 grm. of silver chloride, which corresponds to the chlorine left on the filter paper in 10 c. c. of the contents.

0·1118 × 0·25427 = 0·028427 grm. HCl in 10 c. c., or 0·2842 per cent.

From 25 c. c. of the second filtrate, 0·018 grm. of chloride of silver was obtained, or 0·072 in the total fluid, to which 10 c. c. of the silver nitrate solution had been added, equal to 0·1435 grm. AgCl.

The amount of AgCl remaining on the filter paper was therefore 0·1435 − 0·072 = 0·0715. This multiplied as above gives 0·1807 per cent., for the inorganic chlorides as HCl.

Result.

	Titration.	Gravimetric.
Total chlorine, .	. 0·2774 per cent.	0·2842 per cent.
Inorganic chlorine,	. 0·1825 ,,	0·1807 ,,
Hydrochloric acid,	. 0·0949 ,,	0·1035 ,,

(*f.*) *The Author's Method.* — This method was devised as a simple and ready means of obtaining most of the information afforded by the many and complicated chemical manœuvres of the two preceding methods. Instead of estimating the chlorine, as Hayem and Winter recommend, the acidity before and after evaporation is determined. Ten c. c. of the filtered or unfiltered gastric contents are placed in an evaporating basin, and other 10 c. c. in a beaker. The evaporating basin is placed on a water-bath and the contents evaporated to dryness at the boiling point. The basin is left for an hour or more after the

contents seem to be dry. A small quantity of distilled water is then added, and a drop of the solution tested with vanillin-phloroglucin. If free hydrochloric acid be shown to be still present, it is again evaporated. In cases where there is much proteid material and a high percentage of free hydrochloric acid, it is as well to add water to the dried residue and evaporate again at least three times. Ultimately the dried residue is dissolved in distilled water and well stirred. The total acidity of the 10 c.c., previously placed in a beaker, is determined by means of a deci-normal soda solution and phenolphthalein. The acidity of the 10 c.c., which have been dried and re-dissolved in water, is similarly determined, and gives the acidity remaining after volatilisation of any free volatile acid. Numerous determinations of the results of this method, performed upon artificial digestive mixtures, show that the results obtained are very accurate. In the practical analysis of the gastric contents, the total acidity may be composed of hydrochloric acid in its two forms, volatile organic acids, non-volatile lactic acid, and acid salts. The acidity of the portion after evaporation may be made up of combined hydrochloric acid, lactic acid, and acid salts. As a rule, if there is much free hydrochloric acid present, the organic acids are either absent, or present in very small quantities. When the contents in the evaporating basin are heated, the volatile fatty acids, such as acetic and butyric acids, are first driven off. Free hydrochloric acid, however, does not volatilise until almost all the water has disappeared. In fact, before the end of the evaporation, if free hydrochloric acid be

present, it becomes so concentrated that any proteid bodies in the contents are charred. This charring develops a dark violet coloration which is known as Liebermann's reaction, and serves to indicate, almost as well as Günzburg's test, the presence of the acid in a free state. The violet colour is probably due to the formation of a colouring matter, from the proteids present, similar to the body known as tryptophan, one of the normal products of the tryptic digestion of albuminous bodies. Hydrochloric acid forms a combination with this pigment.

We have now obtained the acidity of the 10 c. c. which have been dried, and that of the 10 c. c. before evaporation. If the figure for the acidity after evaporation be smaller than that obtained in the other portion, some acid must have been driven off during the process of evaporation. If this be hydrochloric acid, a violet coloration of the dried residue appears; if it be due solely to volatile fatty acids, no such change in colour results. If the acidity of the two portions, before and after evaporation, be the same, no volatile acid can be present.

It is not contended that this procedure is absolutely accurate, but it affords an easy and rapid way by which the constituents which go to form the acidity of the gastric contents can be ascertained. The evaporation of the second portion can be carried out, if no water-bath is handy, on the top of hot pipes, such as are used for heating purposes, or an ordinary pan may be half filled with water, boiled on a gas jet, over or close to a fire, and the porcelain basin containing the contents floated on the surface of the water. No doubt some time elapses before the portion is thor-

oughly dried, but while it is drying one can easily attend to other matters, as the evaporation requires little or no actual supervision.

Now let us consider what information we have derived from the results of the analysis in this process. We have estimated the total acidity of the stomach contents; we have determined, more or less accurately, the amount of acid which is volatile; and we have remaining the proportion of acid which cannot be driven off by heating to dryness at the boiling point. We have been afforded evidence by the presence or absence of Liebermann's reaction whether free hydrochloric acid is contained, or not, in the specimen analysed. No one can cavil at the result obtained from the estimation of the total acidity, while even if the proportion for the free acid obtained be a little over or slightly under the real amount, we have learned whether it contains any hydrochloric acid, or only volatile fatty acids. The acidity remaining after evaporation can only consist of hydrochloric acid combined with proteid bodies, lactic acid and acid salts. The presence of lactic acid in such quantity as to indicate abnormal chemical changes during the course of gastric digestion, may easily be determined by means of Uffelmann's test, or any of the other tests detailed under the section in which the methods of detecting this acid are detailed (page 43). The acid salts are seldom present in sufficient quantity to vitiate any arguments based on the quantity of non-volatile acidity found in this way. If the tests for lactic acid be negative, or if they give only a slight reaction, the acidity remaining after evaporation may be regarded as almost entirely consisting of

hydrochloric acid in combination with proteid bodies. The free acid—that is, the acid driven off during the process of evaporation—may of course consist of both hydrochloric acid and volatile fatty acids. It is well to remember, as already mentioned, that the presence of free hydrochloric acid, within normal limit, generally contra-indicates the presence of fatty acids due to fermentative changes. Thus, if by means of Günzburg's reagent, or by the colour produced by drying, a considerable percentage of free hydrochloric acid is shown to be present, a trace of the fatty acids means little. On the other hand, a trace of the free mineral acids with a considerable proportion of free acidity may indicate the occurrence of fermentative changes due to the presence of the mineral acid in insufficient quantity to exercise antiseptic influences. The tests already mentioned on page 45 will serve to indicate whether these volatile fatty acids are present in any large amount.

The significance of the amounts of free hydrochloric acid, and of that acid in combination with proteid bodies, lies in the fact that the free acid may be looked upon as an active force in further digestion, and in the prevention of fermentative changes; while the combined portion of this acid represents the amount of work done,—the expended force,—towards the digestion of the proteids contained in the food. Any conclusions based upon the proportions of these two forms in which the hydrochloric acid is found must include the consideration of the time after the last meal and the characters of the food taken in it.

But this method is capable of further expansion. If the acidities be determined in fireproof porcelain

crucibles, and a third portion of the contents (10 c. c.) be placed in another crucible, the total chlorine present can be determined after the total acidity has been calculated in portion No. 1 by adding a small excess of carbonate of soda, and then by drying the contents on a water-bath, incinerating at a dull red heat, and determining the amount of chlorine present in the residue in the usual way (*vide* Hayem and Winter, page 59).

After estimating the acidity contained by the 10 c. c. in crucible No. 2,—that is, the acidity after evaporation,—carbonate of soda may likewise be added, and the chlorine which remains calculated as in the last.

In the third crucible the contents are simply dried without any addition, incinerated as before, and the amount of chlorine in the ash determined.

If it is wished to find out the percentage of solids in the contents, crucible No. 3 may be weighed beforehand, weighed after the 10 c. c. have been thoroughly dried, and again after incineration. The difference between the second weighing and the first gives the amount of total solids in 10 c. c.; the first weighing subtracted from the third gives the percentage of ash; while the ash deducted from the total solids gives the proportion of organic material present.

The determination of the chlorine is thus very similar to the method advocated by Hayem and Winter, or by Martius and Lüttke. The heat employed in the incineration of the contents of the crucibles should never be raised above that of a dull red; if this degree of heat be continued for some time and not exceeded, the carbon of the residue may be driven off without volatilisation of the inorganic chlorides. The

process of incineration in the first and second crucibles need not go so far as this, nor need the carbon be altogether driven off from a third crucible, unless it is wished to obtain the exact amount of inorganic ash present in the contents.

Owing to the addition of the excess of soda before drying and incinerating the first two specimens, the residue remaining after incineration is strongly alkaline, and, therefore, after solution in distilled water, should be carefully neutralised by the addition of dilute nitric acid, to prevent any fallacy arising from the presence of phosphates and to facilitate the disintegration of the ash. If the amount of carbon left after incineration be considerable, it tends to render the end reaction of the quantitative test for chlorine, by means of silver nitrate and chromate of potassium, indefinite and difficult to determine with exactitude. In such a case, after adding distilled water to the residue, it may be thrown upon a filter, washed several times with distilled water to extract all the chlorine, and the filtrate tested without the carbon which has been left on the filter paper. It may be advisable, in such a case, to use Volhard's method in the estimation of the chlorides, a method which has been already described in the consideration of Martius and Lüttke's process.

The figures obtained from these processes represent the total chlorine present in 10 c.c. (crucible No. 1); the chlorine left in the contents after evaporation at 100° C. (crucible No. 2); and the proportion of chlorine present in the form of inorganic compounds with bases. As in the process of Hayem and Winter, the figure obtained from crucible No. 2 when subtracted from

that of crucible No. 1 gives the quantity of chlorine driven off by evaporation; while the figure which represents the inorganic chlorine, obtained from crucible No. 3, if subtracted from that of crucible No. 2, will give the amount of chlorine which has not been driven off by drying at the boiling point, but which is burned off during incineration.

The figures obtained in the two sections—that is, those for the acidities and those for the chlorine—may with advantage be expressed in each case in terms of hydrochloric acid per cent. They are then exactly comparable, and the amount of free acid can be contrasted with that of the free chlorine, and similarly the percentage of the combined acid with that of the chlorine in combination with organic bodies.

The free chlorine determined in this way consists of hydrochloric acid and of any chloride of ammonia present; and the combined, of hydrochloric acid and other chlorine compounds with organic bases.

Some difficulty may be experienced in determining the exact point at which the end reaction occurs in the estimation of the acidity after evaporation. Often the residue left is highly coloured. The best way to proceed is to divide the solution obtained, after dissolving the residue in distilled water, into two equal parts, and to use one without the addition of soda as a means of comparison with the other, to which soda has been added, so that the point at which the phenol-phthalein, becoming pink, affects the tint of the solution, may easily be determined.

Example.

Stomach Contents removed from a case of nervous dyspepsia with delayed digestion, heartburn, and intestinal symptoms.

Removed two and a quarter hours after breakfast of minced meat, toast, and water.

Fluid turbid ; meat partly digested ; smell sour ; no scum.

1. *Total Acidity.*

   10 c.c. titrated with $\frac{N}{10}$ soda solution and phenol-phthalein.

   7·8 c.c. used $(7{\cdot}8 \times 0{\cdot}00365) = 0{\cdot}02847 = 0{\cdot}2847$ per cent., or 78.

2. *Acidity after Evaporation.*

   10 c.c., 7·3 c.c. $\frac{N}{10}$ soda used.

   $7{\cdot}3 \times 0{\cdot}00365 = 0{\cdot}026645$ grm. HCl = 0·2664 per cent., or 73.

   Faint trace of violet colour in contents of capsule after drying.

3. *Volatile Acidity.*

   0·5 c.c. $(1-2) = (0{\cdot}5 \times 0{\cdot}00365)$ 0·001825 grm. HCl = 0·01825 per cent., or 5.

   Tested with vanillin-phloroglucin, a faint red colour developed on drying.

   Tested with Uffelmann's reagent, the presence of lactic acid was shown.

Such forms the ordinary clinical method, but for the purposes of illustration the further processes available were carried out.

4. *Total Chlorine.*

   The 10 c.c. of capsule 1, after neutralisation, and after the addition of a pinch of sodium carbonate to ensure excess of the alkali, were dried, and ashed at a dull red heat. The resulting ash was dissolved in water, filtered, the filter paper washed with distilled water, and the filtrate tested as in Hayem and Winter's method, after neutralising with nitric acid.

   In this instance a solution of silver nitrate was used, 9·5 c.c. of which corresponded to 10 c.c. of deci-normal hydrochloric acid solution, or to 0·0365 grm. of HCl.

8·3 c. c. of the silver solution was added before the potassium chromate began to be acted on, or $\frac{0{\cdot}0365 \times 8{\cdot}3}{9{\cdot}5}$ = 0·03188 grm. HCl in 10 c. c., or 0·3188 per cent.

5. *Non-volatile Chlorine.*

The contents of No. 2 were similarly treated, after testing the acidity.

8·1 c. c. of the silver solution were required, or $\frac{0{\cdot}0365 \times 8{\cdot}1}{9{\cdot}5}$ = 0·03112 grm. HCl in 10 c. c., or 0·3112 per cent.

6. *Volatile Chlorine.*

The result of No. 5 subtracted from that of No. 4 gives only 0·2 c. c. of the silver solution as the equivalent of the volatile chlorine, and this is equal to 0·0076 per cent. of free hydrochloric acid.

7. *Inorganic Chlorine.*

Other 10 c. c. were dried without addition in a capsule, incinerated at a low red heat for a considerable time, and the ash treated as before.

4·4 c. c. of the silver solution sufficed to combine with all the chlorine, or $\frac{0{\cdot}0365 \times 4{\cdot}4}{9{\cdot}5}$ = 0·01689 grm. HCl, or 0·1689 per cent.

Result.—

1. Total acidity, . .	0·2847	per cent.	
2. Non-volatile acidity,	0·2664	,,	
3. Volatile acidity, . .	0·01825	,,	
4. Total chlorine, . .	0·3188	,,	
5. Non-volatile chlorine,	0·3112	,,	
6. Volatile chlorine, .	0·0076	,,	(4 − 5)
7. Inorganic chlorine, .	0·1689	,,	
8. Organic non-volatile chlorine, or chlorine combined with proteids (5 − 7) . .	0·1423	,,	Chlorine combined with proteids.
9. Total chlorine apart from inorganic chlorides (6 + 8) . .	0·1499	,,	Total chlorine, as HCl, free and combined.

10. Total acidity not due to chlorine (1–9)	=0·1348 per cent.	Total acidity due to organic acids and acid salts.
11. Non-volatile acidity not due to chlorine (2–8) . .	=0·1241 „	Lactic acid and acid salts.
12. Volatile acidity not due to chlorine (3–6) . .	=0·01065 „	Volatile organic acid = acetic acid.

The figures obtained show the presence of a very small quantity of free hydrochloric acid, not sufficient to check the lactic acid fermentation, a moderate amount of combined hydrochloric acid, a comparatively large quantity of lactic acid, and a trace of a volatile organic acid, probably acetic.

4. Quantitative Tests for the Organic Acids.

If the organic acids be volatile the amount present may be estimated by titration of the distillate of a known quantity of the contents.

If partly volatile, *i.e.*, acetic and butyric acids, and partly non-volatile, *i.e.*, lactic acid, titration of the distillate and of a watery solution of the residue of an ether extract of the fluid remaining in the retort will give the total amount of organic acids present fairly accurately (*vide* p. 42.)

5. Other Methods.

Contejean's Method.—Contejean* suggests the use of hydrocarbonate of cobalt, added in excess to the stomach contents, as a qualitative test for the acids in the gastric contents.

The mixture is shaken or stirred frequently, and

* *Journ. d. l. Phys. et. d. l'Anat.*, No. 1, 1893.

becomes pink in the course of a few hours if some oxide of cobalt be formed and dissolved, while the residue after filtering and drying is blue. If absolute alcohol be now added, any chloride of cobalt present is dissolved by it, and can thus be separated from the lactate, which is insoluble in alcohol. The chloride of cobalt solution is of a pink colour when cold, turning to blue on heating. On evaporation rectangular crystals of this salt may be obtained, and serve as irrefragable evidence of the presence of hydrochloric acid. To ascertain the positive presence of lactic acid, he advises that the stomach contents should be shaken up several times with ether, the ether removed, evaporated, and the residue dissolved in distilled water, to which zinc oxide has been added. This mixture has to be kept for some time at a mild heat, when, if lactic acid be present, crystals of lactate of zinc may be found under the microscope on evaporation of the solution.

