that is, one that gave any promise of a freely movable efficient joint. It is to replace this system of drainage that I suggest that excision of the ends of the bones with

CHART 6.—Comminution of head of tibia; dirty wound. Excision of joint third day after injury. E, Excision of knee; S, splint changed under chloroform.

wide separation has its legitimate place. If done early, that is, as soon as it becomes evident that the closed method is doomed to failure, and before any marked oedema of the leg and thigh has set in, limbs will be saved that would otherwise inevitably require amputation. If a policy of waiting is adopted, the risks of the procedure are much increased. If the patient has a good colour, if his appetite remains good, if he is not wasting, if his pulse though rapid is of good tension, if he is cheerful and his condition as a whole fairly satisfactory, excision ought, in my opinion, to be considered, provided always that pus has not broken through the synovial membrane and tracked in the fascial planes of the thigh or leg. If, on the other hand, he is anaemic, if he has lost much flesh, if his appetite is poor, if he is restless and sleepless, if his tongue tends to be dry, if his pulse is rapid and flapping in character, and his condition as a whole gives rise to anxiety, it would be tempting Providence to do anything short of amputation.

If pus has begun to track in the thigh or leg, excision will probably fail and a subsequent amputation will very likely be required.

If the patient is struggling with other severe wounds, excision is, I think, contraindicated unless his general condition is very good indeed.

If one compares the condition of a patient who has been drained in the old way with one after excision he will, I think, be convinced that the morbidity is less after the latter operation, and that the relief of pain is more immediate and complete. We have in some cases had to amputate after excision had failed, but in these the operation had probably been done too late. It is a nice point to decide on the best time for an excision, but we are inclined lately to do it early. In other words, we give the closed method a chance for a few days. If the joint is not at the end of this time beginning to settle down, immediate excision will, I feel sure, save amputation in a fair proportion of cases. In fulminating cases amputation rather than excision will be required to save the patient's life.

It will be gathered that excision is here recommended as an alternative to drainage by the older methods, and to amputation. If the surgeon is satisfied that a less radical measure than amputation will suffice in a case in which the closed method has failed, he will be the more inclined to operate early, and the statistics of excision will improve accordingly.

The accompanying charts will give some idea of the course of the temperature after successful excision.

I am indebted to Captain McDonnell for Charts 1, 2, and 4, to Captain Whittington for Chart 3, to Captain Lock for Chart 5, to Captain Edye for Chart 6, and to Captain Palmer for Chart 7.

Adjustment of Splint.

I have been asked to add a few words on the splint and its management. All our cases have been treated with a Thomas's knee splint. The junctions between the bars and the ring ought to be so welded or brazed that no irregularity is left which might project through the

padding and cause intolerable pressure over the ischial tuberosity. The ring must be firmly padded, and should not be too wide or too thick. If too wide, it will be impossible to keep it in contact with the ischial tuberosity, from which, and not from the perineum, the bearing must be taken. Sizes from 22 to 25 inches in circumference will be found the most suitable. If too thick a ring is used, a firm bearing will be impossible to obtain. Considerable traction will be required to overcome spasm and keep the bones apart. In order to maintain this, the extension straps should be inspected daily, and any slipping or loosening adjusted. A rise of temperature or pulse will often indicate that the traction is insufficient to keep the bones far enough apart to provide free drainage between the ends. In Chart 6, the temperature did not begin to settle until comfortable adjustment and sufficient traction had been obtained. Painful spasm is an indication that either the splint is unsuitable, or has not been properly applied.

There is one other practical point. As we have been making our lateral incisions further and further back in order to secure satisfactory drainage of the cavity between the bones, it has become increasingly difficult to drain the proximal portion of the suprapatellar space, whether the

CHART 7.—Operation by "closed" method on second day after injury; shell fragment removed. No bone injury. Excision of joint six days later owing to failure of first operation. O, First operation; E, second operation, excision of knee.

synovial membrane has been removed or not. To meet this, it has been necessary in some cases to make a median incision at the extreme upper limit of the space in question and insert a tube so as to ensure that no pocketing shall take place. Sir Almroth Wright's most recent irrigating apparatus, "the Boulogne rose irrigator," which is now available, and can be obtained from the Base Medical Stores in France, might be of great service in these cases.

I desire to express my sincere thanks to the officers who have kindly placed their statistics at my disposal. I am also indebted to Professor Symington, F.R.S., and Mr. R. Hunter, of Queen's University, Belfast, for the drawings which illustrate the text, and to Captain Gamlin, R.A.M.C., for the x-ray photograph.

