FIG. 1

Hip of a woman aged 82 years. The medial and lateral trabecular systems are well shown. Where they intersect is the strongest portion of the femoral head.
Method of determining moments which loosen pins in femoral heads.

FIG. 2
Sub-capital fracture in a woman aged 70 years of age suffering from rheumatoid arthritis. The pin is lateral to the medial trabecular system.
FIG. 4

The same patient as in Fig. 3. The pin has cut out.
FIG. 5

A pinned femoral head being loaded from above in a testing machine. The load is transmitted by the square wooden rod resting on the head of the femur.
FIG. 6

Pinned femoral head split by a load of 336 lbs.
Pinned femoral head split by a load of 627 lbs. The head is rotated 90° to show the large defect produced by the fractured off sector.
Hip of woman aged 65 years of age, five months after pinning. The pin is inserted somewhat laterally. The radiographic appearances suggested union and weightbearing was allowed.
FIG. 9

Same patient as in Fig. 8 two months later. The fracture was not united. Weightbearing crushed the femoral head above the pin. The osteosynthesis disintegrated.
FIG. 10

Pushing a vertically orientated trifin nail through a femoral head.
Determination of the angle of friction between a femoral head and cancellous bone

FIG. 11
Frictional forces inside the femoral head. The load acting on the head of the nail is equal in magnitude but opposite in direction to the force $R$ shown inside the femoral head.
FIG. 13

The bruised hip of a woman aged 76, four weeks after nailing.
FIG. 14

Hip of an elderly woman two to three weeks after nailing. Next to the fovea there is a dark area of cartilaginous softening.
FIG. 15

Radiographs of experimentally nailed femoral neck fracture. The head appears normal.
Photograph of same specimen as in Fig. 15. The articular cartilage is extensively fractured.
FIG. 17

Final radiograph taken in the operating theatre of the pinning of the hip of a man aged 85 years.
FIG. 18

Same patient as in Fig. 17. Two days later the head is split in two.
FIG. 19

Radiograph of right femur of a woman aged 71 with a trochanteric fracture. Theatre film.
FIG. 20

Same hip as in Fig. 19 six days after pinning.
FIG. 21

Radiograph of left hip of 71 year old patient, twenty years after pinning. Osteoarthritic changes are present.
FIG. 22

Hip of man aged 68 years. Final film taken in the operating theatre.
FIG. 23

Same patient as in Fig. 22. The distal fragment has fallen into lateral rotation.
FIG. 24

Hip of a man aged 70 years. Final film taken in the operating theatre.
FIG. 25

Same patient as in Fig. 24. Thirty two days later there is extrusion of the pin. The inferior cortex is abutting against the nail.
FIG. 26

Same patient as in Fig. 24. Three and a half months after re-nailing the femoral head has slipped into varus.
Per-trochanteric fracture of a woman aged 78 years, pinned with a sliding pin which has not been inserted far enough.
Same patient as in Fig. 27. Radiograph of post-mortem specimen. The proximal fragment has travelled downwards.
FIG. 29

Radiograph of post-mortem specimen of hip of a woman aged 73 years suffering from Perthes' disease. The head of the femur has been sawn off. The arrow on the left indicates where the load was applied to the pin. On the right the clear triangular area gives an indication of the amount of cancellous bone crushed.
FIG. 30

Determination of the strength of the lateral fragment.
For symbols see text.
Experiment 5, Table III. Left hip of a man aged 40 years. One fin of the nail points upwards. The resistance offered to the descent of the pin was of the order of 200 lbs.
Experiment 6, Table III. Right hip of same patient as in Fig. 31. One fin points downwards. The resistance offered by the latéral fragment was of the same order, as in Fig. 31. The same amount of cancellous bone was crushed in each specimen. The specimens were not photographed under identical conditions and the photographs are somewhat misleading.
Determination of the angle of friction of femoral neck cancellous bone on femoral neck cancellous bone.
Determination of frictional resistance offered by a pinned vertical fracture. The fragments are distracted. The femoral head is being loaded.
Same experiment as in Fig. 34. The fragments have been impacted. A load is again applied to the femoral head.
The effects of the high co-efficient of friction.
A fracture at right angles to the cervical axis is shown.
If the axial thrust is 100 lbs, a force of 119 lbs tangential to the plane of the fracture is necessary to displace the fragments.
A simple classification of femoral neck fractures.
(a) Vertical fractures. The fragments tend to ride over each other. (b) Horizontal fractures. The fragments tend to become impacted.
FIG. 38

