SOME NEW THORACIC SURGICAL INSTRUMENTS

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The whole backward path of surgery is littered, like the plains of the American desert, with the out-worn and clumsy relics of technical advances. With what pride their sponsors must have introduced these clumsy tools to the astonished gaze of an admiring world! Surgical instruments in use today are a curious collection of the awkward heirlooms of the past, mixed with the new, delicate and efficient tools of contemporary technology. As a general statement, few will deny that many surgical instruments could be vastly improved upon. Taken as a whole, they are far behind the ingenious tools of the modern engineer or mechanic. Curiously enough, this criticism applies almost entirely to jointed or articulated tools. It is only within the past few years of this century that serious attention seems to have been paid to their modelling. On the other hand, some of the knives, chisels, bistouries and saws of the old masters cannot be improved upon for balance, delicacy and efficiency. The scalpel and chisel are in the direct line of descent from the sharpened flint or celt, the saw and file, from the neolithic imitation of the teeth of fish and animals. The great imaginative leap forward was in the application of a cutting or crushing force by indirect action brought about by joints. The evolution of this tremendous idea has been traced among the Gallo-Roman finds in France. (See M. Baudouin, *Arch. Prov. de Chir.*, Paris, 1910, **19**: 228-38). Just as the inventor of the first primitive wheel can be held responsible (and what a responsibility!) for the very mixed blessings of modern machinery, so that unknown genius who hinged together two knives to make the first pair of scissors, is the true father of modern surgical instruments. The mind of the modern inventor, whether it be of automobile accessories, radios, aeroplanes or dish-washing machines, is in tune (perhaps he sets the tune) with the spirit of his time. His dissatisfaction with the old, impatience with slowness and inefficiency, are characteristics of his age. Even variation for its own sake, as an artistic gesture of freedom from conventional design, is quite in the modern manner.

Every new surgical upheaval is immediately followed by a tool wave. This is especially true of the two latest major disturbances—thoracic and neurological surgery. These instruments can be divided roughly into two groups—those of necessity, and those of luxury. It used to be a common saying among the older English surgeons that "only a poor surgeon complained about his instruments". Yet on the other hand, confronted with a certain technical problem, the surgeon has, not infrequently, been baffled in its successful solution merely because of the poverty of his technical equipment. In time, luxuries become necessities.

The instruments and apparatus about to be described are the survivors of as many more again, ill-conceived or immature ideas. They were designed to improve craftmanship, and have been modelled, remodelled and tested over a sufficiently long period of time (most of them from two to five years) to warrant description.

Pneumothorax apparatus. — Some hesitation may be understood in describing another pneumothorax apparatus, since approximately twenty-five machines have been described by Italian, French, German, English, Spanish, and American workers since the time of Forlanini. The truth of the matter is that the injection of air into the pleural space is such a simple affair, mechanically considered, that it lends itself to a large number of possible variations. The requirements of such a machine are that it should be simple, one-man, automatic in action, fool-proof, capable of delivery or aspiration of any desired amount of air at any desired pressure, give constant demonstration of pleural pressures, be light, portable, unbreakable and cheap.

I believe Murphy, of Chicago, was the first to employ the gasometer principle in such an apparatus in the '90's. It was not until three years after making my apparatus that I saw one of these early machines, and I was struck by the similarity of their construction. This, of course, was years before the water-manometer was introduced by Saugman in 1910 and when nitrogen was still being used.