Hoffmann's Method. — Hoffmann* has suggested that the amount of free hydrochloric acid in the gastric contents may be estimated by the degree of inversion of cane sugar, measured by the polarimeter, brought about by its action. Or by the splitting of methyl-acetate into methyl-alcohol and acetic acid, by the action of free hydrochloric acid, and titration of the acetic acid formed.

Braun's Method.†—The total acidity of 10 c.c., or any other fixed quantity of the stomach contents, is determined in the ordinary way, and then 1 c.c. more of the deci-normal solution of soda is added.

* *Centralblatt f. klin. Med.*, No. 16, 1889.

† See Leube, *Specielle Diagnostik*, etc., p. 234, 1889.

Dry and incinerate. Then as much of a deci-normal solution of sulphuric acid is added as is required to neutralise the soda used. Warm the mixture to get rid of carbonic acid, and titrate with deci-normal soda again. The quantity of the solution used represents the amount of hydrochloric acid originally present.

*Mierzynski's Gas Volumetric Method.** — Five to 15 c.c. of the stomach contents, after filtration, are mixed with an excess of carbonate of barium in a porcelain crucible, dried, and incinerated. The ash is dissolved in boiling water, and filtered. It often contains, in addition to the soluble chloride of barium, some of the hydrate, owing to reduction of the carbonate during incineration. If this is the case, a drop of phenol-phthalein will colour the solution pink. To get rid of the hydrate all that is necessary is to blow air through a glass tube until the pink colour disappears, and filter once again. To the filtrate ammonium chromate is added in slight excess, the solution heated, and the precipitate which forms caught on a filter paper. This is then washed with very dilute hot ammonia to remove any remaining chromate. The lower end of the filter is now pierced, and the precipitate washed through with 1 in 20 hydrochloric acid solution in excess, to which 10 c.c. dilute sulphuric acid is finally added. The solution is now placed in a ureameter, 5 to 10 c.c. of a 2 per cent to 2·5 per cent. peroxide of hydrogen solution mixed with it, shaken for half a minute, and the quantity of oxygen evolved calculated from the height of the water in the tube of the apparatus.

* *Centralblatt f. innere Med.*, No. 15, s. 1073, 1894.

$$2HCl + BaCO_3 = CO_2 + H_2O + BaCl_2$$
$$BaCl_2 + (NH_4)_2CrO_4 = 2NH_4Cl + BaCrO_4$$
$$2BaCrO_4 + 5H_2O + 5H_2SO_4 = 2BaSO_4 + Cr_2(SO_4)_3 + 10H_2O + 8O$$

Therefore, $2HCl = BaCl_2 = BaCrO_4 = 4O$.

The result is then corrected for temperature and pressure, and the number of c. c. multiplied by half the molecular weight of HCl.

For example—10 c. c. of stomach contents gave 22·4 c. c. of oxygen at 742 mm. pressure, and 16° C. To correct for temperature and pressure 22·4 must be multiplied by 0·08106 (from Baumann's Tables), and by 18·185, or half the molecular weight of HCl. This gives 33·018 m. grm. in 10 c. c., or 3·3 per thousand.

Table of the Methods used for the Detection and Estimation of the Acids present in the Stomach Contents.

1. *Qualitative.*
   - *a.* Simple acidity only. Litmus.
   - *b.* Form of acid present.
     1. Free hydrochloric acid.
        - *a.* Vanillin-phloroglucin.
        - *b.* Resorcin.
        - *c.* Sulphocyanide of potassium and acetate of iron.
        - *d.* Dimethyl-amido-azo-benzol.
     2. Free acids of any kind.
        - *a.* Congo red.
        - *b.* Tropæolin OO (*L'Orange Poirier*).
        - *c.* Benzo-purpurin.

d. Methyl-violet.
e. Emerald green (Vert Brilliant).
f. Fuchsin.
g. Leo's method.

3. Organic acids.
a. Carbolic acid and perchloride of iron.
b. Dilute perchloride of iron.
c. Co-efficient de partage.
d. Alcohol and sulphuric acid, with formation of ethers.

2. *Quantitative.*

a. Total acidity, titration with deci-normal sodium hydrate, and phenol-phthalein or litmus.

b. Acids forming the total acidity.

1. Hydrochloric acid only.
a. Free HCl only. Mintz's method.
b. Hydrochloric acid, free and combined with proteids. Sjöqvist's method.

2. All the acids present.
a. Cahn and Von Mering.
b. Mintz-Boas
c. Hayem and Winter.
d. Toepfer.
e. Lüttke and Martius.
f. Modified Hayem and Winter.

3. Organic acids alone.
1. Distillation and titration of distillate.
2. Titration before and after ether.

3. *Other less known methods.**

1. Contejean's methods. Qualitative.
2. Hoffmann's method. Quantitative for free hydrochloric acid.
3. Braun's method. Quantitative for total hydrochloric acid.
4. Mierzynski's gas volumetric method, for total hydrochloric acid.

* See *Appendix*, p. 161.

CHAPTER VI.

GENERAL CONSIDERATION OF THE DIFFERENT CHEMICAL METHODS DESCRIBED.

THE various methods for the estimation of the hydrochloric acid and fatty acids in the stomach contents, which have been described in the preceding chapters, may be divided into two classes. The first class contains those methods in which the proportion of hydrochloric acid is determined irrespective of the chemical state in which it is present; the second, those in which the amount of acid, both in a free state and combined with proteids, is determined.

The first class consists of the methods of—

1*st.* Cahn and von Mering.
2*nd.* Sjöqvist.
3*rd.* Leo.
4*th.* Martius and Lüttke.

The differentiation of the hydrochloric acid present into that which is free and that which is combined with proteid bodies, is carried out by the processes of—

1*st.* Mintz.
2*nd.* Mintz and Boas.
3*rd.* Toepfer.
4*th.* Hayem and Winter; and
5*th.* Of the Author.

If one wishes to ascertain the total quantity of chlorine present as hydrochloric acid in a sample of stomach contents, no process can be more accurate than that of Sjöqvist. If one desires to determine the quantity of chlorine combined with inorganic salts, and in the form of hydrochloric acid, free and combined together, Martius and Lüttke's method affords good results. The method of Cahn and von Mering may be at once dismissed, because, as has already been noted, it is both costly and difficult. The method of Sjöqvist requires much skill in chemical analysis, while that of Martius and Lüttke, although accurate, does not yield all the information which may be of use. On the other hand, the simple method of Mintz and Boas quickly indicates the proportion of free hydrochloric acid in the contents, accurately if it is the only acid present, slightly in excess of its real value if organic acids are also present. The method of Hayem and Winter affords much more information, and appears to be fairly accurate. By it the total acidity, the free hydrochloric acid, the hydrochloric acid combined with proteids, and the inorganic chlorides, are all determined. It is, however, somewhat tedious to carry out, and requires considerable chemical skill in the estimation of the chlorine present. Toepfer's method is easy and does not take up much time, nor does it require any costly apparatus. It may be warmly recommended for the ordinary clinical examination of the stomach contents. The figures obtained are not, in all probability, absolutely accurate, but for clinical work the accuracy of the analytical chemist is not required. What we wish to know is how acid the

stomach contents in any given case are, and what this acidity is made up of. The modification of Hayem and Winter's method, used for some years past by the author, is likewise attended with the possibility of some error; the process, however, is simple and easy, and in his hands has afforded so much information with little trouble, and has been of so much use in the diagnosis and treatment of cases of dyspepsia of all kinds, that he is disposed to recommend it for employment in clinical work. By it we obtain information as to the total acidity and as to the acidity left after evaporation; while coupled with the ordinary quantitative tests for the presence of free mineral acid or of the fatty acids, the process affords all the information required to diagnose the faulty chemistry which may underlie gastric affections.

After the performance of many of the processes detailed above, in which the principal point aimed at is the estimation of the chlorine present, the presence of the fatty acids, and, if required, the amount of these acids in the contents, may be determined by the use of the various tests described in Chapter IV.

The Significance of the different Acidities obtained in the Stomach Contents.

In an artificial digestion experiment, in which nothing but hydrochloric acid, pepsin, and proteid bodies are present, until the acid has been added up to a certain proportion, namely, to about 7 per cent. of the proteids, no free hydrochloric acid appears in the fluid. It has all combined with the proteids present. It gives no coloration with Günzburg's or with

Mohr's reagent, but still retains the same acid value in titration which it possessed before combination. That is to say, that if 10 c. c. of a deci-normal solution of hydrochloric acid be added to a solution of any proteid in which the proteid is in excess, no free acid can be detected, but the mixture, provided it is neutral before the addition of the acid, is exactly neutralised again by the addition of 10 c. c. of deci-normal soda. This combination of hydrochloric acid with proteid bodies represents the first stage in their digestion, and therefore the amount of the acid in combination may be regarded as an index of work already done. Further, if in our artificial digestion experiment more acid be added, none of it will be found to be present in a free state until from 7 to 9 per cent. of the acid, when compared with the proteid, is contained in the fluid. During the decomposition of the native proteid molecules, however, simpler proteid bodies are formed which have a greater affinity for the acid; and a solution of albumin, which contains at the commencement of digestion a small quantity of free hydrochloric acid, may, as digestion proceeds, exhibit no trace of it; that is to say, the lower proteids resulting from the digestive act are able to combine with more of the acid than the native albumin from which they are derived. Thus, the albumoses appear to be capable of combining with from 11 to 15 per cent. of hydrochloric acid, and pure peptone with about 19 to 20 per cent. If these facts be remembered, the amount of combined hydrochloric acid obtained by any of the methods described above, will indicate the ability of the gastric glands to secrete sufficient hydrochloric acid not only to act upon and

combine with all the proteids of the food, but to provide the slight excess of free acid which enables the process of decomposition of the proteid bodies to go on to its natural termination.

The presence of free hydrochloric acid in the contents, remembering what we have just said, indicates a power of further digestion on the part of the gastric juice. Its absence may denote diminished activity of the gastric glands, unless the contents have been removed shortly after a heavy proteid meal. A low total acidity after food composed largely of carbohydrates, does not invariably indicate diminished digestive powers. The gastric glands appear to be able to regulate the amount of acid secreted, not so much in relation to the combined acid present, but in connection with the proportion of free hydrochloric acid in the contents. So we may say that a low acidity with little combined acid and the normal amount of free mineral acid is by no means abnormal, if the food has contained a small proportion of albuminous material; on the other hand, a very high acidity, even 0·4 to 0·45 per cent. (HCl) with or without free hydrochloric acid, does not necessarily indicate hyperacidity if the contents have been removed after a food chiefly consisting of proteids. But if with a low acidity no free hydrochloric acid can be detected after a meal of carbohydrates, or if the acidity some time after proteid food is normal but does not similarly contain any free hydrochloric acid, we are justified in diagnosing a diminished secretion of acid in the gastric juice. Again, if in the first instance, after carbohydrates, there is a normal total acidity almost entirely composed of

free mineral acid; or in the second, that is, after proteid food, the total acidity be very high with the same proportion of combined acid as should normally be present but with a greater quantity of free acid, we may look upon the patient as suffering from hyperchlorhydria,—in other words, too great a secretion of hydrochloric acid from the gastric glands.

CHAPTER VII.

THE ACTIVITY OF THE GASTRIC JUICE.

Tests for the Activity of the Gastric Juice—Egg Albumin—Günzburg's and Sahli's Iodide of Potassium Test—Oppler's Test—Rennet—The Identification and Estimation of the Forms of Proteid present—Sugar and Starch—Saliva—Toxines.

Tests for the Activity of the Gastric Juice.

To obtain an indication of the activity of the gastric juice, the white of one or two eggs, apart from the yolk, are mixed with 4 oz. of water, and the solution heated to the boiling point, with constant stirring. The albumin is, in this way, coagulated in fine particles. After cooling, it is given to the patient, and by means of the stomach-tube removed from the stomach in half an hour to three-quarters of an hour afterwards, after the addition of 4 or 5 oz. of water. The stomach should be empty before the white of egg mixture is given, or, if it is not empty, should be washed out beforehand. Examination of the fluid removed will show whether the digestion of the albumin has proceeded to a termination or not. The egg-albumin, as yet unaltered, can be separated by boiling the fluid, with the addition, if necessary, of acetic acid, and filtering. The acid albumin is removed after precipitation with an alkali close to

the neutral point. The presence of albumoses or peptone in the filtrate can then be ascertained by means of the biuret reaction. The acidity and the constituents of the acidity can be readily determined by any of the methods described above, and the presence of pepsin investigated by an artificial digestion experiment. The degree of acidity of the fluid obtained in this way will be equal to one-half only of the true acidity of the stomach contents, since an equal part of water has been added to the contents before they are withdrawn.

This method is a very accurate means for determining the activity of the gastric secretion in health or disease. Egg-albumin is readily digested in the stomach, and does not, during its digestion, give rise to any organic acids. If a considerable proportion of the albumin given has been altered, and is no longer in the coagulated form at the end of one-half to an hour, the gastric digestion may be regarded as normal. If, however, very little of the albumin has been rendered soluble, that is to say, has been converted into lower proteid forms, and the contents removed are only slightly acid, we have good evidence of a defective secretion of gastric juice.

Günzburg and Sahli * have proposed another method to ascertain the rapidity of the gastric digestion of albumin and fibrin. A small quantity of iodide of potassium, 0·1 to 0·2 grm. (gr. iss. to iij.) is enclosed in an envelope of fibrin or in a thin gum packet fastened with a string of fibrin. The salt may also be given, placed in a short piece of thin indiarubber

* *Deutsch. med. Wochenschr.*, 1889, No. 41, and *Correspondenzblatt der Schweizer Aerzte*, 1889, p. 402.

tubing, the ends of which are firmly closed with plugs of fibrin. The iodide can only be absorbed by the mucous membrane of the stomach when the envelope of fibrin has been digested. The length of time required for the appearance of the salt in the saliva (see page 12) is regarded by them as an indication of the rapidity of gastric digestion. The time taken for the absorption of iodide of potassium is very variable, and the rapidity with which the fibrin enveloping the salt is dissolved bears no direct relation, in many cases, to the presence of free hydrochloric acid in the contents, as it is often digested as rapidly in the absence as in the presence of this acid in a free state. The time taken, also, for its digestion will vary with the contents present along with it in the stomach.

A simple way of determining the presence or absence of pepsin and free hydrochloric acid in the stomach contents may be performed in the following manner:—Small discs of coagulated white of egg may be cut by means of a double-bladed knife, and the sections thus obtained punched with a cork-borer or other similar instrument, so as to produce discs of albumin equal in size and thickness. These discs may be preserved in glycerine till required. An equal quantity of the filtered stomach contents is then placed in four test-tubes and one or two discs of the albumin placed in each. To the first nothing further is added; to the second, two drops of the dilute hydrochloric acid of the Pharmacopœia to each 5 c. c. of the stomach contents; to the third, 0·2 to 0·5 grm. (gr. iij. to vij.) of pure pepsin is added; and to the fourth, both the acid and the ferment. The test-tubes are then placed in an incubator, the temperature of

which is kept at about 100° F., or in any other warm and suitable place. The rapidity of the solution of the albumin discs informs us whether digestion can take place without the addition of hydrochloric acid or pepsin, or whether one of these bodies or both are necessary. The actual digestive power of the contents upon albumin may be ascertained by adding a known quantity of pure egg-albumin, coagulated or uncoagulated, to 10 c. c. of the stomach contents, and by weighing the albumin which can still be coagulated by the aid of heat on a weighed filter paper. The percentage of loss will give the digestive activity of the specimen examined.

It should be remembered, with regard to these tests, that a perfectly normal and active sample of the stomach contents may exert no digestive action on albumin, unless free hydrochloric acid be added, owing to the fact that all the hydrochloric acid present has combined with proteid bodies originally present. In such a case the contents will have probably been removed before the height of digestion.

Oppler* has lately described a new method of estimating the activity of pepsin. An hour after a test-breakfast the contents of the stomach are expressed, and the organ washed out with a small quantity of distilled water. The contents and washings are then diluted to 1 or 2 litres, as may be, with distilled water and dilute hydrochloric acid added until the total acidity stands at $77 = 0{\cdot}281$ per cent.