REFERENCE.

¹ *British Journal of Surgery*, vol. iv, No. 13, 1916.

GUNSHOT INJURIES TO THE KNEE-JOINT:

SOME SUGGESTIONS WITH REGARD TO THEIR TREATMENT.

BY

LIEUT. WILLIAM EDMOND, F.R.C.S., R.A.M.C.(T.C.),

AND

CAPTAIN WALTER WEIR GALBRAITH, M.B., Ch.B.,
R.A.M.C.(T.C.).

Of the injuries met with at base hospitals, gunshot wounds involving the knee-joint are, perhaps, the most troublesome to deal with, and there is as yet no consensus of opinion as to the most satisfactory methods of treatment. It is still held by some surgeons, of considerable experience in this class of injury, that such wounds may be roughly divided into two main groups: (a) Those which get well without interference; (b) those which are better amputated.

Whilst we do not claim that the treatment outlined here is original, or an improvement on methods adopted elsewhere, yet, in our hands, it has proved highly successful, and has been based on considerable experience, and not a few disappointments.

It must be remembered that the cases, on the average, do not reach us until forty-eight hours after injury. During that time they have passed through a casualty clearing station, where they are cleaned up and splinted, before being evacuated to the base. In many cases wounds have been excised under anaesthetics, and joints injected with some antiseptic preparation.

Our system of treatment is based almost entirely on the pathological report as to the nature of the fluid in the joint, and on the x-ray report. We find that little reliance can be placed on temperature, pulse, or degree of pain, which factors are materially influenced by the mental stress and fatigue which the patient has recently undergone.

The infections we have met with in cases of wounds of the knee-joint have been caused by one or other of the following organisms:

- (a) Mild.—*Enterococcus*.
- (b) Moderate.—*Streptococcus brevis*; *Staphylococcus*; *Bacillus coli*; *Bacillus aerogenes capsulatus* of Welch (*B. perfringens*).
- (c) Severe.—*Streptococcus longus*.

Experience has shown us that some infections are more difficult to combat than others, and since the prognosis and treatment depend on the virulency of the infecting organism, we have classified them accordingly.

We recognize five main types of joint injury: (1) Aseptic and without fracture; (2) mild or moderate sepsis and without fracture; (3) acutely septic and without fracture; (4) aseptic with fracture; (5) acutely septic with fracture.

1. ASEPTIC WITHOUT FRACTURE.

The whole limb is shaved and cleaned, the area of operation being prepared with petrol and iodine. The wound is excised should this be advisable, but we do not recommend it in small wounds in which there is little damage to the tissues; each case must be judged on its merits. The excision is carried down to the synovial membrane, but the latter is not disturbed.

Foreign Bodies.

(a) None Present.—In this case nothing further is done, unless the joint be unduly distended, when we aspirate, thereafter injecting two drachms of glycerine and formalin.

(b) Small Foreign Bodies.—These may be left, the treatment being similar to the case in which there is no foreign body, but it is necessary to keep the joint under careful observation.

(c) Large Foreign Bodies.—Unbroken bullets and shrapnel balls are invariably removed, as we are of opinion that they may become a source of infection at a later date. We prefer to remove such missiles through a counter incision, rather than extract them through the wound of entrance, since even after a most careful excision of the track one cannot be certain that no infected material is left. The joint is then irrigated with normal saline, the wound sutured, and finally 2 drachms of glycerine and formalin preparation injected. Thereafter, in all cases, the joint is immobilized on a splint in a position of slight flexion.

CASE I.

Pte. L., wounded February 1st, 1916, by a rifle bullet in left knee-joint. Dry dressing applied at field ambulance. Re-dressed and limb immobilized on splint at casualty clearing station. Admitted here on February 3rd. There was a small entrance wound immediately internal to the tendon of the biceps. No exit wound. Joint tense and painful. Temperature 99.2° and pulse 84.

The joint was aspirated and found to contain blood-stained fluid, which the pathologist reported sterile. A skiagraph showed an unbroken bullet lying slightly above and to inner side of patella, free within the knee-joint cavity.

Under an anaesthetic, after preparation, the wound edges were excised. An incision 1½ in. in length was made over the inner margin of the patella, the synovial membrane opened, and the bullet removed. The joint was then irrigated with normal saline and the incision sutured. Two drachms of glycerine and formalin were injected. The limb was immobilized in a slightly flexed position on a Neville's splint.