Two transparent jars of unbreakable pyralin are inverted, one inside the other. The outer jar is filled three-quarters full of ordinary tap water. The trapped air is thus under a pressure corresponding to the weight of the inverted inner jar. This has been fixed, arbitrarily, at plus 10 c.c. of water, as a working head of pressure. It can be varied easily by lifting up the inner jar with two fingers, so that a negative pressure of minus 15 c.c. or lower can be obtained, or by pressing down with one finger, so that positive pressure up to plus 20 c.c. is obtainable. In practice, with routine refills, this adjustment is not necessary and the delivery of air is automatic. Only on aspirating air, or for high positive pressure refills, is it necessary to touch any part of the machine, except to turn the tap. For initial injections, the inner jar is run down until the enclosed air is at zero pressure. Two hundred c.c. of air can be sucked into the pleural cavity by virtue of its own negative pressure. There is only one tap to manage. This controls the air flow from the jar to the needle. The water manometer has no tap and cannot be cut off, and registers at all times one of three possible pressures. (1) When the tap is "off" the manometer registers the pressure at the point of the needle. (2) When the tap is "on" and the air is flowing from an unobstructed needle it registers an intermediate pressure between the pressure at the point of the needle, and the head of pressure of the air in the jar. (3) When the tap is "on" but air is not flowing, owing to needle obstruction, it registers the head pressure in the jar only.

In practice the dampened manometric fluctuations show the needle is in the pleural space, even when air is flowing. When the tap is off these fluctuations immediately fall in total pressure, but increase in swing and show at once the true intra-pleural pressure. Both ends of the manometer are protected by small valves which cut off automatically wide excursions in either direction of the water column, such as are produced by coughing or very high or low pleural pressures. These valves drop back of their own weight when the pressure causing them to close is relaxed.

The manometer scale is marked in "true" pressures of c.c. of water, not in half-pressures only, as in so many machines. The capacity of the inner jar is 700 c.c. of air. To recharge, close the tap and simply lift the jar clear of the water, then lower it until it rests on the surface again. At the end of each day pour the water out of the apparatus and refill with tap water when needed. The height of the apparatus is 14½ inches; diameter of outer cylinder, 3⅞ inches; weight without case or water, 3 lbs.; weight with case and without water, 6½ lbs.

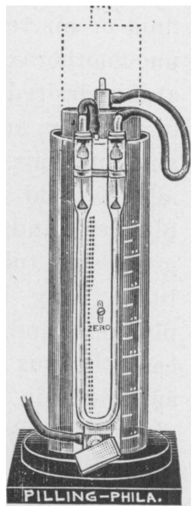


Fig. 1. Pneumothorax apparatus.

Combined pneumothorax and pleural fluid aspirator.—The advantages of such a combined apparatus are obvious and need not be enlarged upon. The same pneumothorax apparatus (1) is used. The vacuum jar of the aspirator is made of unbreakable pyralin, with a capacity of 2,500 c.c. It is easily detachable and is sterilized with cold 5 per cent lysol solution. There is no connection between the vacuum jar and the pneumothorax apparatus. For convenience they are made to sit, side by side, on the same aluminum base, with an instrument board between them containing (1) a pneumothorax apparatus tap; (2) a manometer for pneumothorax; (3) an air filler and fluid trap for protection of the pneumothorax apparatus; (4) a gauge indicating negative pressure in the vacuum jar. There are two tubes leading from, and one tube leading to, the combined apparatus. Of the two outgoing tubes, one is for air from the pneumothorax apparatus to the needle, and the other is for air aspirated from the vacuum jar by the foot pump. The ingoing tube leads from the needle to the vacuum jar and is for fluid or pus. The gauge shows at a glance the negative pressure in the vacuum aspirating jar. It is calibrated from 1 to 30 in inches of mercury. Knowledge of this negative pressure is essential in safe aspiration of fluid or pus in a "closed" pleural space, to avoid dangerously low pressures. The lid of the aspirating jar is made air-tight by a simple counter-acting thumb screw.

In the operation of aspiration of pleural fluid or air replacement, such as in diagnostic pneumothorax, we aspirate, say 200 c.c. of fluid, at any desired negative pressure, say, 10 inches of mercury, and replace with an equal or lesser amount of air. This operation is repeated until all the fluid is aspirated. One needle (with plunger), and two side outlets (one for the outgoing pus tube, and one for the ingoing air tube), may be used, or one needle (with plunger), and one side outlet only. In the last case the pus tube and the air tube must be switched on the single outlet. The other alternative is two needles—one for the outgoing pus, and the other for the incoming air, separated from each other by several interspaces.