A 2·1 per cent. solution of egg-albumin is prepared, and the nitrogen of it estimated by Kjeldahl's method. Twenty c. c. of the albumin solution are then added to

* *Centralblatt f. innere Med.*, February 1, 1896.

50 c.c. of the diluted stomach contents, and the mixture digested at 375° (for three hours). After coagulation and precipitation of the albumin and acid-albumin remaining, and removal of them by filtration, the nitrogen of the proteids in the filtrate is estimated and the percentage of albumin acted on calculated.

He finds that the formation of pepsin is diminished in chronic gastritis, carcinoma of the stomach, especially if situated on the body. When the pylorus is the seat of the disease the ferment persists longer than the hydrochloric acid, but gradually diminishes. In atony and dilatation pepsin is only secreted in less quantity if catarrh be present with diminished acid. Pepsin is increased in gastric ulcer, acid dyspepsia, chronic hypersecretion (*Reichmann's Magensaftfluss*), and sometimes in chlorosis. Nervous dyspepsias and secondary affections of the stomach with lessened acidity are accompanied by diminished pepsin formation.

The activity of pepsin secretion runs parallel with that of the hydrochloric acid, but the correspondence is not always complete.

Rennet.

To ascertain whether the milk-curdling ferment is present, a small quantity, say 10 c. c., of boiled milk of neutral reaction, is mixed with an equal amount of neutralised and filtered stomach contents. If the mixture be kept at a temperature of 100° F. for a short time, the milk generally coagulates in about ten to fifteen minutes. Leo * adds only two to five drops

* *Diagnostik*, 1890, p. 119.

of the stomach contents to 10 c. c. of raw milk without neutralising the former, on account of the relatively small quantity of it added to the milk. Raw milk is recommended by him because it coagulates ten times more rapidly than milk which has been boiled. Neutralisation of the stomach contents is rendered necessary in the first method by the fact that, if it be even moderately acid, the milk coagulates in the absence of rennet, the coagulation in such a case being flaky or lumpy, unlike the characteristic cake or layer of casein floating in the whey when formed by the action of rennet.

Tests for the Identification and Estimation of the Proteids Present in the Gastric Contents.

In some cases it may be desired to ascertain whether the products of the peptic digestion of the native proteids of the food are present or not, or, again, to estimate the quantities of each form contained in solution. Before applying any of the requisite tests the contents must be thoroughly filtered. If there be much mucus present, filtration through paper is a slow and tedious business. It is best to first strain them through well-washed muslin, and then filter through thin white filter paper. If speedy filtration be desired, an exhaust pump may prove of advantage.

A certain quantity of the filtrate, say 10 c. c., is measured out by means of a pipette, and deci-normal soda solution cautiously added. If any acid albumin be present, the fluid gradually becomes opalescent shortly before neutralisation, and the addition of one

or two drops more of the soda brings down a flocculent precipitate of this proteid. The precipitate is filtered off, on a weighed filter paper if desired, and washed with distilled water. The filtrate is still slightly acid in reaction, but no further precipitate comes down when a drop or two of the soda solution is added to it.

The filtrate is now boiled, and at the boiling point made slightly acid with acetic acid. All the coagulable proteids fall and may be filtered off, and the precipitate washed with boiling distilled water.

The proteids remaining in this second filtrate consist of albumoses and peptone.

The biuret test may be applied to a small portion of the filtrate for the purpose of detecting the presence of these bodies in it. To this end a drop of 1 per cent. sulphate of copper solution is added to a portion in a test-tube, giving it a slight greenish-blue tinge, which changes to a more or less bright pink on the addition of a small amount of liquor potassæ, or of a 40 per cent. solution of caustic potash, indicating the presence of albumose or peptone. Fehling's solution may be similarly used, a small drop being added by means of a glass rod, and a little potash if needful. Fehling's solution may also be used in bulk, some of the filtrate being floated on its surface, when a pink ring at the point of contact appears if these bodies be contained in the liquid. This is not nearly so delicate a method, and seldom a negative proof, if the proteids be small in amount, requiring corroboration by other means.

The biuret reaction, it should be remembered, cannot be obtained in any solution to which phenol-

phthalein has been previously added, the alkali giving that dye a colour similar to the pink caused by the lower proteids.

The xantho-proteic reaction may also be employed.

A small quantity of the liquid is heated in a porcelain basin with strong nitric acid, allowed to cool, and some ammonia added. If proteids are present a reddish-orange colour appears.

These last tests only serve to tell us whether albumoses or peptones are present. To ascertain whether the proteid be of the nature of an albumose or of a peptone, or if both are contained in the liquid, the filtrate after the removal of the albumin is boiled, rendered slightly acid, and saturated at the boiling point with neutral sulphate of ammonium [$(NH_4)_2 SO_4$.] The albumoses are precipitated, and can be separated from the still soluble peptone by filtration, and washing the precipitate on the filter paper with hot saturated ammonium sulphate solution.

The persistence of the biuret and xantho-proteic reactions in the filtrate denotes the presence of peptone.

If the nature of the albumoses caught on the filter paper is of moment or interest, they may be dissolved up in hot water, the resulting solution concentrated and saturated with chloride of sodium.

The primary albumoses are precipitated, proto- and hetero-albumose; the secondary albumose, deutero-albumose, remains in solution.

The ammonium sulphate and chloride of sodium may be removed by dialysis from both solutions, and the proteids obtained in a nearly pure state. Hetero-

albumose can be separated from proto-albumose by taking advantage of its insolubility in distilled water, in which the latter is soluble. The precipitation of hetero-albumose by the removal of salts from the solution is rendered more complete by the application of heat.

A rapid and easy method to ascertain the forms of proteid bodies in the stomach contents is :—1. To test for acid albumin as above. 2. To add an equal quantity of 10 per cent. trichloracetic acid ($C_2HCl_3O_2$.) This precipitates proto-albumose in the cold, and coagulates all albumins and globulins. If the solution now be boiled and filtered while hot, the proto-albumose dissolves up and passes through along with deutero-albumose and peptone. The usual tests will reveal their presence or absence. On cooling, the proto-albumose in the filtrate again separates out.

Mucin and nucleo-albumins may be present in the filtrate when the acidity is low and the digestive power weak. In fluids obtained, or regurgitated, from œsophageal pouches, the presence of mucin in considerable amount may aid in the diagnosis.

The addition of a very small quantity of acetic acid, just enough to render the solution acid, precipitates mucin. The specimen to which the acid is added should be allowed to stand for twenty-four hours, when the precipitate, if any, will be apparent. This precipitate is insoluble in excess of the acid. A similar precipitate from the nuclein in nucleo-albumin occurs, but this is soluble in excess.

Nucleo-albumins are acted on by active gastric juice, the proteid portion being digested like other

albumins, the nuclein left. As this is insoluble in an acid medium, it does not appear in the filtered contents of the stomach.

Tests for Sugar and Starch in the Stomach Contents.

It will not be necessary to enter into all the particulars of the tests for sugar, or for starch, in this place. Sugar is at once detected by the reduction of Fehling's solution when boiled with some of the filtered contents, deprived of proteid bodies; starch, by adding a drop of the contents to a mixture of iodine, iodide of potassium, and water, when the appearance of a blue colour indicates its presence, of a violet, erythrodextrin.

Saliva.

In some instances it is of importance to know whether the fluids vomited or removed from the stomach are composed of gastric secretion, or of saliva which has been swallowed and regurgitated, as in cases of water-brash, or with œsophageal pouches. If chiefly composed of saliva the reaction will be slightly alkaline, neutral, or perhaps very slightly acid. A few c.c. added to some starch solution, and kept at 38° C. for about twenty minutes, will convert some of the starch into dextrins or maltose, as evidenced by the colour produced on the addition of the iodine and iodide of potassium solution; and lastly, the addition of dilute perchloride of iron to some of the fluid, which should be first rendered slightly acid with the merest

trace of hydrochloric acid, causes the development of a red colour owing to the presence of sulphocyanide of potassium. This red colour disappears on the addition of mercuric chloride, unlike the similar colour yielded by meconic acid in cases of opium poisoning. Colosanti * advocates precipitation of the saliva with alcohol, filtration, evaporation of the filtrate to dryness, solution of the residue in water, and the addition of copper sulphate. If sulphocyanide of potassium be present, a bright emerald green developes.

Toxines in the Gastric Contents.

For the separation and study of the toxines present in the stomach contents, Turck † recommends the withdrawal of the stomach fluid either before breakfast or after a preliminary washing out, and the introduction of starch or albumin only. The fluid obtained is filtered through a sterilised Pasteur filter, and the filtrate concentrated under a vacuum pump. The degree of concentration is measured, and a quantity corresponding to 1 c.c. of the original filtrate injected into an animal for each 1000 grammes of its body-weight. This proportion is gradually increased. The unused portion of the fluid is now heated to 136° or 158° F. under a vacuum for four hours. The proteids coagulated by this temperature, which does not destroy bacterial products, are filtered off, and the new filtrate injected as before. The products of the growth of the organisms grown from the con-

* Maly's *Jahresber.*, xix. 72, 1890.

† *New York Med. Journ.*, Feb. 22, 1896, p. 233.

tents, and cultivated in boullion, are similarly treated and injected.

The toxic effects of the filtered and sterile stomach contents are due to two factors: to albumoses, or other proteids in them, or to bacterial products.*

* *Vide* also Cassaet et Terré, *Compt. Rend. d. l'Soc. d. Biologie*, 1894, pp. 532 and 633.

CHAPTER VIII

THE DETERMINATION OF THE MOTILITY, SIZE, AND POSITION OF THE STOMACH.

The Motility—Salol (Ewald, Huber)—Oil (Klemperer)—Gastrograph (Einhorn)—Kymograph (Hemmeter)—Power of Absorption—Potassium Iodide (Penzoldt)—Rhubarb—Size and Position—Filling Stomach with Water—With Gas—With Air—Clapotement—Determination of the exact quantity of the Stomach Contents.

The Motility of the Stomach.

SEVERAL tests have been devised for the purpose of determining the motor function of the stomach. Leube has suggested that the presence or absence of solid contents a definite period of six to seven hours after a large meal, or of two to two and a half hours after Ewald's test-breakfast, might serve as an indication of the power of that organ to empty the food into the duodenum. That is to say, if the stomach is empty at these hours, its motility may be regarded, according to him, as normal; if there is still some solid material in it, the motility is weakened. This method, however, is subject to fallacy, depends upon the nature of the food taken, requires the use of the stomach-tube, and takes no account of the process of absorption as well as that of motility.

Ewald* has proposed the use of salol. Salol is a

* *Therapeutische Monatshefte*, August 1887.

compound of carbolic and salicylic acids, a phenol-ether of salicylic acid, which is said not to be changed by acid solutions, but to be converted in alkaline fluids into salicylic acid and phenol. Ewald imagined that, if this supposition was true, salol would prove an excellent means for determining how rapidly substances pass into the duodenum from the stomach, and, in addition, might help to show if the action of the pancreas and the intestinal cells were normal, as the salol would not be affected by the acid of the gastric juice, but would be split up in the duodenum; its derivatives absorbed and excreted in the urine. When salol has been decomposed into the two acids above named, the salicylic acid, absorbed into the blood, appears in the urine as a further decomposition product, viz., salicyluric acid.

Normally, salicyluric acid can be detected in the urine forty to sixty, or, at most, seventy-five minutes after gr. 15 (1 grm.) of salol has been given during the course of digestion. Any delay in the appearance of the acid in the urine will indicate some retardation of the time taken by the stomach to empty itself. The salol is best given in gelatine capsules, to guard against any action of the alkali in the saliva on it, and which readily dissolve in the stomach. Salicyluric acid may be recognised by the violet colour, similar to that produced in the formation of Uffelmann's reagent, on the addition of a neutral solution of perchloride of iron. To detect the first trace of the acid some of the urine should be rendered acid with hydrochloric acid, shaken up with ether, and the ether extract tested with the iron solution, as the salicyluric acid readily combines with the ether used.

A simple method, recommended by Ewald, is to place a drop of the urine on a filter paper and then let a drop of 10 per cent. solution of chloride of iron fall upon the moistened spot. Where the iron solution touches the moistened surface, a violet colour appears if there is even the smallest trace of salicyluric acid present.

This test, however, is of little practical value.

Ewald, indeed, states that the reaction is obtained, *in the great majority* of a large series of experiments, between sixty to seventy-five minutes after the salol has been taken. Other observers, however, have obtained very various results, and if Stein's observation is correct,* viz., that salol is absorbed by the mucous membrane of the stomach, although it is not decomposed in that organ, and that it may appear in the urine in the form of salicyluric acid before its entrance into the bowel, the method can hardly be regarded as accurate. Stein has obtained this reaction in dogs with duodenal fistulæ before the contents of the stomach reached the bowel, and in cases where there was no evidence of any decomposition of the salol in the stomach.

Huber † estimates the motility of the stomach wall by the same drug, but in a different manner. He determines how long the salicyluric acid reaction in the urine lasts. He finds that traces of this acid may be found in healthy people for 24 hours after ingestion, while in those in whom enfeeblement of the muscles of the stomach wall is present salicyluric acid can be detected 48 hours or even longer after

* *Wien. med. Wochen.* 43, 1892.

† *Münch. med. Wochen.*, 1887, No. 19.

administration. Here, again, it is difficult to say what portion of the time taken is dependent on the movements of the stomach wall, and what portion on delay of intestinal absorption. To carry out Huber's test, the urine should be examined 24 to 30 hours after the salol has been given, and if salicyluric acid is still present at the latter period (or later), we may infer that there is some disturbance of the motor activity of the stomach.

Klemperer* has proposed still another method for determining the motor activity of the stomach. He introduces a definite quantity, 100 c. c. (a little more than 2 oz.) of pure olive oil into the empty stomach, which may be washed out beforehand if necessary. Two hours afterwards the oil is removed by the stomach-tube as completely as is possible, and the difference between the quantity originally introduced and that obtained after the two hours is regarded by him as an indication of the gastric motility. This method is of doubtful value, and to many patients very objectionable.

Einhorn's Gastrograph.†—One of the many instruments introduced by Einhorn, the gastrograph, consists of a stomach-tube with a hollow ball at the lower end containing a free ball of platinum. (Fig. V.) By the movements of the stomach walls the platinum ball is moved about in the bulb, coming in contact with the terminals of an electric circuit therein, and by breaking and making the current, signals the occurrence of gastric movements on a suitable apparatus outside.

Hemmeter's Kymograph. — Einhorn's gastrograph

* *Deutsche med. Wochenschr.*, 1887, No. 47.

† *Zeitschr. f. klin. Med.*, xxvii. 3|4, s. 242.

only records the active movements of the stomach, and Hemmeter has devised another method for testing both the active and passive gastric peristalsis. Moritz of Munich has independently conceived and described a similar apparatus.

A deglutable elastic stomach-shaped bag of thin rubber is attached to the end of a stomach-tube. It is introduced while collapsed, and then blown up with air. The outer end of the tube is then attached to a manometer or tambour, and the movements of the stomach walls, however slight, can be registered on paper attached to a revolving drum. A time record is also kept on the paper, and, as the movements of respiration affect the size of the stomach, a separate line indicates the respiratory movements, as recorded by a pneumograph (see p. 162).

The methods recommended for the determination of the motility of the stomach can seldom be employed, except in cases where the motor insufficiency gives rise to such characteristic symptoms that the evidence they afford can, as a rule, be only corroborative.

The Power of Absorption of the Stomach.

The absorptive power of the gastric mucous membrane may be tested with potassium iodide. Penzoldt* recommends small doses of this salt, 0·1 grm. (gr. 1½), enclosed in gelatine capsules. A capsule is given, and the time which elapses before iodine appears in the saliva is determined by means of the ordinary reaction with starch paste. To perform this test a filter paper should be moistened with starch paste

* Penzoldt and Faber, *Berliner klin. Wochenschr.*, 1882, No. 21.

