TECHNICAL NOTE
A NEW TUBULAR FORM OF HIP NAIL*

1. INTRODUCTION
The magnitude of the problem of the internal fixation of fracture of the neck of the femur is evidenced by the wide variety of devices which have been employed by orthopaedic surgeons over many years.

A large number of these devices, from the engineering viewpoint, appear to be mechanically weak at their most highly stressed region, and in addition, some of the designs incorporate stress-raising features in the form of holes, recesses and sharply bent corners. The accepted view of the function of such an internal fixation device is that it has to prevent rotation of the loose femoral head with respect to the neck of the femur, while at the same time it must allow a measure of absorption of bone at the line of fracture during the process of union. Most existing hip nails require to be hammered forcibly into position before being attached to the shaft of the femur, and this process in itself may cause irreparable damage to the head of the femur and to its surrounding cartilage.

The tubular nail which is described in this Technical Note has been designed to overcome such difficulties and to fulfil the following requirements:

1. Prevent rotation of the head of the femur.
2. Allow absorption at the line of fracture.
3. Anchor the head of the femur to the nail tube.
4. Avoid the need for punching into position.
5. Provide adequate resistance to bending under load.
6. Reduce the tendency for crack propagation in the femoral head, due to bursting forces in application.
7. Permit easy removal if required.

2. THE "ROSS-BROWN" TUBULAR HIP NAIL
The "R.B.T." nail assembly is composed of three parts fabricated from 18-8 Mo stainless steel (FMB quality) (Fig. 1), viz. a nail plate, a nail tube and an expansion piece. One member of the nail plate is of square cross-section, which smoothly adjoins (at an angle of 135°) the second member, the function of the latter being to secure the nail plate in the usual manner to the shaft of the femur.

The dimensions of the square cross-section member, which is of fixed length, are such as to provide a good sliding fit within the square tubular nail. The nail tube, which may be of any suitable length as required, has two angular slots cut in opposite sides at one end (Fig. 2). These slots permit the expansion piece to be forced out from inside the tube, after the tube has been inserted into the head of the femur (Fig. 3). At the other end of the nail tube, two D-shaped slots are provided (Fig. 2) for the engagement of the tools necessary for the insertion of the expansion piece, and for the attachment of an extractor hammer for removal of the nail tube from the patient should this be necessary at a later date.

The expansion piece has a centrally drilled hole to allow for the engagement of a self-tapping screw which is carried in a withdrawal tool. This provides a means of retracting the expansion piece into the nail tube, prior to removal of the latter from the patient, if required.

3. TECHNIQUE OF INSERTION AND WITHDRAWAL
The normal guide wire and guide is used to give direction and measurement of depth prior to the use of a hand-operated straight-fluted cannulated drill (Fig. 4) which carries its own depth stop. This tool may have its own handle, or alternatively be used in a hand brace. Removal of some of the hard surrounding bone using an osteotome is desirable in order to give the drill a clean start and to prevent deflection of the guide wire in the initial stages of drilling. The diameter of this drill matches the size of the nail tube across its flat surfaces, and therefore only the corners of a square hole now

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require to be cut out. This is achieved using a square tubular broach (Fig. 5) which has a combined depth stop and angular guide, so that the orientation of the square hole may be correct to allow the nail plate to lie along the axis of the shaft of the femur. The broaching operation requires relatively light punching forces, as compared to those required for the insertion of conventional hip nails.

The nail tube carrying within it the expansion piece is lightly tapped into position using an introducer (Fig. 6). The expansion piece is now pushed forward and through the angular slots, using the expansion tool (Fig. 7) which operates on the screw jack principle, the amount of expansion being controllable by means of a stop in the tool. Since this tool is engaged in the D-shaped slots at the end of the nail tube, and is also bearing on the expansion piece, the action is a self-straining one, and is entirely contained within the tube so that no forces are presented to the surrounding bone, apart from the movement of the expansion piece prongs into the head of the femur.

Should it be necessary to withdraw the expansion piece, a withdrawal tool (Fig. 8) is used, the frontal self-tapping screw being engaged in the hole in the expansion piece. This tool bears on the outer end of the nail tube, so that the withdrawal process is also a self-straining action contained within the tube. For withdrawal of the nail tube, an extractor hammer (Fig. 9) is used. This tool engages in the D-shaped slots in the tube in the same manner as the expansion tool.

The nail tube now being securely attached to the head of the femur, and bridging the line of fracture, the nail plate is slipped into position and secured to the shaft of the femur by self-tapping screws in the normal fashion.

By the production engineering technique of an "operation layout", the process of hip nailing with the "R.B.T." nail and tools can be conveniently summarized (Table 1).

A cross-section of the head of a femur carrying a nail tube and expansion piece (Fig. 10) shows that the latter cuts its way cleanly into the surrounding bone and provides an adequate area of contact which will prevent the nail from "backing out" of the head.

4. DESIGN CONSIDERATIONS

The nail tube/nail plate assembly was arranged to be at least as stiff as a tri-fin nail in current use (J. T. Brown's sliding nail-plate, supplied by Down Bros.), of which only one mechanical failure in approximately 400 has been found. The graph (Fig. 11) shows the load-deflection curves for such a tri-fin nail, compared with the corresponding curve for an "R.B.T." nail, and indicates that the square section nail is 1.4 times as stiff, for comparable dimensions.

Since most hip nails fail mechanically by plastic yielding at the junction of the nail and the nail plate (the most highly stressed region in all nails of this type)