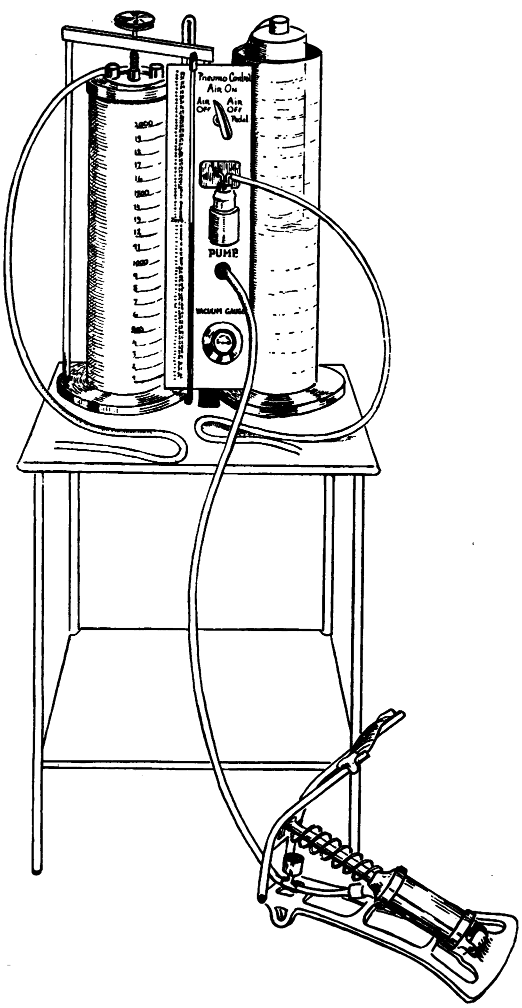


Fig. 2.—Combined pneumothorax and pleural fluid aspirator with foot-pump.

The important things are: (1) use 16 gauge needles or larger for pus; (2) always use a needle equipped with plunger or stilette. Nothing is more annoying than to have a pus needle plug with fibrin, and to be continually detaching the rubber tube to clear it.

We use this apparatus for empyema or large pleural effusions of 1,000 c.c. or more. One may start with a zero pressure in the vacuum jar and obtain any desired negative pressure up to 20 inches. Incidentally, the extremely low negative pressure obtainable on aspiration with a Luer glass syringe of 20 or 30 c.c. size is often not appreciated. Minus 20 inches of mercury negative pressure can be obtained! One is never afraid of losing the partial vacuum in the aspirating jar as it is so quickly regained with one or two strokes of the foot pump. One always knows what negative pressure there is in the aspirating jar. It was on account of this lack of definite knowledge of negative pressure, and of the slowness of obtaining the partial vacuum, which induced us to discard Potain's aspirator.

An aspirating foot pump.—This pump is placed on the floor beside the bed and is operated by pressure of the foot. One stroke gives about five inches of partial vacuum, equivalent to about ten strokes of a Potain's aspirator, using a 2,000 to 3,000 c.c. vacuum jar or Winchester. The gauge on the pump informs the operator at all times of the negative pressure in the jar. The pump is strong and sturdy and the original model was made for me in England by a well-known Sheffield firm of pump makers. For those who still wish to use the ordinary large Winchester as an aspirating jar the gauge has been built into the pump. It is called in our hospital, "The Nurses' Friend".