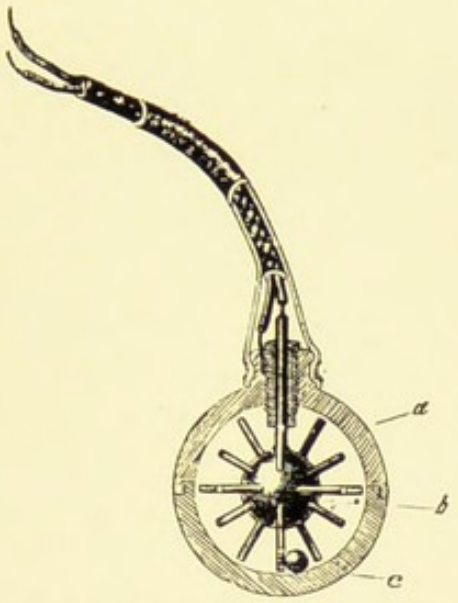

FIG. 5.—Einhorn's Gastrograph. (See page 111.)

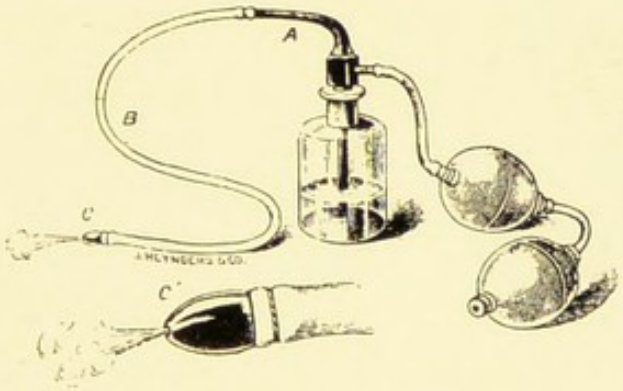

FIG. 6.—Einhorn's Gastric Spray. (See page 121.)

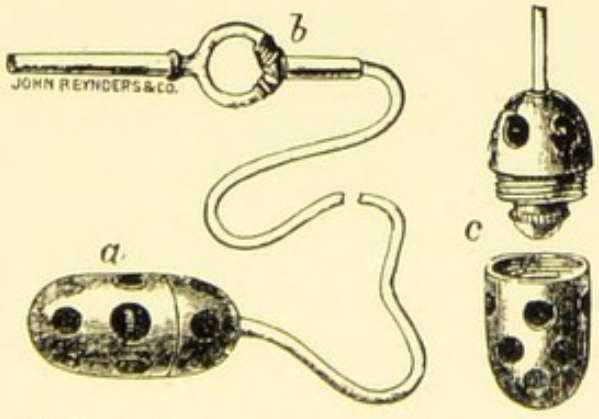

FIG. 7.—Einhorn's Deglutable Electrode.
(See page 127.)

and dried, and every five minutes after the capsule has been taken, a drop of the saliva placed upon it. The addition of a drop or two of fuming nitric acid will cause the appearance of a blue colour when iodine is secreted in the saliva. The time which elapses before this reaction can normally be obtained varies from ten to fifteen minutes, but may be delayed from thirty minutes to a whole hour, or even longer, when the absorptive power of the gastric mucous membrane is diminished. It should be remembered in connection with the test that, if the capsule be given without food, it may pass almost at once, indeed before solution of the gelatine, into the duodenum. It should, therefore, be always administered with or soon after food.

Another test makes use of rhubarb. Two grains of powdered rhubarb are given, and fifteen minutes afterwards the addition of liquor potassæ to the urine should cause the formation of a red colour.

Before using any of these tests in which the appearance of the drug in the urine is noted, it is necessary to be sure that the patient has not emptied his bladder immediately beforehand.

The Size and Position of the Stomach.

A description of the usual clinical methods for the determination of the size and position of the stomach does not enter into the scheme of this book. There are several methods, however, which may be legitimately described under this heading, without trenching on the purely clinical aspect.

One of the earliest instruments suggested for the determination of the lower margin of the stomach

consisted simply of a rigid bougie, the point of which could be felt, after introduction, through the abdominal wall. This method was found to be not unattended with risk, and has consequently been abandoned.

Einhorn's Gastrodiaphanoscope and Turck's Gyromele are described elsewhere (pp. 132, 161).

When instruments cannot be used, Dehio* directs that the patient should be percussed both when lying down and when erect, after drinking various quantities of water. He says that the normal stomach when empty is entirely within the thorax, and is not percussible ; that a quarter of a litre of water produces a dull area, extending 11½ cm. below the xiphi-sternum, in the erect posture ; and that a second draught of the same amount lowers the dullness to 2·7 cm. A litre causes it to reach to almost the level of the umbilicus, generally to within an inch of that spot.

On the other hand, Jaschtschenko† avers that the empty and normal stomach is percussible, and that filling it with water causes an upward, not a downward, extension of dullness.

In cases where much difficulty is experienced in distinguishing the percussion note of the stomach from that of the colon, the stomach may be filled with water, and the colon with air *per anum*, when the sharp demarcation between the dull note of the stomach and the tympanitic resonance of the bowel can readily and accurately be determined.

If the colon be loaded, the reverse method may be used. The patient is given some bicarbonate of soda

* *Separat Abdruck aus den Verhandlungen des Congresses f. innere Med.*

† *St Petersburg med. Woch.*, 29, 1888.

in solution, and then a corresponding amount of tartaric acid. The evolution of carbonic acid gas, which results, expands the stomach, and renders the percussion note over it tympanitic, in marked contrast to the dull note of the loaded colon. Another way is to pass the stomach tube and expand the stomach by blowing down it, and has the merit of being quite free from risk.

Fleming * suggests a method of combined percussion and auscultation, whereby the slightest change in the note can be detected by a stethoscope placed over the stomach region, where it is uncovered save by the abdominal wall.

Splashing Sound, or Clapotement.

The sound caused by the movements of the gastric contents when the body is shaken, or the abdominal wall over the stomach strongly percussed, indicates the presence of both fluid and gas in it. It is often obtainable in healthy subjects, and indicates nothing unless the sounds be abnormally loud, or obtainable by percussion below the normal lower limit of the stomach. Percussion for this purpose is best performed with the edge of the hand; but in some cases of dilated stomach, with thin and lax parietes, tapping with the finger may suffice to produce it. Normally, percussion elicits a splashing sound not lower than midway between the sternum and the umbilicus, and then it is only feeble. In atonic conditions the splashing sounds are heard in the same region, but may persist for four to six hours after a

* *Edin. Hosp. Reports*, Vol. I.

meal, denoting delayed emptying. In simple enlarged stomach — Ewald's megalogastria — the splashing sound may be produced as far down as the umbilicus, while in cases of pronounced dilatation it may be elicited more or less over the whole of the anterior abdominal surface. The localisation of splashing sounds to a somewhat circumscribed area about the umbilicus and below it, and the absence of these sounds higher up, are suggestive of possible gastroptosis. But it must be remembered that forcible percussion of one part of the abdomen often suffices to elicit splashing sounds, although the stomach does not occupy a position directly beneath it. The actual spot under which the sound is produced can in some cases be more accurately determined by combining auscultation with percussion. Another point to be kept in mind is the frequent disappearance of "clapotement" sounds after the first few strokes, owing to the resultant stimulation of the muscles in the gastric walls, and their consequent contraction.

The Determination of the exact quantity of the Stomach Contents.

As a rule the quantity of chyme can be estimated from the amount of fluid obtained through the stomach tube. In many cases, especially where the stomach walls are lax, all the fluid cannot be withdrawn. Mathieu and Remond * suggest that in such circumstances a small portion of the contents should be removed through the stomach tube, and, without removing the tube, a measured amount of water

* *Soc. de. Biologie*, Nov. 8, 1890.

poured down it. The patient now, by shaking himself, etc., mixes the water and the stomach contents, a sample of which is withdrawn.

The difference between the acidities of the undiluted and the diluted samples affords evidence of the total quantity present.

Thus, if b represent the undiluted portion ; a, its acidity ; q, the amount of water added, and á the acidity of the diluted contents :

$$ax = áq + áx$$

$$\text{or} \quad x = \frac{áq}{a - á} \text{ so that } x = b + \frac{áq}{a - á}$$

That is, the quantity of the original contents is equal to the number of c.c. of water added, multiplied by the acidity present after its addition, divided by the result of subtracting the second acidity from the first, and adding the portion withdrawn on the first occasion.

Example.

Ten c. cm. withdrawn with an acidity of 0·365 per cent. 200 c. cm. of water added, and another sample withdrawn with an acidity of 0·3285 per cent.

$$x = 10 + \frac{0{\cdot}3285 \times 200}{0{\cdot}365 - 0{\cdot}3285} = 1810 \text{ c. cm.}$$

CHAPTER IX.

THE MECHANICAL METHODS USED IN THE TREATMENT OF THE DISEASES OF THE STOMACH.

Lavage — Auto-lavage — Friedlieb's Apparatus — Gastric Spray (Einhorn)—Needle Douche (Turck)—Treatment by Electricity—Apparatus—External Electrisation—Internal Electrisation—Illumination of the Stomach—Diaphanoscope (Einhorn)—Other Instruments—Gyromele (Turck, Boas)—Massage.

The Process of Washing Out the Stomach (Lavage).

THE method of introducing the stomach tube has already been described. It only remains, therefore, to add a few particulars concerning the process of washing out the stomach. After the tube has been passed down and some of the contents of the stomach removed for the purpose of analysis, warm water is introduced into the stomach, until the patient signifies uneasiness from distension of the organ. The funnel is then depressed, and the fluid with the remaining portion of the contents syphoned off into a pail or basin. This process is repeated until the water returning through the tube is clear. As, in many instances, the pouring of the water into the funnel carries down a considerable proportion of air with it into the stomach, often causing the patient much pain

and discomfort, and as this air is frequently expelled through the tube again at unexpected moments, it is a good plan to hold the funnel in the left hand, and, compressing the tube just below with the little finger, to only allow the water to pass slowly down when the funnel is full. If this is not done, and the water is allowed to run down as fast as it is poured in, much air is carried down with it. If the return flow of water from the stomach is checked at any time, generally owing to blocking of the eyes of the tube with solid particles in the contents, the funnel should be raised, a little more water poured down to dislodge the obstruction, and the funnel again depressed. Usually some small portion of the fluid introduced remains behind when syphonage alone is relied on to empty the stomach. In this case expression by pressure over the epigastrium may be resorted to.

Several solutions have been recommended to be used for washing out the stomach. The best seems to be one made by adding a few drops of a solution of permanganate of potash to warm water until it becomes light pink in colour. A 3 per cent. solution of boric acid, 2 to 4 per cent. of bicarbonate of sodium, or a 1 per cent. solution of common salt may also be used. The permanganate of potash solution has this advantage over the others, that when the stomach is thoroughly washed out and all the contents removed, the returning fluid retains a pink colour; but should any of the contents still remain, the fluid returned is of a brown hue.

Auto-lavage.—The foregoing method cannot be used by the patient himself. When a patient, therefore, is instructed to personally continue the process

of lavage, another method is called for. In this, the stomach tube is connected by a glass T or Y tube to a rubber tube running from a reservoir filled with the warm solution to be used, and to another leading into the receiving pail (Frontispiece). The rubber tube leading from the reservoir is furnished with a pressure clip close above the upper limb of the T or Y tube, and a similar clip is placed on the corresponding part of the lower tube, rather further away from the glass connection (see p. 165 Appendix).

The reservoir, for which an ordinary metal douche-can may be advantageously employed, capable of containing at least two litres, is filled with the warmed solution and hung on to a nail fixed in the wall a little above the level of the patient's head when sitting down. The clip on the tube leading from it must be closed beforehand. The tube leading from the lower limb of the T is conducted into a pail placed on the floor, or directly into a sink, if convenient. The clip upon this tube is also closed.

The patient now introduces the stomach tube, attaches the upper end to the free limb of the T tube, and pressing the clip on the tube leading from the reservoir, allows the warm water to enter the stomach. When the stomach is full of fluid, the lower clip is opened a short time before the upper is closed. The water from the reservoir at once fills the lower tube in preference to that going to the stomach, following the path of least resistance, and if the upper clip be now closed, syphon action—sufficient to empty the stomach through the lower tube—is started. This process is repeated until the outgoing fluid is clear or almost clear.

Friedlieb's Apparatus. — Another very simple method by which auto-lavage can be satisfactorily performed is by Friedlieb's apparatus. This consists of a stomach tube provided with a bulb at a part sufficiently far from the end of the tube to remain outside the lips after introduction of its extremity into the stomach. Compression of the bulb, followed by closure of the tube beyond it by pressure of the fingers, causes, by its succeeding expansion, the stomach contents to be drawn up into it. Closure of the tube between the bulb and the lips and compression of the bulb forces the contents out through the funnel at the distal end. The bulb need only be used if ordinary syphonage proves to be insufficient.

*Einhorn's Gastric Spray.** This instrument consists of a stomach tube in which the usual eyes are replaced by a terminal bulb, having at its extremity a small aperture (Fig. VI.). The tube is introduced into the stomach, which must be empty—*i.e.*, after lavage or fasting—the outer end attached to a spray-producer, and the indiarubber pump compressed in the ordinary way. The spray should be set in action whenever the nozzle has entered the cardiac orifice; that is, when the tube has been passed in beyond the teeth of the patient for a distance of 18 inches (45 cm).

Antiseptic, analgesic, and astringent solutions may be used for spraying the stomach in this manner. The inventor employs a 1 to 2 per thousand solution of silver nitrate, 10 c.c. at a sitting, in cases of gastric

* *New York Med. Journ.*, Sept. 1892.

erosions,* or of hypersecretion with hyperchlorhydria.†

Turck's Needle-Douche.—Dr Turck demonstrated an apparatus which he called a 'stomach needle-douche' at the meeting of the American Medical Association in May 1895. Two tubes are attached to each other, side by side. One is of smaller calibre than the other, and is only intended to reach the stomach cavity immediately beyond the cardiac orifice. The larger is continued further, and should extend as far as the lowest part of the larger curvature. The smaller and shorter tube is supplied with a small perforated bulb at its extremity, or is perforated by minute holes towards the lower end, where it terminates in a blind extremity. The ball or bulb possesses the advantage that it can be removed and cleaned, and that the tubes may be used without it, a nebulizer being employed instead. Hot or cold water, or both alternately, are forced through the smaller tube under the pressure of a force-pump. A shower bath is thus produced in the stomach, and, if considerable pressure be employed, mucus and adherent material can be removed from the walls, and a powerful vasomotor and muscular stimulating action induced. The larger tube serves to drain off the fluid introduced, and thus to prevent any overdistension of the stomach (*c.f.* Fig. XIV., p. 164).

Indications for Lavage.

Lavage is of service, apart from its value for diagnostic purposes, whenever stagnation of food in the

* *Berlin. klin. Wochensch.*, 20-21, 1895.

† *Med. Record*, Nov. 23, 1895.

stomach is present, when there is much mucus in the organ, in cases of hyperacidity, and in many of the various forms of nervous dyspepsia. In cases of nervous origin the mere act of washing out the stomach is often followed by a great amelioration of the symptoms, owing more, perhaps, to stimulation of the nervous system and to mental suggestion than to the actual removal of contents which are often normal in character.

Some recommend lavage in the morning before or after breakfast; others prefer the evening before bedtime. In severe cases of dilated stomach with hypersecretion, it may be required before breakfast and before the evening meal, to remove the stagnating remains of food and to permit of the digestion of the food under as favourable circumstances as possible.

If the patient suffers from insomnia or restlessness during the night from auto-intoxication due to absorption of the products of gastric fermentation, lavage before going to bed is often followed by marked relief. As a rule the best hour of the day, should sleep be undisturbed, is before breakfast, when as much nourishment has been extracted from the ingesta as possible. If sleep is not affected the fermentative processes are seldom very active or deleterious. After lavage, some light nourishment should at once be taken; liquids such as milk and potash water, or bovril, may be administered by the tube before withdrawal.

If lavage is practised more than once daily, care must be taken to avoid emptying the stomach shortly after each meal. Absorption, in most of the cases in which lavage is beneficial, is slow, and the regular removal of the food within four or five hours of its

ingestion practically starves the patient. Patients, however, with largely dilated stomachs, due to non-malignant contraction and narrowing of the pyloric orifice, in whom little or nothing can pass into the duodenum, may derive much relief from the artificial removal of the contents before each meal.