On February 4th the temperature rose to 100°, pulse 98. Joint tense and painful. On the following day the pain was less, but swelling remained the same. The patient made an uninterrupted recovery. On February 21st the splint was removed.

D

Joint movement was free. A plaster-of-Paris splint was then applied, preparatory to the patient's evacuation to England.

CASE II.

Lance-Cpl. C., wounded April 6th, 1916. Admitted here on April 8th. There was a penetrating wound of right knee-joint; entrance at inner border of patella. Knee tense and painful. Skiagraph showed small shell fragment lying free within the joint cavity, midway between the condyles of the femur. Knee-joint aspirated, and 1 oz. of a serous fluid withdrawn; this relieved the pain somewhat. Temperature 99.4°.

On April 11th knee-joint again aspirated, and 2 oz. of turbid yellow fluid withdrawn. Temperature 101.4°. The pathologist reported: "Fluid from knee-joint on April 8th, and also on April 11th, does not show any sign of the presence of organisms. Two cultures of both specimens are sterile. There are large numbers of pus cells present, and a small deposit of pus settles to the bottom of the tube. The condition is probably either traumatic or there is an infective focus shut off from the general joint cavity."

On April 13th the swelling and pain were less. Temperature 102.2°. From this date the temperature gradually subsided, and after April 16th remained normal. The swelling gradually decreased.

On April 22nd the patient was discharged to England.

2. MILD OR MODERATE SEPSIS WITHOUT FRACTURE.

In this class of case there is every prospect of the joint recovering its full function. Treatment is accordingly directed to this.

The operation is carried out on the same lines as in the previous class, with the addition that counter incisions into the joint are made on either side of the upper part of the patella. These incisions are made as small as possible, but large enough to admit a rubber tube ¼ inch in diameter. Before the tubes are inserted the joint is thoroughly irrigated with normal saline solution. The tubes are inserted just through the opening in the synovial membrane and are anchored in position by a skin suture. The ends of the tubes are left long enough to project through a light dressing, but they must be covered by a moist pad of gauze. The limb is fixed, slightly flexed, in a Thomas knee splint, and light extension applied. Into one of the tubes one drachm of 0.5 per cent. eusol is injected hourly; the other acts as a drain. After the third day the injection is given every four hours. The tubes are generally removed on the sixth day. After this dry dressings are used until the incisions heal.

CASE III.

Pte. H., wounded July 7th, 1916. Admitted July 9th. Patient had multiple shell wounds over limb and trunk. The left thigh seriously infected, and numerous small wounds in near proximity to right knee-joint.

On July 10th a skiagraph showed numerous small shell fragments near the right knee-joint, but none actually in the joint. Under an anaesthetic multiple incisions made in the left thigh for severe suppuration; right knee-joint aspirated, and found to contain a turbid but sterile fluid. Glycerine and formalin, 2 drachms, injected.

On July 18th knee-joint tense and painful; aspirated, and glycerine and formalin again injected; patient's general condition grave.

On July 21st thigh dressed under an anaesthetic; patient had oedema of both legs and thighs; the knee-joint appeared to be improving.

On July 31st the knee-joint, which appeared to have quietened down, was again swollen and painful; knee aspirated, and 2 oz. of thick but non-offensive pus withdrawn.

On August 2nd patient's general condition slightly improved. Pathologist reported fluid from knee-joint to be infected with *enterococcus* and *Streptococcus brevis*. Under an anaesthetic two lateral incisions made into joint cavity, which was then irrigated with eusol, and two ¼ in. rubber tubes introduced. Limb put up slightly flexed on a Thomas splint.

August 4th: Since operation 1 drachm of 0.5 per cent. eusol was injected into one tube every four hours. There was a slight discharge; pain slight, and joint not excessively tense.

On August 8th there was still some swelling of joint and discharge; tubes changed.

On August 12th the knee was doing well; tubes removed; dry dressing; Thomas splint removed, and back splint applied.

On August 20th the knee seemed to have quietened down; back splint removed.

On August 24th the knee was healed; general condition good; slight movement of knee without pain. Patient discharged to England.

3. ACUTE SEPSIS WITHOUT FRACTURE.

The virulency of the organisms in this class of case is such that free drainage is called for. Should drainage be inadequate the infection will spread up and down the limb far beyond the confines of the knee-joint cavity in a remarkably brief period. The surgeon is then confronted with the necessity for amputation under most unfavourable

conditions. Whilst we recognize that perfect drainage of the knee-joint can only be obtained by laying open the joint by an anterior incision dividing the ligamentum patellae and crucial ligaments, yet such treatment is so drastic that we have, after many trials, devised another method, which gives good and adequate drainage, and is an improvement, inasmuch as the great anterior ligament of the joint, the ligamentum patellae, is undivided. Convalescence is greatly shortened, and the patient has the prospect of a useful limb.