A self-retaining scapula lifter and retractor.—This instrument lifts and holds the scapula up and forwards, off the chest wall, during an upper stage thoracoplasty. A really extraordinary range of movement is obtained by three universal ball and socket joints, operated by two turnscrews. It can be taken apart in three pieces, and is completely sterilizable, either by boiling or by autoclave. We use the latter method. It consists of an "arm", a "fore-arm", and a "hand". The joints are the "shoulder", the "elbow", and the "wrist". The shoulder joint has a short, thick, square pin which fits into a socket on the table. All three joints are operated by the assistant from the "elbow", by two turnscrews. This instrument is swung out of the field of operation when not needed. Two or three turns of the screws fix, independently, the wrist and the clawed hand, the elbow and fore-arm, the shoulder and arm. To operate, place the clawed hand beneath the scapula, lift the fore-arm up, pull back the arm, and tighten both screws. It will then "stay put" in the desired position. It will do what an assistant cannot do, willing as he may be, that is, maintain a steady lift and retraction. It is lift and not retraction (this last only pulling the patient forward on his face, out of position) that is desired in an upper stage thoracoplasty. Even with cutting or separation of the upper three digitations of the serratus magnus, as is the routine in this clinic, the self-retaining lifter is still a boon, and, more so, if they are not cut, as in some clinics. It is necessary to point out that the socket attachment receiving the lower end of the arm must be bolted firmly to the table. Otherwise a movement of give or sway will occur between the socket attachment and the table which will render the whole instrument worse than useless. This socket attachment needs only a thumb screw to hold the instrument in it, as a turning movement is prevented by making the pin square and not round. The socket attachment can be made and bolted on the table by any skilled local mechanic. To look well, it should be nickeled, and one fixed on each side of the table at a distance of one foot from the top end. A socket for the chest rest should be bolted six inches below it (see Fig. 3). This instrument was invented because its originator acted for one year as second assistant, with the job of scapula retractor. Of the operating team he was the one who was the most fatigued at the end of an operation. The original model has been altered within the past year to one with larger ball and socket joints, so that the total area of friction is increased. It will now hold in any position a weight of 50 lbs. This instrument has been in constant use for the past five years and is extremely satisfactory. The exposure it gives of the first rib is a new experience to those surgeons who have been accustomed to manual retraction. In no case has the patient complained after the operation of pain in the shoulder, nor has any instance of brachial plexus injury been observed. On reflection, it will be seen that the plexus is actually relaxed by such steady lift-retraction. In our clinic it is called "The Iron Intern".

Two adjustable chest rests. — Metal arms carry hinged, slightly curved wooden boards which serve as rests for the chest. One rest is for the front, the other for the back. They only differ in their width. The front rest is covered with an ordinary pillow, and the back rest has a rounded sausage-like pillow between it and the body. The upright pin, at right angles to the horizontal arm, fits into a socket bolted to the table, 18 inches from the top end on each side. A broad strap across the hips, a pillow between the flexed knees, and one under the head, and the patient is ready for operation.

Rib cutters (two models).—Rib shears were the first thoracic surgical instrument which aroused my dissatisfaction six years ago. There were then four models with which I was familiar—the Doyen, the Gluck, the Liston, and the double action Liston. All seemed to me to possess some fault, either the too-sharp points, the short handles, or their heaviness and general clumsiness. I do not include the special first rib shears of Sauerbruch, Lilienthal or Stille, the last of which is still a great favourite of mine and one which I think cannot be improved upon for cutting the posterior end of the first rib.

My original model of 1928 was a copy of a leather-cutting shears made by the United Shoe Machinery Company. The only alteration made was to blunt the points. Two years later it was remodelled, using a stiffer steel (the first was too flexible), and putting rubber grips on the handles. For ordinary use it is still my favourite. The ratio of jaws to handle length is 3.5 cm. to 29.5 cm. This gives tremendous leverage; most ribs can be cut with one hand. It is as powerful as a double-action shears and is lighter and more graceful in manipulation. (Fig. 4). It takes the hard work out of rib work.

For cutting the anterior ends of the ribs in the modern complete costectomy the jaws were angulated more in the second model. Since then Welles and Meyer introduced (1933) even more sharply angulated-jawed cutters, which seem to me to be very useful for cutting the anterior ends of the ribs. Only one posterior section is made of any rib in our technique. This section includes the transverse process of the vertebra. (We abandoned the Sauerbruch technique of double posterior section several years ago, as time-consuming, without compensating in improved results.)