Lavage is contra-indicated under the same conditions noted already as rendering the passage of the tube inadvisable or dangerous. When the tube is easily tolerated, however, lavage may be practised in conditions which forbid the use of the stomach tube, because its passage occasions violent retching and discomfort.

Treatment by Electricity.

The application of the Faradic and Galvanic currents is often of service in the treatment of some forms of dyspepsia.

The application may be made in two ways:—

1. Both electrodes may be placed upon the skin.
2. One electrode may be introduced into the stomach, the other applied to the skin.

Apparatus Required.

1. *The Battery.*—The best form of cell for generating the current is the Léclanché-Barbier, as recommended by Herschell. In this cell the outer case is made up of zinc, a cone of carbon occupies the centre, and the space between is filled with a jelly containing chloride of ammonium. The carbon cone is hollow, and when the jelly becomes too dry, it may

be moistened by the introduction of a solution of chloride of ammonium into its cavity.

2. *A Dial Collector, or a Rheostat.*—The first should be so constructed that the cells used can be taken from any part of the series. The rheostat, by diminishing the resistance, allows the gradual application of an increased current to the part treated.

3. *A Galvanometer.*—The best form for use is what is known as a 'dead-beat' galvanometer, in which the needle moves back at once to its original position without oscillation.

4. *De Watteville's Key.*—This is necessary to allow of a reversal of the current, or a change in the form of electricity.

5. *A Faradic Coil.*—With a key for turning the current on, and two or three cells for generating it.

6. *Conducting Cords (Rheophores) and Electrodes.*—The conducting cords should be of considerable length. Many forms of electrodes have been recommended, both for external and internal use.

1. External Electrodes.

(*a.*) *For use where both electrodes are placed on the skin.*—For the purpose two large flat electrodes are employed. The one is applied to the anterior abdominal wall over the gastric region, the other placed on the side close by. Or, if it is desired to apply the current to the sympathetic in the cervical region, the electrode placed on the skin over it should be smaller—*i.e.*, two and a half by one and a quarter inches.

Ziemssen got good results by using electrodes of

about 500 to 600 square centimetres in area (80 to 100 square inches), a strong galvanic current, and brief faradisation of the skin of the abdomen, chest, and back. The surface of the electrodes for application to the skin should be covered with flannel, spongio-piline, or better, a sponge may be used. A serviceable electrode consists of a sponge about five inches in diameter carried on in a wooden base (Herschell); another, of a sponge about three inches across, in a vulcanite cup.

The advantages which accrue from the use of a sponge electrode consist in the greater ease with which it can be cleaned, and in the power it affords the operator of gradually increasing the strength of the current by increasing the pressure whilst applying it.

(*b.*) *For use when one electrode only is applied to the skin.*—In this case the best results are obtained with large electrodes. A flat electrode, six inches by four, covered with spongio-piline, answers very well. It is placed over the epigastrium.

2. Electrodes for Direct Use in the Stomach.

(*a.*) The simplest form of electrode for use in the stomach consists simply of an ordinary red-rubber stomach tube of large diameter, perforated with several small openings close to the end; if it has a lateral eye, this should be situated nearer the extremity than in the ordinary tube. A flexible metallic rod is also provided, with a rounded bulb at the lower end, very similar to that of an œsophageal bougie. This bulb fills up the lumen of the tube

completely when passed down it, and is of sufficient length to extend from the tip of the tube up to and beyond the terminal eyes. The rubber tube is passed into the stomach in the usual way. If it is made with one lateral eye of the ordinary size it can be used to wash out the organ and to introduce the water beforehand; the metallic rod is now introduced down the lumen. During the progress of the rod the patient should throw back his head as far as possible to straighten the curve of descent, as, although flexible, a metallic rod exerts considerable pressure outwards at the convexity of its curve, thus causing increased pharyngeal discomfort.

(*b.*) *Einhorn's Deglutable Stomach Electrode.*—Einhorn of New York has devised a novel form of electrode, in the shape of an ovoid hard-rubber capsule about the size of an almond. The capsule is perforated with numerous eyelets (Fig. VII.) and contains a small button electrode. The electrode is connected with a delicate wire covered with indiarubber, which is continuous with the rubber of the capsule. To use it, the patient drinks a glass of water, when fasting, or after a light meal, then opening his mouth widely the capsule is placed far back on the root of the tongue. Taking a mouthful of water and swallowing, the capsule passes easily over the pharynx, and finds its way into the stomach. A mark on the rubber cord, 16 inches (40 cm.) from the capsule, serves to denote when the electrode has reached the stomach—*i.e.*, when the mark comes to the teeth.

Once in the stomach the connecting wire is joined to the negative pole of the battery.

If on withdrawal of the capsule any resistance be

felt at the cardiac orifice of the stomach, no force should be used. Let the patient swallow once or twice, and at the moment when the larynx rises during deglutition, slight traction will serve to withdraw the electrode.

(*c.*) Ewald has modified Einhorn's electrode, and invented a very useful instrument. It consists of a hollow sound of rubber, about the size of a Nélaton's catheter No. 13, through which the wire is drawn. The wire terminates in an electrode very similar to that suggested by Einhorn, but the greater rigidity of the connecting tube renders it possible to exert some force on the electrode should its passage down be arrested in the œsophagus, as sometimes occurs during the use of Einhorn's instrument.

Details of the Application.

External Electrisation.

1. *Galvanisation.*—The electrodes used should be thoroughly soaked with warm salt and water, and it is as well to wash the skin with soap and water beforehand.

The connecting wire from the negative pole of the battery is attached to the electrode placed over the epigastrium in the direction of the long axis of the stomach. This electrode should be as large as possible. The positive and smaller electrode is applied on the left side of the abdomen, close to the first. If the patient be a male he can hold the larger electrode in position himself, and a sponge electrode may be used. In female patients the dress need only be

loosened, and an electrode covered with flannel used. The pressure of the clothes suffices to keep it in position.

The sitting should not last longer than from five to ten minutes, and the current used should be strong enough to cause marked contractions of the abdominal muscles, apart from the causation of pain.

The positive electrode may be placed on other parts of the body if desired; over the sympathetic in the neck, as Baradini* has recommended; or over the spinal cord, when the electrode may be slowly passed up and down the spine, or it may be fixed in one position.

2. *Faradisation.*—In applying this form of electricity two small electrodes may be employed, placed one or two inches apart over the stomach region; or a large flat electrode may be placed over the stomach, and another on some insensitive part, as over the buttocks. The application may last ten minutes, and the current used should be strong enough to cause muscular contractions. It is often advisable, especially in neurasthenic cases, to apply the current to the spinal region. The smaller electrode should then be slowly passed up and down the spine, and especial attention paid to the left side in the cervical region, to stimulate the left pneumogastric nerve which chiefly goes to the stomach.

The electric brush can be used if a more stimulating effect is desired, when the current should be just strong enough to produce sparks between the brush and the skin. The skin must be dried thoroughly beforehand.

* *Journ. de la Soc. Scient.*, 1891, No. x., p. 97.

Internal Electrisation.

As noted above, the application of the electric current directly to the stomach should only be undertaken after fasting, or after washing out the organ. To prevent any direct contact between the mucous membrane and the actual electrode, the stomach must be partially filled with water. If the case be one of great gastric dilatation, a considerable quantity of water may be required, as the current only affects those parts of the viscus in contact with the water.

Galvanisation.—The large electrode placed on the abdominal wall is connected with the positive pole, and should be moved about over the stomach region. The current used is of a strength equal to from 15 to 20 milliampères, and should not be continued for more than eight minutes at each sitting.

Faradisation.—The external electrode should be kept in motion over the skin of the gastric region, and current used as rapidly interrupted as possible. In this way the application is rendered much smoother. As before, the strength of current employed must be such as to cause muscular contractions without giving rise to pain.

Indications for the Use of Electricity.

In atony of the stomach walls.—Faradisation, both internal and external, acts most beneficially. If the atony be an accompaniment of neurasthenia, the continuous current should also be used.

In dilatation of the stomach.—The evidences of its effects here are very conflicting, but it acts beneficially in cases of moderate enlargement, especially if associated with nervous symptoms.

Gastralgia.—For this it may be used externally first, and, if necessary, directly to the stomach wall afterwards.

Hypochlorhydria.—The internal application of the interrupted current acts better in such cases than the use of the galvanic stream, or external electrisation.

Illumination of the Stomach.

Einhorn has invented an instrument for the direct illumination of the stomach cavity, by means of which a slightly luminous area, corresponding to the portion of the stomach uncovered by other tissues save the abdominal wall, can be seen on the anterior wall of the abdomen in a darkened room (Fig. VIII.).

The Gastrodiaphanoscope, or, as it has been more lately christened, the Gastrodiaphane, consists of a soft rubber tube, such as is usually employed in lavage, bearing at the end an Edison lamp of hard glass. The electric lamp is connected with a battery by two wires enclosed in the tube. The lamp is connected with the stomach tube by means of a metal mounting. The lamp and the mounting are of the same diameter as the tube. Before using the instrument on the human subject, it is as well to attach it to a battery, and, immersing the lamp in water, to test its stability by passing through it a somewhat higher current than is used when in the stomach. The patient should drink one or two full tumblers of water beforehand. To avoid all untoward consequences, the stomach should be almost full of water. When the current is turned on in a darkened room, a feebly-illuminated area of the abdominal wall may be seen. This area, in healthy people, corresponds to the portion of

the stomach uncovered save by the abdominal walls, and is situated below, and a little to the left of the xiphi-sternum. In dilatation of that organ, or in gastroptosis, the illuminated area takes a lower position, and a more rectangular shape. In some cases, under favourable circumstances—that is, when the abdominal walls are thinly clothed—thickenings and tumours of the gastric walls may be shown by a local decrease in translucency, or by an altered form of the luminous area. (Figs. IX-XI.)

It is evident that this instrument can only prove of value under favourable conditions. If the patient be stout, little or nothing can be seen, while a pyloric tumour is only perceptible when the end of the tube is able to be introduced below and behind it, as in a dilated stomach, where the greater curvature hangs down to a lower level than the tumour.

Other Instruments.

Turck's Gyromele.—Fenton B. Turck * describes in this journal an instrument which he had invented some time previously. Designed to indicate the position, shape, and size of the stomach, it is called the 'Gyromele,' and consists of a tube containing a cable, with a sponge at its extremity. An apparatus for producing rapid rotation of the cable and the sponge attached to its lower extremity is attached to the outer end. After introduction of the tube into the stomach, if the cable be passed onwards down it, the rotating sponge glides over the mucous membrane of the larger curvature, turns up towards the pylorus, and then along the smaller curvature. The positions

* *New York Med. Journ.*, Feb. 22, 1896.

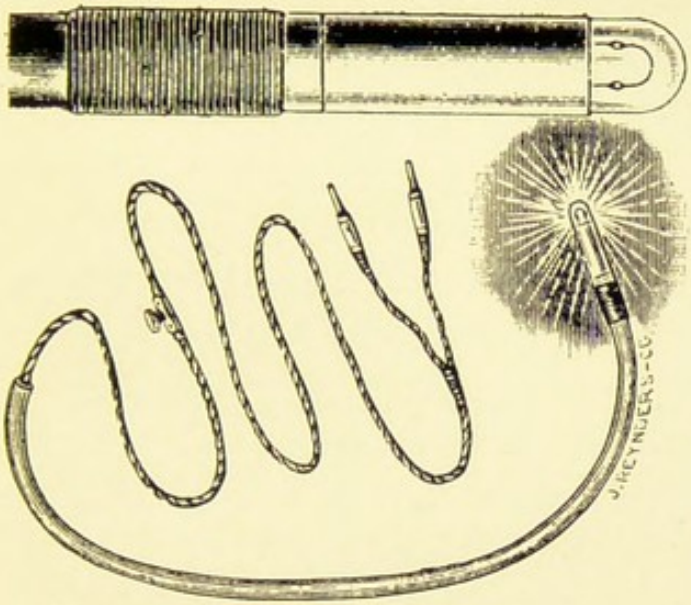

FIG. 8.—Einhorn's Gastro-Diaphanoscope. (See page 131.)

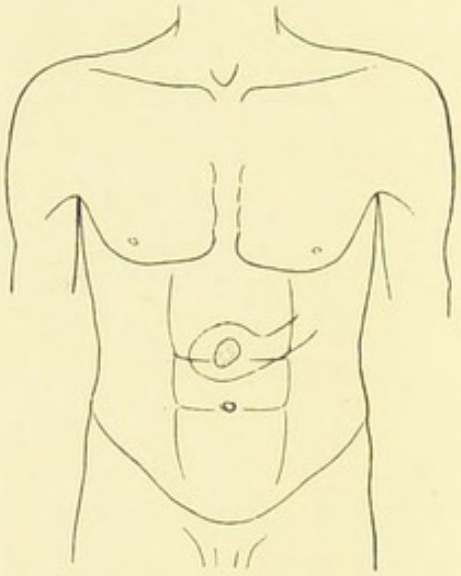

FIG. 9.—Normal transillumined area. (See page 132.)

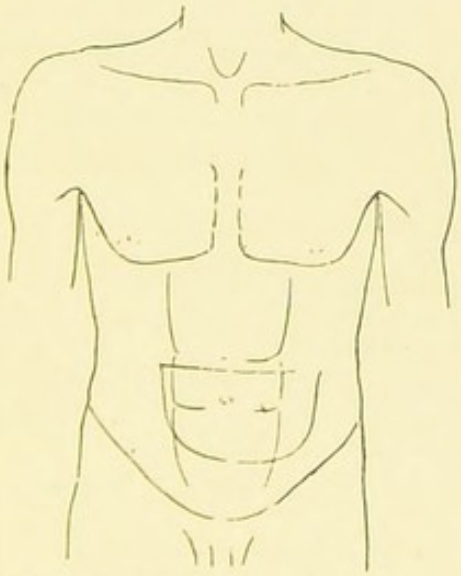

FIG. 10.—Area transillumined in Dilatation. (See page 132.)

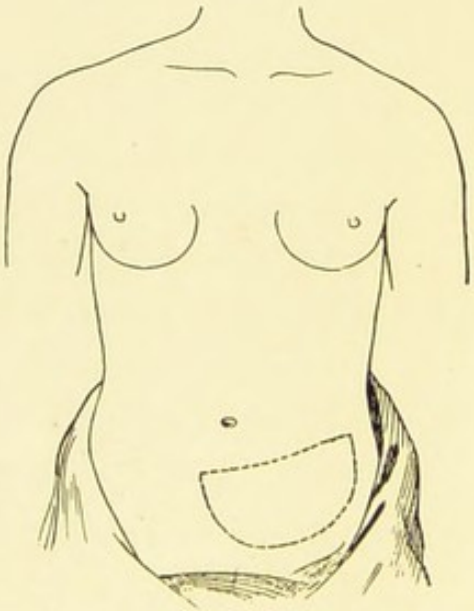

FIG. 11.—Area transillumined in Gastroptosis. (See page 132.)

of the cable and sponge can be easily felt through the abdominal wall if rotated rapidly. When cables of different flexibility are used, the distensibility of the stomach walls can be gauged. Thus a very flexible cable is used first and pushed in until it meets with resistance at the lesser curvature. The length introduced is noted. The revolving sponge is at the same time palpated through the abdominal wall, and the depth of descent ascertained. A stiffer cable is now used in the same way, and the difference between the length of the stiff cable which has been introduced before the resistance is felt and that of the more flexible one, serves to indicate the power of distension of the walls. (Fig. XII.)

The movements of the gyromele can sometimes be felt behind the liver, and in thin subjects the rotatory movements of the sponge can even be seen through the abdominal wall. If the stomach be prolapsed the sponge can be felt as it follows the lesser curvature below the margin of the liver. The revolving sponge acts also as a curative agent by removing any mucus adhering to the mucous membrane, can be used for the direct application of therapeutic substances, or as an electrode capable of applying the electric current topically to various parts of the organ. The vibratory effects arising from its use are often of service in cases of dilated stomach; the motor power of the stomach is stimulated, and the mucous membrane becomes more vascular from its rubbing or massage-like action.