The preliminary steps are as previously described, the wound being excised, swabbed with iodine, and packed with gauze. Two vertical incisions are made on either side of the ligamentum patellae close to its lateral margins. Each incision is $1\frac{1}{2}$ in. in length, its centre being over the articulation. From the lower ends of these incisions further incisions are made at right angles, outwards in the case of the outer incision, inwards in the case of the inner incision, and extending for a like distance. These incisions are made down to the joint capsule. The flaps thus formed are turned up.

The joint capsule is now excised over as wide an area as possible, care being taken that the lateral ligaments are not cut. The next step is to remove the semilunar cartilages, together with the pad of fat which lies behind the ligamentum patellae. Free access can now be had to the posterior parts of the joint. The synovial reflections on either side of the patella are incised in their most dependent parts. The suprapatellar pouch is opened by lateral incisions 1 in. in length. The joint is now thoroughly irrigated with normal saline. The knee being fully flexed, small Carrel drainage tubes are introduced through the lowest incisions—one in each. They go between the joint surfaces, in the notch between the condyles, to the posterior part of the joint. Ordinary drainage tubes are introduced through all other incisions—they go no farther than the opening in the synovial membrane and are sutured to the skin. Finally the limb is fixed in a flexed position on a Thomas knee splint. Eusol is introduced every two hours through the small tubes, and in addition the joint is irrigated night and morning with eusol. The small tubes are removed on the fourth day, but irrigation through the other tubes is continued until all acute sepsis has disappeared—this is generally about the tenth day. The latter tubes are then removed under a general anaesthetic, and the leg is straightened and fixed in a Thomas splint.

CASE IV.

Pte. S., wounded August 8th, 1916. Treated at casualty clearing station, where he was found to have a wound of the left knee involving the joint, and two wounds of the left ankle. He was admitted on August 9th. His field card stated: "Foreign bodies removed from both wounds in ankle, but no foreign body found in knee. All wounds excised. It was impossible to get full extension of the knee." He had a wound immediately external to the lower edge of the patella. The joint was tense and very painful and held in a slightly flexed position. Temperature 101° , pulse 112. A skiagraph showed shell fragment lying within the joint cavity. Fluid withdrawn from the joint contained enterococcus and *Streptococcus longus*.

Under an anaesthetic the wound in the knee was explored; it was found to have been excised down to the synovial membrane. The patella had been grazed by the projectile and some fibres of the ligamentum patellae severed. The wound was freely excised, and the capsule of the joint removed over as wide an area as possible. On the inner side of the ligament a V-shaped flap was turned up and the capsule opened. The foreign body was seen to be lying on the crucial ligament; it was removed. The semilunar cartilages and infrapatellar pad of fat was excised. The lateral synovial pouches were incised and drained; the suprapatellar pouch was incised on each side. Tubes were stitched into all these incisions; and, finally, two Carrel tubes were inserted through the lowest openings into the posterior part of the joint. The joint was thoroughly flushed with normal saline solution and a light gauze dressing applied, the limb being fixed in a Thomas splint under extension.

On August 13th the temperature had not risen above 99° since operation. The Carrel tubes had been injected, at first two-hourly but latterly four-hourly, with 2 drachms of 0.5 per cent. eusol, and the superficial gauze dressings changed twice daily; discharge now slight. The Carrel tubes were removed under an anaesthetic, and the limb fixed on a straight back splint without extension.

On August 16th the temperature was normal. All drainage tubes were removed; there was still slight discharge of synovial fluid from the wound. Dry gauze dressing to be changed every other day.

On August 24th the incisions were almost healed. Joint quiet; no pain. Discharged to England on back splint.

4. ASEPTIC WITH FRACTURE.

Under this heading there are two types of injury. In one case the missile traverses or penetrates the joint cavity, causing a fracture of one of the bones entering into the articulation. In the other case, the missile causes a fracture of bone in close proximity to the joint, and though the missile itself has not entered the joint, yet the fracture extends into it. In the former case the treatment coincides with that employed in Class 1.

In the latter case we have a fissured fracture in close proximity to, and extending into, the joint. The effusion, at first aseptic, rapidly becomes infected by direct extension from the wound.