In about 50 per cent of cases the anterior end of the first rib, after the separation of the anterior scalene muscle from Lisfranc's tubercle, can be twisted out easily, the chondrocostal junction of the rib breaking through edge. This facilitates its introduction between the periosteum and the rib. Since the leading edge of the jaws is sharp, it is a "pusher" stripper. The first assistant, who stands above the operator on the same side of the table, strips the upper edge of the rib from behind forward. He then hands the stripper to the second assistant, standing opposite, who then strips the lower edge of the rib from in front backwards. The Doyen stripper is used only very rarely by us. The stripper described is very useful also in clearing off the muscular and ligamentous attachments to the posterior ends of the ribs about its angle and off the transverse process (Fig. 5).

Periosteum scrapers (two models).—These are modifications of two scrapers which have been used by Dr. Archibald, of the Royal

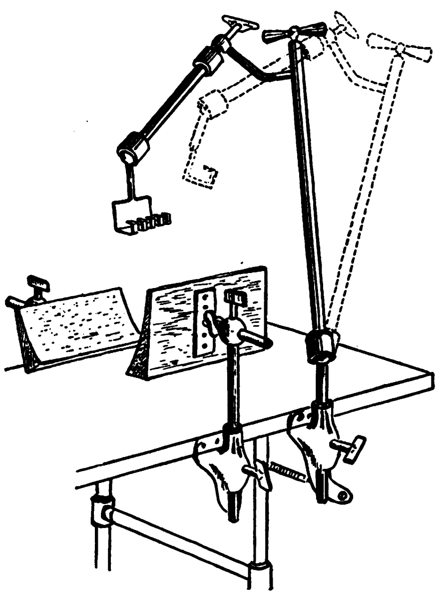


Fig. 3

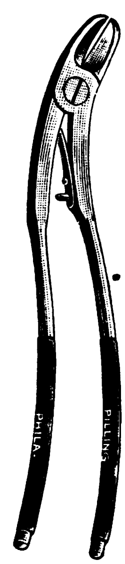


Fig. 4

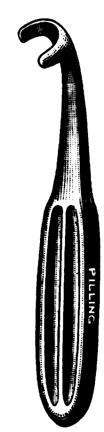


Fig. 5

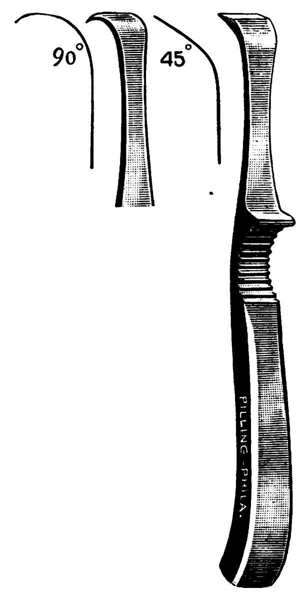


Fig. 6

Fig. 3.—Self-retaining scapula lifter. Adjustable chest rests—front and back. **Fig. 4.**—Rib cutter. **Fig. 5.**—Rib stripper. **Fig. 6.**—Periosteum scrapers.

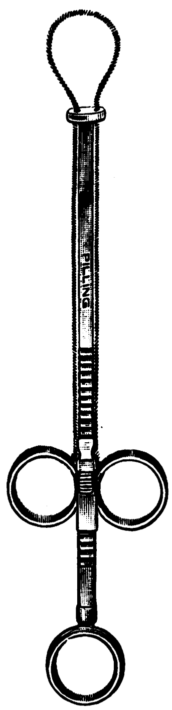
like a piece of cheese. If it has to be cut, I prefer an angulated shears, such as my second model, or the Welles or Meyer. The brachial plexus and subclavian vein are held away with a retractor.

Rib enucleator or stripper.—I was very much taken with the ingenious Matson-Plenk stripper some years ago. I have modified it to suit my own particular fancy. The jaws have been shortened and the angle between them reduced. A cutting edge forward has been added and the jaws twisted so that the trailing edge is now at an angle of 45 degrees to the leading Victoria Hospital, for the past twenty years. I believe they are Faraboef's, originally. One has its "beak" set at an angle of 45 degrees and the other at 90 degrees—called by us "the 45" and "the 90". The former is a universally applicable model, the latter, for the first rib. The original handles have been reshaped and lengthened (most scraper handles are too short), and finger rests added. "The 45" is sharp, "the 90", half-sharp. Blunt scrapers are as dangerous as blunt knives (Fig. 6).