Boas* uses a modified gyromele in which the sponge is attached to the end of a soft solid bougie,

* *Centralbl. f. innere Med.*, Feb. 8, 1896.

and the apparatus rotated as in Turck's instrument.

Massage of the Stomach.

Little need be said here about massage for stomach diseases. It is especially indicated in cases of dilated stomach, nervous dyspepsia, and, indeed, all cases with delayed motility. It may with advantage be combined with electrical treatment.

At first the patient should be placed on his back with his legs bent and his head slightly raised, two or three hours after a meal. Massage of the abdominal wall over the stomach is then begun, from the cardia towards the pylorus. The patient is then placed on his right side and *pétrissage* performed from over the pylorus towards the cardia. The sitting should last about fifteen minutes.

It has been found to shorten the duration of emptying of the stomach—by an hour in some cases.

In cases of moderate stagnation of the stomach contents, good may often accrue if the patient be told to lie on his right side at night, and to personally rub the epigastric region from the left side upwards and to the right.

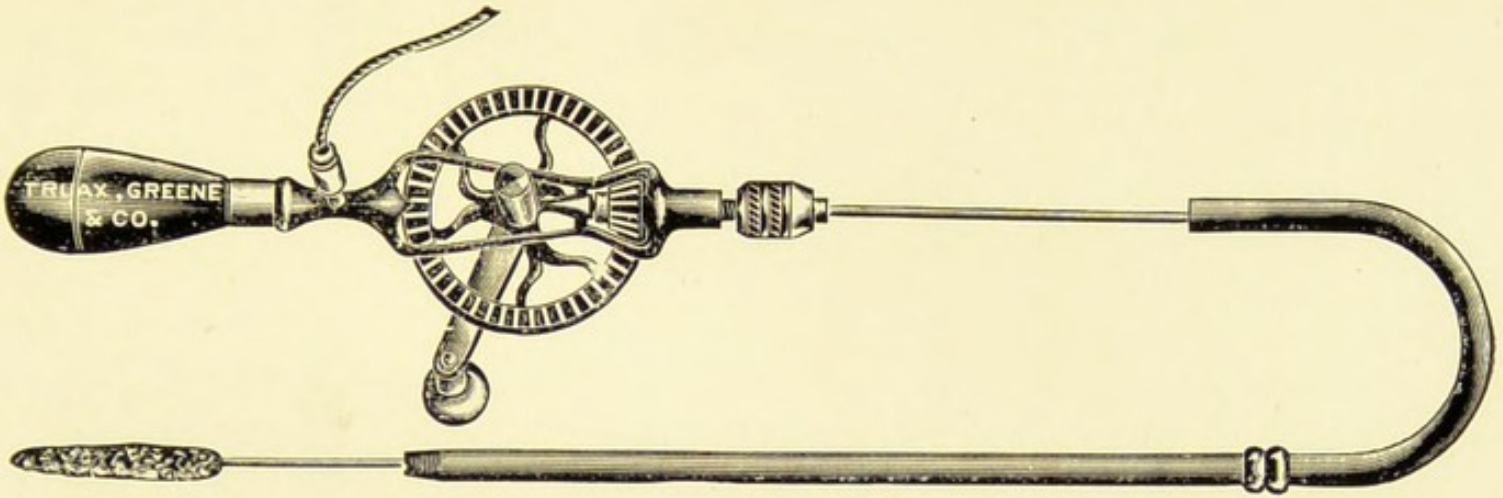

FIG. 12.—Turck's Gyromele. (See page 133.)

CHAPTER X.

THE MECHANICAL METHODS USED IN YOUNG CHILDREN.

By JOHN THOMSON, M.D., F.R.C.P. Ed.

Gavage—by the Nose—by the Mouth—Indications; Lavage—Method —Indications.

THE mechanical treatment of the stomach in young children may be considered under two heads—(1) *Forced Feeding, or Gavage;* (2) *Stomach Washing, or Lavage.* Both these measures are simple of application and of great value in suitable cases as therapeutic measures. At present, however, the use of the latter as an aid to diagnosis is limited to exceptional cases.

1. Forced Feeding, or Gavage.

Methods and Apparatus.—There are a great many devices by the use of which fluid food and medicine can be introduced into the stomach of a child who is unable or unwilling to swallow them in the ordinary way. In some of these the nose is used as the way of access to the pharynx, while in others the food is passed through the mouth.

(*a*) *Nasal Feeding.*—Of this there are several

methods. The *first* of these, and the simplest, consists in pouring a bland form of liquid nourishment into one nostril, through which it rapidly finds its way into the pharynx and is inevitably swallowed. In doing this, the child should be kept lying on his back, and his head must be held steady. The food given must, of course, be quite unirritating in character (*e.g.* milk). It is poured into the nose by means of a glass or rubber ear-syringe, over the nozzle of which a short piece of indiarubber tubing has been fitted; or a special spoon may be used, the sides of which are folded over near the point, so as to form a kind of narrow spout. The process of feeding must take place slowly, and regular pauses must be made to allow of swallowing.

The *second* method resembles the first in all respects, except that the rubber tube attached to the nozzle of the syringe is long enough in this case to reach through the nasal cavity to the nasopharynx. It is used when the fluid to be given is of such a nature as to irritate the delicate mucous membrane of the nose. When the fluid is bland, the first method is preferable, as the pressure of the rubber tube is itself a cause of irritation.

The *third* method consists in the passage of a tube through the nose, pharynx, and gullet into the stomach. For this a soft rubber catheter, No. 12 or No. 13 (French), is suitable. It is thoroughly oiled and passed backwards through the nose into the pharynx. This may be done with the patient lying on his back; but often, in older children especially, the sitting posture is preferable When the end of the catheter reaches the pharynx, there is often retching, and

some resistance is felt. The patient's head should then be inclined slightly forward and the tube pushed gently on. When it gains the œsophagus it generally ceases to irritate the pharynx; and, soon after, the passage of gas and liquid from its upper end indicates that it has reached the stomach.

The catheter occasionally passes into the larynx; this is not common, and its occurrence is at once announced by the onset of cough and dyspnœa. Much more frequently it finds its way forward into the mouth, and this is very apt to happen if there is much coughing or retching while the end of the catheter is passing the pharynx. When the catheter has reached the stomach and the retching has stopped, the food is introduced into it by a funnel or syringe.

Probably the best funnel for the purpose is a glass syringe of moderate size from which the piston has been removed. It fits into the catheter easily, and, should any obstruction occur in the process of feeding, the piston can be replaced and used to clear it away. While the catheter is being withdrawn, its end must be tightly compressed, lest the few drops remaining in it should get into the larynx in passing.

(*b*) *Forced Feeding by the Mouth.*—This is generally carried out by the passage of an œsophageal tube into the stomach. The apparatus required is the same as that used for stomach-washing, namely: a soft rubber catheter, connected by an inch or two of glass tube, and a foot and a half of rubber tubing with a vulcanite funnel, large enough to hold from 3 to 6 oz. The catheter should have one or two extra eyes, and its

size varies with the size of the child from No. 14 to No. 18 (French).

The child is placed flat on his back, his head being held steady by an assistant. The left forefinger is then placed lightly on the tongue to depress it, while with the right hand the catheter, well oiled, is passed down the pharynx for 8 or 10 inches. The stomach being reached, the funnel is raised for a few moments to allow the escape of gas. The food is now poured into the funnel and rapidly finds its way into the stomach. When the funnel empties, the tube is tightly compressed, and rapidly, but gently, withdrawn. If the withdrawal of the catheter is done slowly or carelessly, it is apt to excite vomiting. In infants who have no teeth, or only one or two, no gag is required. In older children some sort of gag is necessary, as there is otherwise danger of the tube being bitten. In them, however, the process is much more difficult than in babies, and not nearly so generally useful.

A simpler form of forced feeding (first recommended by Mr Scott Battams) often proves of great value. For this all that is necessary is an ordinary glass or ball syringe, to the nozzle of which four inches of rubber tube are attached. The child, who is refusing food, or who for some reason ought not to be allowed to suck in the ordinary way, is laid on his back, the tube is passed towards the back of the mouth, and the liquid is gently injected. In older children who close their teeth, the tube may easily be passed backwards inside the cheek, and the liquid thus readily reaches the pharynx.

Indications for Forced Feeding.

In children these are many and various, and the method chosen must depend on the requirements of the case in hand and on the nature of the fluid to be administered. The following are perhaps the most important conditions in which forced feeding proves valuable.

1. In the rearing of *premature infants*, periodic feeding, either through the nose with a spoon or by means of a catheter passed through the mouth, has been found of great use. It was first made use of by Prof. Tarnier of Paris.

2. Similarly, in young infants and others who are *so weak* that the effort of sucking and swallowing exhausts them, great benefit may be got from forced feeding either through the nose, or preferably through the mouth by Mr Scott Battams' method.

3. In some cases of prostration (*e.g.* in typhoid) there is *obstinate refusal of all food* and medicine to an extent which seriously endangers life. These cases may be effectually treated by one of the methods of nasal feeding or by the syringe and short tube.

4. The same methods are very serviceable when swallowing is interfered with by pain due to *ulceration of the mouth or throat.*

5. A few years ago, Dr Kerley drew attention to the fact that regular forced feeding by means of an œsophageal tube passed into the stomach was extremely useful in *persistent vomiting* in infants. Babies who are not able to retain even a teaspoonful of fluid swallowed in the ordinary way, can usually retain a much larger amount of nourishment if it is

poured into the stomach through a catheter. The explanation of this remarkable fact is obscure, but of the value of its application in practice there can be no doubt whatever.

6. When in *cerebral cases*, in cases of *narcotic poisoning*, and in *convulsive conditions* such as tetanus, the process of swallowing is interfered with, life may be prolonged and sometimes saved by forced feeding with a tube either through the nose or mouth. In the same way, in cases of *diphtheritic paralysis* affecting the pharynx, feeding through a tube is of the greatest value in keeping the patient alive until the part recovers its function.

2. Stomach Washing, or Lavage.

Methods and Apparatus.—A soft rubber catheter connected with a vulcanite funnel by 18 inches of tubing, such as is used for ordinary gavage, constitutes the best apparatus for stomach washing. The catheter used should be the largest that can be easily passed, and should have two or three eyes. Plain lukewarm water is probably as good as any other fluid.

The child is made to sit or lie on his mother's knee with his face looking towards her left side, and with his clothes and hers duly protected by a mackintosh sheet. A slight pressure on the chin generally makes him open his mouth, and the catheter is then passed gently backward over the tongue, and down the œsophagus, as already described in speaking of gavage. When the stomach is reached and the funnel has been momentarily raised to allow any gas present there to escape, the water is poured into it from an ordinary jug. In doing this one must be careful,

especially in weakly children, not to over-distend the stomach by running in too much water at a time, or by holding the funnel too high. When a sufficient amount of water has been introduced, the funnel is lowered, and the contents of the stomach rapidly fill it by syphon action, and are allowed to run away. The tube is then pinched to prevent the entrance of air, the funnel raised again and refilled with water, and the process repeated. The washing-out should be continued until fragments of curd, etc., cease to be found in the returning fluid.

Indications for Stomach Washing.

1. In so-called '*summer diarrhœa*' or '*milk infection*,' stomach washing, combined with irrigation of the lower bowel, constitutes the most rational and successful preliminary treatment. When first introduced it was supposed that it should only be employed in those children who were not very weak. It is now recognised that the weaker the infant the more important is it to wash out his stomach without delay, because the very active poisons to which the most alarming symptoms are due can be partially removed in this way. The process itself is practically without danger if carefully carried out.

2. In all forms of chronic vomiting of gastric origin in children, irrigation of the stomach may be useful; but owing to the practical difficulties met with in its application to older children, its use is mainly confined to babies. In a great many cases one washing-out is sufficient to initiate improvement in the symptoms; in others, the process may have to be repeated daily for several days. Not infrequently in an infant who

has been vomiting several times a day for weeks, the symptom will cease altogether after one washing-out of the stomach. This may be the case even when, owing to blocking of the tube with curd, the irrigation has been so imperfectly carried out that no improvement is expected. Further, it has been found that in some cases mere passing of the stomach tube, and holding it in position for a minute or two, seems to exert a favourable influence and stop the vomiting. The writer is not prepared to give a satisfactory explanation of this curious fact, but has observed it sufficiently often to be sure that the improvement which follows in these cases is more than a mere coincidence.

References.

W. Scott Battams.—*Lancet,* June 16 and 23, 1883.
L. Emmett Holt.—*New York Med. Record,* April 28, 1894.
Chas. G. Kerley.—*Archives of Pediatrics,* February 1892.

CHAPTER XI.

CLASSIFICATION OF GASTRIC CONDITIONS.

In Relation to the Variations in the Acidities — To the Digestive Power—To the Duration of Digestion.

Classification of Gastric Conditions in relation to the Acidities Present.

1. ACIDITY NORMAL.

Total acidity rising to 0·25-0·35 per cent. HCl.

Free hydrochloric acid present up to 0·1 per cent.

Lactic acid in traces in early stages.

Hydrochloric acid combined with proteids, increasing until third stage, 0·2-0·3 per cent.

No free HCl in first stage, unless food be free of proteids.

In health. (Free HCl may be absent during most of digestion, if the food taken be in large bulk, and chiefly of proteids.)

In dyspeptic symptoms, and hæmorrhage, from congestion of the liver.

Gastric erosions (occasionally).

Carcinoma of the cardiac end, or of the œsophagus.

Sometimes in pyloric carcinoma, especially if arising after previous ulceration.

In many cases of nervous dyspepsia, and dyspepsia accompanying anæmia, or chlorosis.

2. INCREASED ACIDITY. HYPERACIDITY.

(*a.*) *Due to an increase of Hydrochloric Acid.*

Total acidity high, 0·3-0·45 per cent.

Free hydrochloric acid in excess, 0·2-0·3 per cent.

Combined hydrochloric acid normal.

Free HCl appears early.

First stage, therefore, short, and lactic acid may be absent.

After a large proteid meal acidity may rise to a high point.

In most cases of gastric ulcer, and of gastric erosions.

From nervous causes. (Simple hyperchlorhydria.)

In some cases of dilated stomach.

Hypersecretion of gastric juice. (Gastrosuccorrhœa continua periodica, *vel* chronica. Reichmann's disease; Gastroxynsis. Rossbach's disease.)

(*b.*) *Due to an increase of Organic Acids along with lessened secretion of Hydrochloric Acid.*

Total acidity high but variable, 0·3-0·8 per cent.

Free hydrochloric acid absent or only in traces.

Combined HCl generally small in amount.
First stage long, lactic acid present.
Lactic and volatile fatty acids present during later stages.

In carcinoma of the pylorus and adjacent parts.
Dilatation of the stomach ; *a*, with pyloric obstruction ; *b*, with atony of walls.
Atonic dyspepsia, and chronic gastric catarrh.

In some cases of nervous origin, functional in character.

In the later stages of chronic ulcer, owing to catarrh.

3. HYPOACIDITY.

(*a.*) *Acidity composed chiefly of Hydrochloric Acid.*

Total acidity low, 0·05-0·15 per cent.
Free HCl absent, or in traces.
Combined HCl small in amount, 0·05-0·1 per cent.
All stages prolonged ; lactic acid present in first, or throughout.
Traces of volatile organic acids present.

In Hypochlorhydria, without fermentation.
Acute gastritis, during recovery, or at commencement.
Carcinoma of the stomach, without bacterial fermentation.
Cirrhosis ventriculi.

In moderate dilatation of the stomach without fermentation.
During acute or chronic febrile and suppurative disorders.

(*b.*) *Acidity due to Organic Acids.*

In extreme cases of atrophy of the mucous membrane of the stomach; in cancer; waxy degeneration; cirrhosis; phlegmonous gastritis; and in the most acute stages of febrile diseases.

Here little or no hydrochloric acid is secreted, and any acidity which may be present is due to the organic acids of fermentation.

From the table given above, it will be seen that different conditions may accompany the same disease or form of gastric disorder. The variations are due very largely to the absence or presence of bacterial fermentation, and, in a less degree, to the existing amount of motility possessed by the stomach walls.