In many cases the missile is embedded in the bone, and with it are numerous infected foci. Such a wound is freely excised, detached portions of bone are removed along with the missile, and the track is thoroughly cleansed and scraped. A salt pack is the ideal dressing, provided one can be sure that it is in contact with all parts, otherwise we use continuous eusol irrigation.

CASE V.

Pte. L., wounded on August 20th, 1916. Admitted on August 21st. He had a small wound on entrance over the inner side of the head of the left tibia. Knee-joint swollen, tender, and painful. Temperature 100.8° , pulse 96.

Skiagraph shows a shrapnel ball lying embedded in the head of the tibia with a fracture extending into the joint. Joint aspirated and a blood-stained fluid withdrawn, which the pathologist reported to be sterile.

Under an anaesthetic the wound was freely excised; the shrapnel ball with portions of clothing was removed, and the wound in the bone gouged. The cavity in the bone was packed with a salt bag, and finally 2 drachms of glycerine and formalin were injected into the joint.

On August 23rd the temperature rose to 102° and pulse to 118. The joint was painful.

On August 24th the pain was less; temperature 101° , pulse 110.

On August 25th the temperature was normal, pulse 90; pain less. Wound re-dressed with salt pack.

On August 30th the swelling in joint had subsided; temperature normal since August 25th; no pain; wound healing well. Discharged to England.

5. ACUTE OR MODERATE SEPSIS WITH SEVERE FRACTURE.

This class of case, unfortunately common, is too frequently temporized with till amputation is inevitable. It is almost invariably associated with extensive comminution of one or more bones entering into the articulation. Many are of opinion that amputation should be performed in these cases, but we think that, should the fracture not extend further than 1 in. above the articular surface of the femur or below the level of the tubercle of the tibia, the limb can be saved, and we consider it worth while, even at the expense of a permanently fixed knee and a certain amount of shortening.

Our treatment, in brief, amounts to an excision of the joint, but modified, so that the septic nature of the wound can be efficiently dealt with.

The knee-joint is opened by curved incision over the front, dividing the ligamentum patellae and lateral ligaments, a flap being thrown up which includes the patella and all superficial tissues. The knee-joint is fully flexed, the crucial ligaments divided, semilunar cartilages, tags of synovial membrane, and all necrotic tissues removed. The interior of the joint, being thus rapidly and freely exposed, is searched for any pockets of pus, which, if found, are freely laid open.

If one condyle of the femur is found to be shattered, both must now be removed. Similarly, should the head of the tibia be involved, it is excised. If either femur or tibia is intact it is left till a later date. The joint is now thoroughly irrigated with 0.5 per cent. eusol.

We have had considerable difficulty in preventing retraction of the patellar flap. To obviate this we have devised the following: Three aluminium plates, 1 in. long and $\frac{1}{2}$ in. broad, with one hole bored through them near each end, are used. These plates take up the tension of sutures passed through the flap near its edges. The sutures are tied to elastic bands which are supported by a metal arch fixed anteriorly on a Thomas splint (see figure).

Tubes are now inserted down to the posterior parts of the joint; these are packed round with salt bags. Gauze wrung out of hypertonic saline is laid over this, and a few turns of bandage loosely applied, to keep the gauze in position; the last foot of this bandage is left hanging from the limb to act as a drain.

Extension is applied to the leg and the limb suspended, on a bent Thomas knee splint, by 4-in. rubber slings. The back of the knee-joint is supported on a bent perforated zinc splint reinforced by aluminium strips, which is, in turn, suspended from the Thomas splint by rubber

Thomas splint adapted for excision of knee.

tubes above and below. The knee-joint is thus firmly supported in a slightly flexed position under extension, and moreover, in spite of continuous drainage and frequent dressings, the limb can be kept dry and comfortable.

The bed is so arranged that the discharge drains into a bucket placed below it. The wound dressings are kept moist by hypertonic saline solution being sprayed on them, and thus the bandage never acts as a plug.

The dressing is removed when indicated, a general anaesthetic being given, and a similar dressing applied.

Later, this dressing may be replaced by one of eusol irrigation twice daily.

This treatment is continued until the wound is clean. We then, under a general anaesthetic, remove the articular cartilage from the ends of the undamaged bone. The flap formed by the patella and superficial tissues, which has up till now been kept under extension, as previously described, is sutured in position, plates of aluminium being employed to give equal tension and prevent the sutures cutting through.

A thin piece of rubber is left in the posterior part of the wound to act as a drain.

Finally, the limb is put up straight on the Thomas splint with a ham splint posteriorly to support the knee.