Lobectomy tourniquet.—This tourniquet may be slipped over the liberated lobe as a loop, or with one free end pulled below and up, and tied. The action of closure of the loop is quick and steady and needs only one hand. The cord is of strong, braided, non-stretchable cotton. To loosen the loop the catch on the rack is depressed. We use two of these tourniquets in a lobectomy, and cut between them to prevent soiling the pleura. We have designed three different models of tourniquets in the past three years, and this would seem to be the best. Although quite efficient, my own feeling is that it could be improved upon (Fig. 7).

A set of five phrenicectomy instruments.—These consist of three retractors, a hook, and an avulser. The three retractors have blades of the following lengths: 1st (the operator's) 2 cm.; 2nd (the assistant's) 2.5 cm.; 3rd (the assistant's) 3 cm. The handles are light and short, with engine-turned surface. The blades are set at the angles which we have found most suitable, but can be bent to will. The third retractor is included for those cases which have extra-deep necks. Even in the ordinary case, for the assistant to use two retractors to the operator's one gives a better exposure. There is a perforation in the top centre of the blade of the assistant's retractors, to admit the tip of the avulser. This steadies the forceps and gives it a fulcrum as it twists the nerve out. The hook picks the nerve up off the muscle. The avulser has the guard or shoulder on the lower jaw only. Other avulsing forceps have a split guard divided between the two jaws. The lower jaw, being unencumbered, can be slipped easily under the nerve. When closed and the nerve cut above, the tip of the avulser is lifted slightly and introduced into the hole in the assistant's retractor and can then be rotated without slipping (Fig. 8).

Lung expansion recorder and chart.—This is to take the place of the ordinarily used Wolff's blow bottles after empyema operations. The idea is that the patient keeps a graphic record of his exertions and is thus encouraged to persist. It is a home-made instrument. Take a Tycos sphygmomanometer, and attach a short length of rubber tube with a glass or vulcanite mouth piece. Insert between the mouth piece and the manometer an air filter filled with absorbent cotton. The patient is given a chart marked off in days and pressures, with a horizontal red line drawn across—his "par of expansion". The average par on a Tycos is about 100. He keeps his own score. Day by day he tries blowing to reach "par", and as his lung expands, his capacity increases. The chart is really a record of his intra-bronchial pressure.



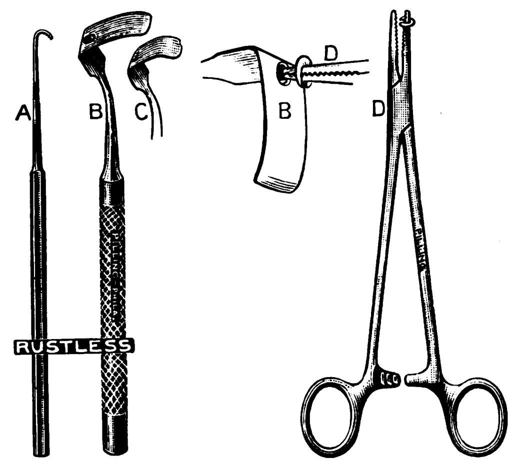
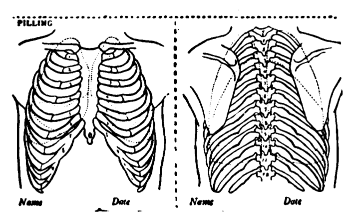


Fig. 8



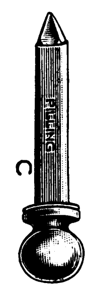


Fig. 7 Fig. 9 Fig. 10

Fig. 7.—Lobectomy tourniquet. **Fig.** 8.—Phrenicectomy retractors, hook and avulser. **Fig.** 9.—Sticker chest chart. **Fig.** 10.—Intercostal trochar and cannula.