The main indications consist in the recognition of the amount of acidity per cent. of the contents, and the determination of the proportion of the total acidity, which is composed of hydrochloric acid, free or combined. The nature of the acids producing the acidity not due to hydrochloric acid affords a means of recognising the nature of the fermentative process at work in each individual case.

Classification in Relation to Digestive Power.

1. NORMAL OR INCREASED.

Hydrochloric acid and pepsin may be increased.

In health.

Gastric ulcer, and gastric erosions.

Hyperchlorhydria.

Many cases of nervous dyspepsia.
Many cases of cancer of œsophagus and cardiac end of stomach.
Early stages of catarrh.
Early stages of dilated stomach from pyloric obstruction, not due to cancer.
Hypersecretion.

2. DIMINISHED.

(*a.*) *Due to diminution of Hydrochloric Acid.*

Cancer of pylorus and body, earlier stages.
Chronic catarrh, early stages.
Severe nervous depression.
Dilated stomach.

(*b.*) *Both Hydrochloric Acid and Pepsin diminished or absent.*

Atrophy of mucous membrane.
Cancer of pylorus and wall in the later stages.
Chronic catarrh, later stages, or with atrophy of cells.
Dilated stomach if accompanied by catarrh.
Acute gastritis.
Acute fevers.
Phthisis, especially towards the end.
Cirrhosis of stomach.

Speaking generally, in functional disorders of the stomach there is seldom any marked diminution in the secretion of pepsin, although the amount of hydrochloric acid may be much lessened. In organic diseases the secretion of the acid is affected before that of the pepsin, but the latter is markedly diminished in the course of time.

Classification in Relation to the Duration of Digestion.

1. NORMAL.

In health.
Megalogastria.
Gastroptosis without dilatation (may be slightly delayed).
Gastric ulcer (may be shortened).
Hyperchlorhydria (may be shortened), and hypersecretion.
Gastric erosions.

2. LENGTHENED.

(*a.*) *From decreased motility.*

Dilated stomach.
Cancer of pylorus, early stages.
Many cases of nervous dyspepsia.

(*b.*) *From decreased digestive power.*

Atrophic catarrh.
Acute gastritis.
Cancer of walls and cardiac end.

(*c.*) *From both causes.*

Cancer of pylorus, later stages.
Cirrhosis of stomach, and dilated stomach with catarrh.
Many cases of nervous dyspepsia.

CHAPTER XII.

THE APPARATUS AND REAGENTS REQUIRED IN THE EXAMINATION OF THE STOMACH CONTENTS.

Apparatus—Reagents—Tables of Standard and Deci-normal Solutions —and of their Equivalents.

1. APPARATUS.

(*a.*) *For the usual clinical methods, without special arrangements.*

Pipettes to hold 2, 5, and 10 c. c.

Pipettes are usually more accurately graduated and satisfactory than the ordinary measure-glasses.

Measure graduated in cubic centimetres to hold 50 or 100 c. c.

Two or three urine glasses.

Iron tripod and copper gauze.

Porcelain evaporating basins, to hold 20 to 100 c. c.

Glass beakers, as thin as possible, to hold 50, 100, and 1000 c. c.

Spirit lamp, or Bunsen burner.

Glass funnels, 3 and 6 inches in diameter.

Test tubes.

Filter papers.

Glass rods.

Two burettes to hold 50 c. c., graduated in 5ths of a c. c., preferably with Shellbach's band.

Burette stand, double.

Water bath. This may be dispensed with when evaporating fluids, by floating the evaporating dish on water in a larger basin; the addition of some common salt to the water in the outer basin hastens the process of evaporation as its boiling-point is raised.

Half-a-dozen fireproof porcelain crucibles, to hold 20 c. c.

Microscope.

(*b.*) *When special analytical facilities are accessible.*

In addition to the apparatus detailed above:—

Drying chamber, capable of being kept at a constant temperature: 100° or 110° C.

Separating funnels.

Sand-bath.

Balance, to weigh to 0·001 grm.

Nickel, or platinum capsule.

Carbonic acid apparatus.

Bacteriological requisites.

Gas-volumetric apparatus, for Mierzynski's method.

2. SOLUTIONS.

Colour Reagents.

Alcoholic.

1. Phenol-phthalein, 2 to 4 per cent.
2. Congo red, saturated.
3. Günzburg's.

   Phloroglucin, 2 grm., gr. xxx.

   Vanillin, 1 grm., gr. xv.

   Absolute alcohol, 30 c.c., ℥j.

4. Boas' reagent.
   Resorcin, 5 grm., gr. lxxv.
   White sugar, 3 grm., gr. xlv.
   Dilute alcohol, 100 c.c., ʒiijss.
5. Dimethyl - amido - azo - benzol, 0·5 per cent. in absolute alcohol.
6. Cochineal.
7. Tropæolin OO, 1 in 30.

Watery.

1. Litmus. (A more delicate solution of this dye is that termed Azolitmine. Powdered litmus is extracted with boiling water, evaporated to small bulk, acidified with acetic acid, further evaporated almost to dryness, and then precipitated with 85 per cent. alcohol. The precipitate is collected, dissolved in water, and a drop of chloroform added to preserve it. *
2. Benzo-purpurin. Saturated solution.
3. Mohr's reagent.
   10 per cent. solution of potassium sulphocyanide, 2 c.c., ʒss.
   Solution of acetate of iron (neutral), 0·5 c.c., ♏ viij.
   Distilled water, 20 c.c., ʒvj.
4. Perchloride of iron, diluted with water until almost colourless.
5. Uffelmann's reagent.
   A few drops of a dilute perchloride of iron solution.
   10 c.c. of 2 to 5 per cent. carbolic acid (ʒijss).

* *Pharmaceut. Journ.*, vol. lvi, March 7, 1896.

6. Sodium-alizarin-sulphonate, 1 per cent. in water.

Other Solutions.

1. Lugol's solution. Iodine, 0·1 grm., gr. iss.
   Potassium iodide, 0·2 grm., gr. iij.
   Distilled water, 200 c. c., ℥vj., 3vj.
2. Deci-normal solutions of:—
   Caustic soda, 4·0 grm. in 1000 c. c.
   Hydrochloric acid, 3·65 grm. in 1000 c. c.
   Silver nitrate, 17·0 grm. in 1000 c. c.
   Sulphocyanate of ammonium, 7·6 grm. in 1000 c. c.
3. Standard Solutions.
   1. Silver nitrate, 29·075 grm. in 1000 c. c., 1 c. c. 0·01 grm. NaCl, or 0·00624 grm. HCl.
   2. Fehling's solution, 10 c. c. = 0·05 grm. glucose; and sulphate of copper, 5 per cent.
      Caustic soda, 10 per cent.
      Hydrochloric acid.
      Acetic acid.
      Nitric acid.
      Trichloracetic acid, 10 per cent.

Tables of Standard Solutions and Equivalents used in the Different Methods.

Normal and Deci-normal Solutions.

Normal solutions of all chemical bodies for use in analysis contain in each litre the exact amount of each substance in grammes which corresponds to its molecular weight.

Deci-normal solutions are formed from normal solutions by diluting them ten times with distilled water.

Thus sodium hydrate with a molecular weight of 40 (23 + 1 + 16) forms a normal solution in water when each litre contains 40 grammes, or a deci-normal solution when the litre contains 4·0 grm. A known quantity of a normal solution of one substance is exactly equivalent to the same quantity of a normal solution of another.

Thus a normal solution of hydrochloric acid contains 36·5 (1 + 35·5) grm. in each litre, or 3·65 grm. in the same quantity of its deci-normal solution. 1000 c. c. of either solution exactly neutralises 1000 c. c. of the corresponding solution of sodium hydrate.

If the substance used be dibasic or tribasic, the amount in each litre of its normal solution is only one-half or one-third of its molecular weight.

So as H_2SO_4 is dibasic, its molecular weight being 98 (2 + 32 + 64), only 49 grm. are contained in each 1000 c. c. of its normal solution. Similarly, oxalic acid (126) forms a normal solution with 63 grm. per litre.

Deci-normal solutions are generally employed in the analysis of gastric contents.

To make a deci-normal solution of sodium hydrate, for example, a little more than 4·0 grm. of caustic soda should be dissolved in about 900 c. c. of distilled water, and more water added up to the 1000 c. c. It is then titrated against a standard deci-normal solution of an acid, of which a small quantity of guaranteed accuracy can be obtained from a chemical laboratory. If 10 c. c. exactly

neutralise 10 c. c. of the acid solution, the solution is of the proper strength. If, however, 9·8 c. c. suffice to turn litmus or phenol-phthalein blue or pink respectively, 2 c. c. of water must be added to each 9·8 c. c., or 20 c. c. to each 980, to correct the error.

When more of the soda solution than of the acid is used, it is too weak, and more soda must be added. It is easier to add an excess at once, and then to calculate the additional water required, than to try to add the exact amount of soda.

The solution as corrected must again be standardised against the acid, and any necessary correction made.

If the solution of soda be used uncorrected, as for instance when 9·8 c. c. corresponds to 10 c. c. deci-normal acid, the proper result of a titration with it can be obtained by regarding each 9·8 c. c. as equal to 10 c. c. of the acid. So if hydrochloric acid be used, and 9·8 c. c. of the soda neutralises 10 c. c. of the acid, 9·8 c. c. is equivalent to 0·0365 grm. HCl.

If the quantity of the stomach contents titrated be 10 c. c., the amount of acid equivalent to the number of c. c. of deci-normal soda solution added, multiplied by 10, will give the acidity per cent. in terms of the acid value made use of in the calculation. If 5 c. c. are titrated the amount obtained is multiplied by 20, or if only 2 c. c., by 50, to obtain the percentage acidity.

Thus 10 c. c. of a stomach contents required

7·5 c. c. $\frac{N}{10}$ soda = 0·02737 grm. HCl.

5 c. c. „ 3·75 c. c. „ = 0·013687 grm. HCl.

2 c. c. „ 1·5 c. c. „ = 0·00547 grm. HCl.

Multiplying the first by 10, the second by 20, and the third by 50, the acidity *per cent.* as HCl is 0·2737.

TABLE to show the Acidity per cent. in terms of HCl when 10 c. c., 5 c. c., and 2 c. c. of the stomach contents are titrated in relation to the quantity of Deci-normal Sodium Hydrate Solution used.

$\frac{N}{10}$ NaHO. c. c.	HCl in grammes.	HCl per cent.		
		10 c. c. titrated.	5 c. c. titrated.	2 c. c. titrated.
·1	0·000365	0·00365	0·0073	0·01825
·2	0·00073	0·0073	0·0146	0·0365
·3	0·001095	0·01095	0·0219	0·05475
·4	0·00146	0·0146	0.0292	0·073
·5	0·001825	0·01825	0·0365	0·09125
·6	0·00219	0·0219	0·0438	0·1095
·7	0·002555	0·02555	0·0511	0·127
·8	0·00292	0·0292	0·0584	0·146
·9	0·003285	0·03285	0·0657	0·164
1·0	0·00365	0·0365	0·073	0·1825
1·1	0·004015	0·04015	0·0803	0·20075
1·2	0·00438	0·0438	0 0876	0·219
1·3	0·004745	0·04745	0·0949	0·23725
1·4	0·00511	0·0511	0·1022	0·2555
1·5	0·005475	0·05475	0·1095	0·2737
1·6	0·00584	0·0584	0·1168	0·292
1·7	0·006205	0·06205	0·1241	0·31
1·8	0·00657	0·0657	0·1314	0·328
1·9	0·006935	0·06935	0·1387	0·346
2·0	0·0073	0·073	0·146	0·365
3·0	0·01095	0·1095	0·219	0·5475
4·0	0·0146	0·146	0·292	0·73
5·0	0·01825	0·1825	0·365	0·9125
6·0	0·0219	0·219	0·438	1·095
7·0	0·02555	0·2555	0·511	—
8·0	0·0292	0·292	0·584	—
9·0	0·03285	0·3285	0·657	—
10·0	0·0365	0·365	0·73	—

When the acidities are expressed in terms of hydrochloric acid, it is convenient, for purposes of comparison, to express the chlorine values in the same way.

Mohr's Standard Silver Nitrate Solution.

This solution contains 29·075 grm. of pure nitrate of silver in the litre, and each cubic centimetre corresponds to ·006 grm. of chlorine, or ·01 grm. of sodium chloride, or ·00624 grm. HCl:—

Thus
·029 × ·2088 = ·006 grm. chlorine.
·029 × ·3441 = ·01 grm. NaCl.
·029 × ·2147 = ·00624 grm. HCl.

To express chloride of silver in terms of hydrochloric acid, its weight is multiplied by 0·25427.

Solutions used in Martius and Lüttke's Method.

Deci-normal Acid Solution of Silver Nitrate.

17 grm., or, more exactly, 16·997 grm. of dry and pure nitrate of silver, are dissolved in 900 c. c. of a 25 per cent. pure nitric acid solution. 50 c. c. of the 'liquor ferri sulfurici oxidati' of the German Pharmacopœia are added, the same quantity of the liquor ferri persulphatis, B.P., may be substituted for this—and the mixture made up with distilled water to 1000 c. c.; or more than 17 grm. of the silver nitrate may be used, and the solution standardised against an exact deci-normal solution of hydrochloric acid.

Each cubic centimetre of the solution is equivalent to one c. c. of deci-normal HCl, or 0·00365 grm.

Deci-normal Ammonium Sulphocyanate Solution.

When correct, this solution should contain 7·6 grm. of pure NH_4 CNS in each litre. To make it, 8 grm. of the salt are dissolved in 1000 c. c. of distilled water, and the mixture standardised against the acid silver solution.

For this purpose a burette is filled with it, and 10 c. c. of the silver solution placed in a beaker and diluted with distilled water to about 200 c. c. The sulphocyanate solution is run in until a permanent red colour results. If only 9·5 c. c. are required, 950 c. c. of the sulphocyanate solution must be made up to 1000 c. c. with distilled water.

The new solution is now titrated a second time against the silver solution. If the difference between them be small, the number of c. c. required for 10 c. c. of the silver solution is noted, and the correct result of any subsequent titrations worked out by calculation. If correct, 1 c. c. corresponds to 1 c. c. of the silver solution.

Deci-normal Solution of Nitrate of Silver.

170* grm. ($AgNO_3 = 170$) in the litre forms a normal solution, therefore a litre of the deci-normal solution contains 17 grm.

1 c. c. of this, or ·017 grm. $AgNO_3$, corresponds to ·00365 grm. HCl.

That is, 1 grm. of $AgNO_3$ corresponds to ·2088 grm. of chlorine.

1 grm.	do.	·2147 grm. of HCl.
1 grm.	do.	·3441 grm. of NaCl.

* 169·97 grm. to the litre is the absolute and exact amount necessary·

TABLE showing the percentages of Chlorine in 10 c. c. of a fluid when tested with the Deci-normal Solution.

C. c. of Deci-normal Silver Nitrate used.	Chlorine per cent.	HCl per cent.	NaCl per cent.
1	·0355	·0365	·0585
2	·071	·073	·117
3	·1065	·1095	·1755
4	·142	·146	·234
5	·1775	·1825	·2925
6	·213	·219	·351
7	·2485	·2555	·4095
8	·284	·292	·468
9	·3195	·3285	·5265
10	·355	·365	·585

To transform the figures for chlorine directly into those for HCl, they should be multiplied by 1·028, and into those for NaCl, by 1·648.

If the solution of nitrate of silver employed be of known strength but not deci-normal, the amount of the silver salt in the number of c. c. used may be multiplied by ·2088 to give the amount of chlorine present, by ·2147 for HCl, and by ·3441 to express the result in terms of chloride of sodium.

Table of Equivalents in Normal Solutions.