Right femur with a transverse fracture viewed from above. The bulge on the distal fragment is the posterior projection of the great trochanter. The pin has been centrally placed. Left: The lower arrow acting on the lateral fragment indicates the action of the psoas during straight leg raising. The upper arrow acting on the femoral head is the reaction of the acetabulum on the femoral head, equal in magnitude, but opposite in direction, to the force produced by the psoas. Right: The action of this couple has caused disintegration of the osteosynthesis and lateral rotation of the distal fragment.
Analysis of the bull's eye position. The symbols are explained in the text.
Experimental loading of pinned femoral head.
FIG. 41

Same experiment as in Fig. 39. The lateral cortex is ploughed up.
FIG. 42

Analysis of 2.1.5. The inset shows the orientation of the pin.
Radiograph of left hip of girl aged 16 showing a vertical cervical fracture.
FIG. 44

Same hip as in Fig. 43 three months after internal fixation with four thin wires.
FIG. 45

Same hip as in Figs. 43 and 44 six months after operation. Three wires have failed in tension.
Analysis of pinning by a nail plate with the nail inserted centrally into osteoporotic bone. Notice how the moment acting on the pin is transferred to the shaft in three stages corresponding to the number of screws.
Analysis of a pinning by a nail plate with the nail inserted centrally into hard bone.
Analysis of method 2.1.9. Notice the tensile forces distracting the fragments.
Analysis of a near vertical nail attached to a plate. Notice the transfer of the bending moment on the pin to the shaft in three stages to keep the incision short.
Analysis of internal fixation of trochanteric fracture.
FIG. 52

Radiograph of left hip of woman aged 57 a few days after internal fixation with a McLaughlin nail-plate.
Same hip as in Fig. 52. The osteosynthesis has disintegrated. The patient was allowed to walk a few days after operation.
Radiograph of hip of man aged 22 years four months after pinning. The fracture united in two years.
FIG. 55.

The writer's pin. Left: Tube-plate and above it the pin with its distal end just inside the locking device. Centre: The assembled pin fully extended. Right: The pin fully collapsed.
FIG. 56

Experimental fracture secured with the pin described. The tip of the implant has been screwed right up to the articular cartilage.
FIG. 57

Same specimen as in Fig. 56. Lateral radiograph.
FIG. 58

Same specimen as in Figs. 56 and 57. The femoral head is undamaged.
Pinned experimental fracture tested to destruction. The split off fragment mentioned in the text is not shown. The femoral head has been rotated 90°. The defect shown should face upwards.
FIG. 60

The guide wire block, the most commonly used introducer.
FIG. 61.

Tools used for inserting the pin. (a) Alternative guide wire introducer. (b) Caliper. (c) Counterbore tool. (d) Notched, cannulated cylinder. (e) Direct reading rule. (f) Calibrated flat drill used before the screwing in of the pin. (g) Box spanner for screwing the pin into the femoral head via the tube.
The notched cannulated cylinder has been passed over the upper of the two guide wires. The lower guide wire is correctly placed, but it is four notches = 1" too short.
Same specimen as in Fig. 62. The heavy line indicates the central axis of the femoral head and neck. There is angular displacement of the two guide wires. The tip of the chamfered cylinder shows the point where the guide wires pierce the cortex. The angular displacement of the guide wires from the central axis can thus be estimated or measured.
The foot has been strapped to the sole plate of the orthopaedic table, well clear of the heel support.
FIG. 65

Hip of woman aged 54 two weeks after insertion of a trifin nail.
Same hip as in Fig. 65 showing insertion of the writer’s pin. Notice the two guide wires steadying the femoral head. The pin was subsequently slightly withdrawn.
FIG. 67

Same hip as in Fig. 66, thirteen months after operation. The hip was painless. Nearly an inch of telescoping has occurred.
FIG. 68

Types of trochanteric fractures treated: (a) Basal and intertrochanteric. (b) Per-trochanteric. (c) Comminuted trochanteric.
FIG. 69

Age distribution of the 99 patients reviewed.
Follow-up periods of trochanteric fractures of this series.
FIG. 71