Sticker chest charts.—These are for the clinician to carry about with him, to record physical findings or fluroscopic recordings, in a sort of short-hand. They are like large postage stamps, with mucilage on one side. They are torn out of the book of 50, moistened, and stuck on the patient's case record or skiagram. A dozen or more can be put on one sheet of paper. The charts come in pairs of "front" and "back" (Fig. 9).

An oval intercostal trocar and cannula.—This was originally intended, and was used, for the introduction of pleural scissors, clip applicators, and trans-illuminator. Dr. Milton Lloyd, of New York City, has utilized it for introducing a two-way rubber empyema tube for closed drainage (*J. Thoracic Surg.*, 1933, **2**: 302). I think the handle of the trocar should be larger and longer (Fig. 10).

Pilling and Sons Company, of Philadelphia, Pa., are the makers of most of these intruments.

Confessional note.—I have abandoned the use of the following instruments:

1. An air-tight pneumatic empyema tube, made in 1931 but not described. I was not able to prevent it being punctured by the cut ends of the rib.

2. A combined aspirator and pneumothorax apparatus described in the *Canad. M. Ass. J.* (1929, **20**: 663). Its whole conception was shortly seen to be basically unsound. Fortunately, only one was made.

3. The squeeze tap, suspension arm, and glass cylinder of early models of the pneumothorax apparatus, introduced, but not described, in 1928, 1929, and 1930. The glass cylinders were abandoned because they broke; the squeeze tap, because, being attached to the needle, it was necessary, yet difficult, to sterilize; and the suspension arm, because it was unnecessary.

4. A phrenicectomy necklace described in the *Am. Rev. of Tuberculosis* (1932, **26**: 3), was abandoned as unnecessary. It was taken, as it was meant to be, as an amusing little trinket.

5. A lipiodol oil gun described in the *Canad. M. Ass. J.* (1929, **20**: 286), was abandoned as having no great advantage over an ordinary 30 c.c. Luer syringe.

6. Silver clips and applicator, described in the *J. of Thoracic Surg.* (1933, **2**: 302), were discarded in favour of electro-coagulation.

7. A pleural transilluminator, described in the *J. of Thoracic Surg.* (1933, **2**: 302), was discarded in favour of Mauer's cock-up illuminated probe, which is very much better.

Case Reports

A WOUND OF THE HEART WITH FRAGMENT OF STEEL RETAINED IN THE MYOCARDIUM

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"There . . . Alkathoos was slain . . . when the hero Idomeneus smote him in the midst of the breast with the spear . . . and he fell with a crash and the lance fixed in his heart, that, still beating, shook the butt-end of the spear." Thus does Homer describe the first recorded wound of the heart.

Rudolph Matas, in his summary of the history of the surgery of the heart, quotes Sherman as saying: "The road to the heart is only two or three centimetres in length in a direct line, but it has taken surgery nearly twenty-four centuries to travel it." Up to comparatively recent times wounds of the heart were considered to be hopelessly fatal. George Fischer's monumental work, published in 1868, summarized the knowledge then available and suggested surgical approach to the heart as a remote possibility. The famous Billroth is quoted as saying in 1883 that "the surgeon who should attempt to suture a wound of the heart would lose the respect of his colleagues." Sir Stephen Paget, writing in 1896, says: "Surgery of the heart has probably reached the limits set by nature to all surgery; no new method and no new discovery can overcome the natural difficulties that attend a wound of the heart. It is true that 'heart suture' has been vaguely proposed as a possible procedure and has been done on animals, but I cannot find that it has ever been attempted in practice." The rashness of attempting thus to limit the scope of surgery is apparent when it is recalled that in that very year Rehn, of Frankfort, successfully sutured a wound of the human heart.

Since that time with constantly improving methods, "the heart", as Matas says, "has become a surgical organ, and is subject to the same laws and technical procedures which govern the interventions of surgery in the treatment of the injuries and traumatisms of all the hollow viscera." With the passage of time, too,