	Normal Solution.	Deci-normal Solution.		Centi-normal Solution.	
	Per litre.	Per litre.	Per 1 c. c.	Per litre.	Per 1 c. c.
Hydrochloric Acid.	Grammes.	Grammes.	Grammes.	Grammes.	Grammes.
HCl 36·5 (35·5 + 1).	36·5	3·65	0·00365	0·365	0·000365
Sulphuric Acid.					
H_2SO_4, 98 (2 + 32 + 64) Dibasic.	49	4·9	0·0049	0·49	0·00049
Oxalic Acid.					
$H_2C_2O_4 + 2\ H_2O = CO(OH)\text{-}CO(OH) + 2\ H_2O = 126$. Dibasic.	63	6·3	0·0063	0·63	0·00063
Lactic Acid.					
$C_3H_6O_3 = 90$.	90	9·0	0·009	0·9	0·0009
Acetic Acid.					
$C_2H_4O_2 = 60$.	60	6·0	0·006	0·6	0·0006
Sodium Hydrate.					
$NaHO = (23 + 1 + 16) = 40$.	40	4·0	0·004	0·4	0·0004
Potassium Hydrate.					
$KHO = (39·1 + 1 + 16) = 56·1$	56·1	5·61	0·00561	0·561	0·000561
Sodium Carbonate.					
$Na_2CO_3 = (46 + 12 + 48) = 106$. Dibasic.	53	5·3	0·0053	0·53	0·00053
Silver Nitrate.					
$AgNO_3 = (108 + 14 + 48) = 170$.	170	17·0	0·017	1·7	0·0017
Ammonium Sulphocyanate.					
$NH_4CNS = (14 + 4 + 12 + 14 + 32) = 76$.	76	7·6	0·0076	0·76	0·00076

APPENDIX.

As, owing to unavoidable delay, some time has elapsed between the preparation of the text and publication, it has been found advisable to add, in the form of an appendix, short notes of several recently devised instruments and methods.

New Intragastric Instruments.

Fenton B. Turck, of Chicago, has devised a number of ingenious and useful instruments and methods for the more thorough treatment and diagnosis of the pathological conditions of the stomach and bowels.

1. Gyromeles.

His gyromele has already been mentioned, but a further note may be made as to its different modes of application.

Gyromeles can be introduced into the œsophagus, large intestine, bladder, or other cavity. Small instruments are made for the posterior nares. For the purpose of exploring strictures of the œsophagus, ivory bulbs can be attached; and strictures can be located anywhere from the œsophagus to the cardia. The flexible cable, encased in a rubber tube, proves less dangerous than the stiff, short whalebone formerly

used for exploring purposes, which is quite inadequate, and always involves the danger of puncture. When the ivory bulb has passed a stricture and entered the stomach cavity, revolutions are produced which, felt through the abdominal wall, prove that the bulb has passed into the stomach, not into a diverticulum at the side of the stricture.

2. Gastric Motor Meter.

A small oblong rubber bag attached to one end of a small tube is passed into the stomach cavity, inflated with air, and the other end of the tube connected with a manometer. The records of the manometer show the longer respiratory waves and the shorter aortic and peristaltic movements. The mercury may rise 30 mm. during ordinary respiration, 200 mm. or more during forced respiration. In health the change of level occasioned by gastric peristaltic movements varies from 10 to 15 mm.; in cases of dilated stomach, only from 2 to 5 mm. These results point to the marked influence which the acts of inspiration and expiration exert upon the mechanical mixing of the stomach contents.

3. Stomach Tube Filter.

By means of this instrument—an ordinary stomach tube in which the usual terminal apertures have been replaced by a bulbous point penetrated by minute holes—the fluid portion of the stomach contents are drawn off by aspiration, free from the solid contents, and without risk of injuring the mucous membrane. By this means the fluid toxin-containing moiety is

removed, the solid, innocuous, and nourishing solids left behind. Its use helps to mitigate the starvation which necessarily follows the total removal of gastric contents after each meal.

4. Intragastric 'Resuscitator.'

This is a means of supplying heat locally to the stomach walls, and more widely to the whole organism. One side of a stomach tube, divided into two compartments, is connected with a hot-water supply apparatus, the other side with a graduated bottle, and the double tube ends by passing into a thin indiarubber bag, which fits closely to it when empty, to the stomach walls when full (Fig. XIII.). The temperature of the water is maintained at from 20° to 130° F. by an automatic arrangement. Water passed through the bag in a room is not so promptly reduced in temperature as when passed in and out of the bag within the stomach. Even when placed in cold water its temperature does not fall so rapidly as when within the stomach or colon ; but after a certain time elapses (about ten minutes), the viscus reduces the temperature less quickly. (W. Gilman Thompson has made some interesting experiments on dogs by the introduction of hot air into the trachea and various other parts of the body, and observed a great reduction in the temperature of the air during its passage.) The direct action of this high temperature upon the vessels within the viscus leads to prompt results from marked vasomotor stimulation.

During irrigation of the stomach with hot water by this method, the surface of the body begins to glow

and the hands and feet become warm—results of the reduction of visceral congestion. Not only is it of use in intestinal diseases, but also in cases of shock marked by internal congestion. The method may be employed during operation where shock is imminent.

5. Needle-Douche and Double-Force Irrigator.

The stomach filled with water is weighed down by the weight of fluid introduced in ordinary lavage, while only the loose, non-adherent materials are removed. The needle-douche consists of a double tube (Fig. XIV.), one of the component tubes, smaller and shorter than the other, ending in a perforated ball; the other, wider and longer, projecting so far beyond the first as to reach the fundus of the stomach when it is blown up with air, while the bulbous end of the first just reaches beyond the cardiac orifice. After inflation of the stomach with air passed through the smaller tube, a strong stream of water propelled down it, causes the formation of a shower of fine jets striking the walls of the viscus with considerable force. The water is at once returned through the longer and wider tube, sucked up by means of an aspiration apparatus.

The advantages of the needle-douche are as follow:—

1. It removes material from the walls.

2. The water returns at once, avoiding over-distension and weighing down of the stomach with water.

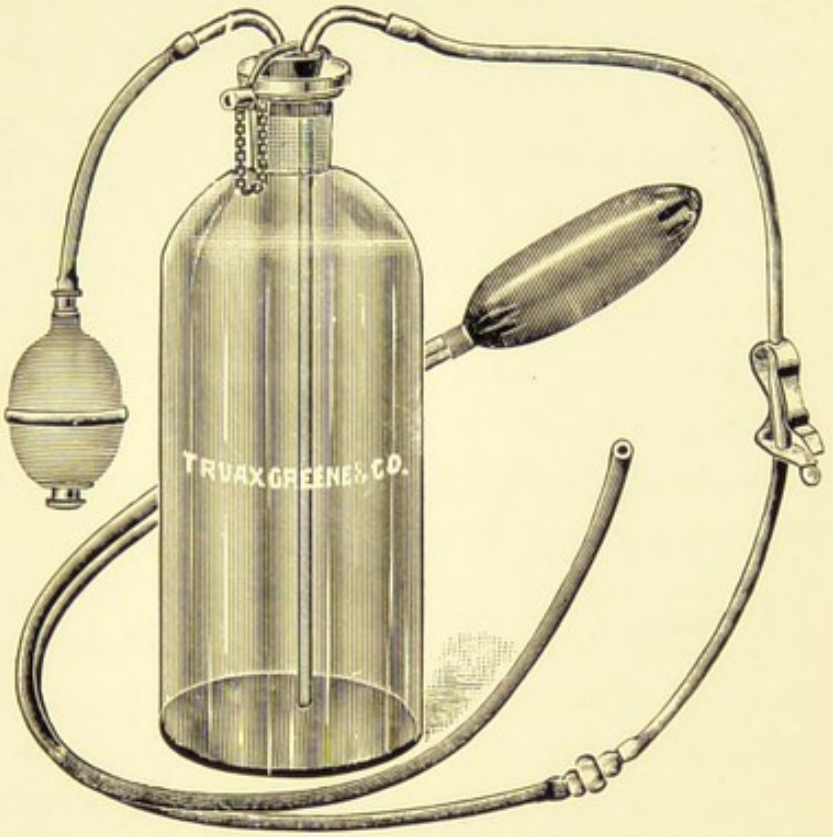

FIG. 13.—Turck's Gastric Resuscitator. (See page 163.)

FIG. 14.—Turck's Needle Douche. (See page 164.)

3. It acts as a vasomotor stimulant. By using hot and cold water from 115° to 45° F. alternately, it is a powerful muscular stimulant, and quickens sluggish circulation.

For general purposes it is not necessary to use a force-pump to compress the air, but simply a small rubber bulb similar to that used with an atomiser. When hot and cold water are used alternately two irrigators are necessary. The irrigators are made in the usual way. A bottle, through the cork of which a glass tube passes, is connected with a rubber bulb. By compression of the rubber bulb the air pressure over the water in the bottle is increased, forcing the water out of the bottle into the irrigating tube. Thus a shower is produced under pressure by means of a single bulb. By using a glass Y-tube, connected with a single bulb attached to the stem of the Y, the ends of the glass tube being attached to two rubber tubes, which again led to separate bottles—namely, the hot and cold water bottles, the air can be compressed in both. The outflow tubes from the irrigators are connected with another glass Y-tube, the stem of the Y-tube being connected with a single rubber tube. Hot and cold water can be used alternately by placing simple cut-off snaps on the tubes leading from the bottles (see Fig. XV.)

6. Nebuliser.

This instrument is practically a variant of the needle-douche. The double tube is the same, but, instead of water, a nebulising solution is converted into a fine cloud by the use of a nebulising bottle. From this bottle the suspended particles traverse a

second bottle provided to arrest any stomach contents ejected, and, along with air, are forced into the stomach, the air and particles not arrested there escaping by the second tube. Oleum caryophylli, and oleum cinnamomi, in equal parts, along with 15 per cent. of menthol, act as a powerful analgesic when applied in this way; as antiseptics and as vaso-motor stimulants, camphor, or creolin, lysol, formalin, and other bodies may be used.

7. Intragastric Capsule.

Each capsule contains in a gelatine capsule a small piece of rubber tubing, through slits in which strips of Congo red, dimethyl-amido-azo-benzol, and amphoteric litmus papers are inserted; one or two small lead shot are attached to the lower end of the silk thread, by which the capsule containing the rubber tubing is lowered into the stomach. The shot are added to facilitate the passage of the capsule downwards through the gullet and to the dependent portion of the stomach. A piece of bread given with the capsule often assists in its deglutition. Five minutes are to be allowed after its entrance into the gastric cavity, by which time the gelatine has melted, the rubber tube expanded, and the test papers come in contact with the contents. The advantages claimed are as follow:—

1. No tube has to be swallowed.
2. The use of the capsule is perfectly free from risk in cases of ulcer.
3. It can be used frequently without prejudice to the patient, his disease, or his organs.
4. It excites no flow of gastric juice.

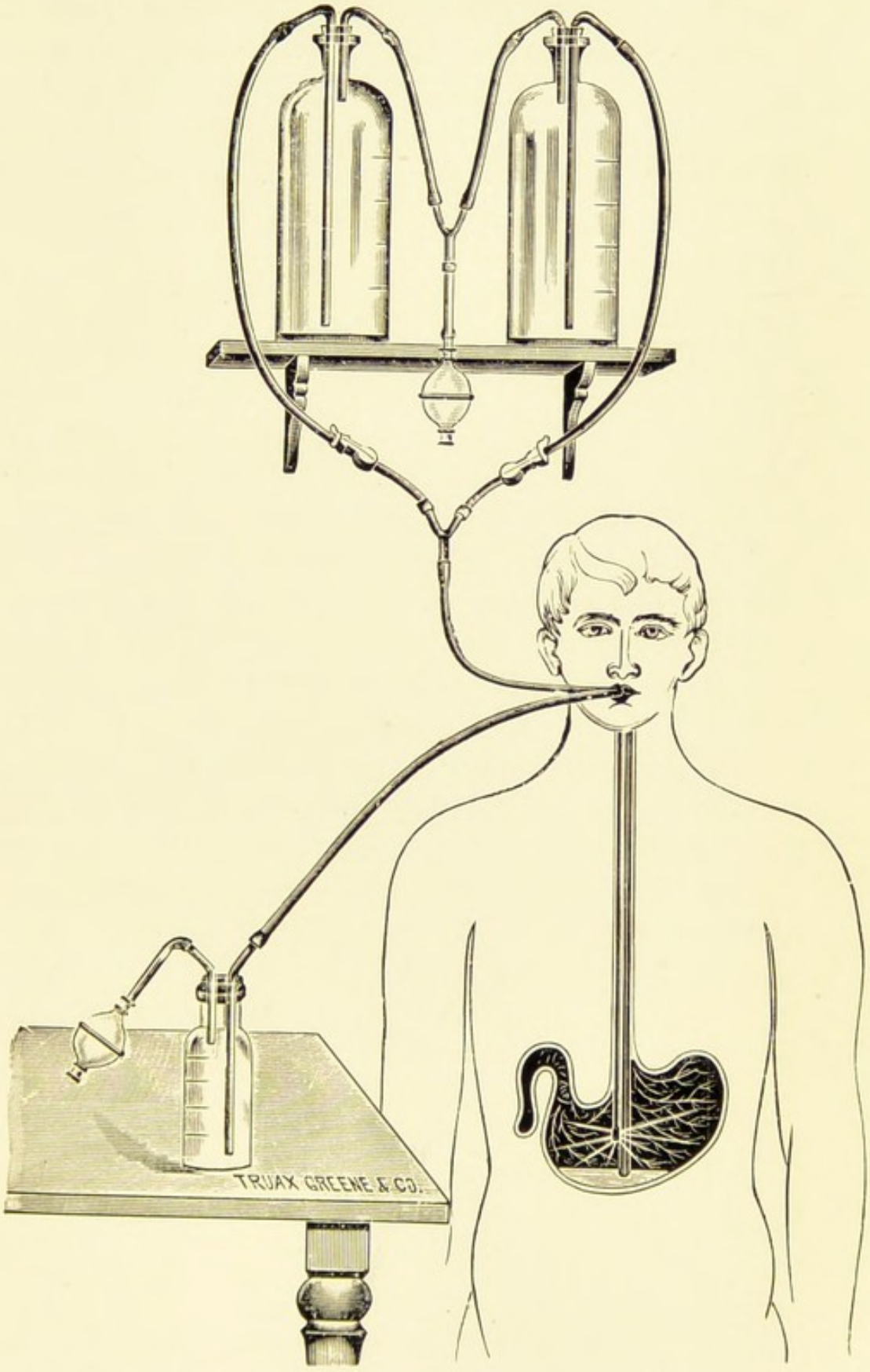

FIG. 15.—Turck's double force Gastric Irrigator and Aspirator. (See page 165.)

5. After patients have become accustomed to swallowing these capsules the later use of the stomach tube, if necessary, is rendered easier.

6. A microscopical examination can be made from the drop of contents always removed from the stomach in the lumen of the tube.

Mechanical Vibrator (Herschell).

Dr Herschell recommends the use of apparatus for producing mechanical vibrations with which he has successfully treated cases of atony of the stomach and constipation. The vibrator consists of an oscillating rod in a handle to which a reciprocatory motion is communicated by means of a revolving cable, this in its turn being rotated by an electromotor. The vibrating rod terminates in a disc, or other suitable appliance for application to the body of the patient. The effect of vibration applied to the epigastric region is in most cases to dilate the pupil, to increase the tension of the radial pulse, and to contract an atonic stomach. In many cases it is possible at once to empty a distended and dilated stomach by this means, and to procure passage of the contents into the duodenum.

TESTS.

Alpha-Naphthol test for free Hydrochloric Acid.

Winkler * recommends alpha-naphthol as a test for the presence of free hydrochloric acid. One or two drops of a 5 per cent. alcoholic solution of this reagent (or 10 per cent. in chloroform) added to a small quantity of stomach contents in a porcelain basin, along with a few grains of dextrose, causes the appear-

* *Centralblatt für innere Med.*, 1897, xviii, 39.

ance of a fugitive blue-violet colour round the edges of the mixture when it is carefully heated to dryness. The sugar may be dissolved beforehand in the alpha-naphthol solution.

Test for Lactic Acid.

Arnold * uses a solution of gentian-violet (0·2 c.c. saturated alcoholic solution in 500 c.c. distilled water), and 5 c.c. of the Tinctura ferri perchloridi, U.S. Pharm., with 20 c.c. distilled water to determine the presence of lactic acid. A drop of the iron solution strikes a blue colour with 1 c.c. of the gentian-violet, which alters to a green or yellow-green when a few drops of gastric contents, should they contain lactic acid, are added.

* *Journ. Amer. Med. Assoc.*, 1898, viii, p. 21.

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