CASE VI.

Pte. M., wounded by shell fragment on June 2nd, 1916. Admitted June 4th, 1916. The patient had a large lacerated wound on the inner side of the left knee-joint, with a smaller wound on outer side of thigh about four inches above the condyle. Wound very foul, with free discharge of pus and synovial fluid. Temperature 99°, pulse 108. Skiagraph showed a comminuted fracture of the internal condyle of the femur.

On June 5th, under an anaesthetic, wound edges trimmed and loose portions removed. The wound on outer side of thigh appeared to be the entrance wound, the projectile passing between the large vessels and the bone. Fluid taken from the joint, which the pathologist reported to contain enterococcus and streptococcus.

On June 7th temperature 102°, pulse 110; joint painful. Free discharge of pus from the wound.

On June 8th, under an anaesthetic, joint opened up by anterior incision. The interior severely infected, and in a sloughing condition. Internal condyle extensively comminuted. Both semilunar cartilages removed and crucial ligaments divided, the lower ends of the femur then excised immediately above the condyles. All tags of synovial membrane and sloughing tissues removed. The limb was fixed in a flexed position on a Thomas knee splint, the wound packed with salt bags, and patella flap extended.

June 12th. The wound had discharged freely for the past three days. Temperature 99°, pulse 110. Dressing changed under an anaesthetic, wound cleaning up well and sloughs beginning to separate. The patient has a bromide mixture, with morphine when necessary.

June 16th. Wound dressed without anaesthetic. The dressing came away easily with little pain. Eusol irrigations twice daily, with light eusol dressings substituted for salt pack. Temperature 99°, pulse 90. Little pain.

June 23rd. Wound almost clean, and covered with healthy granulations. Under an anaesthetic the articular cartilages on the head of the tibia were removed and the spine chiselled away. The patella flap was sutured in position, aluminium plates being employed. A thin rubber drain was left in the posterior parts of the joint. The limb was put up straight on a ham splint, suspended in a Thomas splint. The wound healed well, and when evacuated to England on July 9th there was only a small sinus discharging on the internal aspect of the joint.

The foregoing is a summary of a wide subject, and one which we venture to think has not as yet received the attention it merits. We hope that this short article may prove an incentive to others to make known their views.

Owing to the present stress of work we apologize for the somewhat crude method in which the subject has been presented.

THE USE OF ATROPINE AS AN AID TO THE DIAGNOSIS OF TYPHOID AND PARATYPHOID A AND B INFECTIONS.

(Preliminary Note.)

By H. FAIRLEY MARRIS,

CAPTAIN (TEMPORARY) R.A.M.C., BRITISH EXPEDITIONARY FORCE, 1916.

DURING the past year I have studied and recorded graphically the various cardiac irregularities met with in typhoid and paratyphoid fevers. In the course of this investigation, carried out on lines advocated by Sir James

Mackenzie, I was led to devote special attention to the relatively slow heart rate which commonly occurs in this group of fevers. It is well known that atropine increases the rate of the heart by some twenty to forty beats per minute. I found that the rate of a slowly beating heart in each of these fevers was

hardly accelerated at all by the injection of $\frac{1}{3}$ grain of atropine sulphate hypodermically.

Further observations showed me that in practically all

cases of the typhoid group during some period of the infection the rate of the heart could not be increased by atropine as the rate can be accelerated in normal people and those suffering from other diseases. As I found that the failure of the heart to respond to atropine was so constant in all cases bacteriologically proved to belong to the typhoid group I began to use this reaction as a means of diagnosis.

The whole of the work on this subject was carried out at a stationary hospital (under command of Lieutenant-Colonel C. R. Evans, D.S.O., R.A.M.C.) which is specially equipped for typhoid cases and possesses a full bacteriological laboratory, where, in addition to the ordinary routine of examination by cultures, Professor Dreyer's

method of diagnosis by agglutination has been employed under his personal advice, and used to control all the cases enumerated in this paper.

Method of Making the Test.

At least one hour after a meal should elapse. The patient should lie horizontally and be instructed to keep

perfectly quiet throughout. The pulse-rate is then taken and recorded minute by minute until found to be steady. Usually ten minutes will be found to suffice for this;

CHART I.—Effect of hypodermic injection of $\frac{1}{3}$ gr. of atropine sulphate (A) upon the pulse-rate of a healthy man aged 24 who was bacteriologically and serologically shown to be free from typhoid, paratyphoid A, or paratyphoid B infections. (Mackenzie polygraph.)