Trochanteric fracture in a female patient aged 81 years.
FIG. 72

Radiograph taken in operating theatre. (Same patient as in Fig. 71)
FIG. 73

Early union 39 days after fracture. (Same patient as in Fig. 71)
FIG. 74

Firm union three months after injury. (Same patient as in Fig. 71)
FIG. 75

Trochanteric fracture in a female patient aged 85 years.
FIG. 76

Radiograph of post-mortem specimen shows early bony union. (Same patient as in Fig. 75)
Histological preparation of case shown in Fig. 75. (H and E x 1.5). There is bony union across the shaft. The great trochanter is still ununited.
Histology of cortical portion of preparation shown in Fig. 77. (H and E x 120). Notice the formation of cartilage.
FIG. 79

Field from same slide as in Fig. 78. Osteoid tissue is present.
Per-trochanteric fracture in a man aged 82 years.
FIG. 81

Same fracture as in Fig. 80, two days after pinning.
Post-mortem specimen viewed from behind 21 days after internal fixation. On gross examination there is bony union laterally and abundant callus medially. (Same case as in Fig. 80)
FIG. 83

Radiograph of right elbow of a 37 year old housewife and secretary showing that the trabeculae in the lateral humeral condyle, the proximal end of the ulna and the upper end of the radius are normal to their respective joint surfaces.
Radiograph of left femur of a middle aged man who died in a road traffic accident. The arrangement of the two trabecular systems is as described in the text. The origin of the lateral system is not clearly outlined, but is identifiable. Notice that the two trabecular systems end normal to the articular surface of the femoral head. Ward's triangle is well shown.
The dimensions and the load acting on this cantilever are indicated. The shear and flexural stresses acting on point P, 2 cm above the neutral axis and 10 cm distant from the free end of the beam were calculated and are shown in the inset at the top of the figure. By means of Mohr's circle the principal stresses were determined and are demonstrated in the inset above point P.
FIG. 86

Principal stresses in a cantilever with a load at its free end. The curves arching from above downwards represent tensile stresses and the ones coursing in the opposite direction compressive stresses. (Fig. 63 in Strength of Materials by J.P. Den Hartog, 1949, Dover Publications, Inc. New York)
FIG. 87

Notice the hypertrophied tibia and the screw remnant.

29 years later he had no worthwhile disability.

He had no treatment other than removal of the plate. The tibia was replaced immedi-ately and fractured. He was treated further and broke his elbow. This is a 13 year old ex soldier who was paraplegic into Hungary in 1942 and broke his right tibia.
FIG. 88
Close up of pseudarthrosis in Fig. 87
FIG. 89

Radiograph of right hip of seven year old boy with severe Perthes' disease.
FIG. 90

Same hip as in Fig. 89 eighteen months after varus osteotomy. A newly formed trabecular system extends from the medial end of the osteotomy to the weightbearing area of the femoral head.
Radiographs of upper ends of femoral of a young man prepared as described in text. Only the medial trabecular system is clearly discernible. The appearances resemble a honeycomb.
Lateral radiograph of dorsal spine of lady in her eighties demonstrating increased kyphosis.
FIG. 93

Lateral radiograph of spine showing a pathological fracture in the mid-dorsal region. The patient was an elderly woman.
FIG. 94

Radiograph demonstrating swelling of the discs causing a so-called cod fish vertebra. The vertebral score in this case is 57. The meaning of this term is explained in the text. The woman's age was 84 years.
FIG. 95
Lateral radiograph of femur of elderly woman.
FIG. 96

Block diagram demonstrating how an image intensifier and monitor work. The intensity of the light entering the television camera can be measured by a microammeter. Alternatively the video signal can be analysed by an oscilloscope.
Graph showing exponential absorption in Experiment III. The ordinates are the natural logarithms of the light meter readings in Table X. The abscissae give the numbers of units of Perspex traversed by the X-Rays. The regression line shows a 99% correlation.
FIG. 98

Idealized oscillogram of a perfectly round bone. The distance of each point of the double peaked curve from the base line is directly proportional to the amount of bony tissue traversed by the photons. Their source would be at the top of the diagram. The rays must of course be parallel.
Schematic drawing of the blood supply of the upper end of the femur: (1) Lateral epiphysial artery. (2) Medial epiphysial artery or artery of the ligamentum teres or foveolar artery. (3) Lateral metaphysial artery. (4) Inferior metaphysial artery. (5) Digital anastomosis sending an unnamed vessel into the femoral neck. (6) Nutrient artery of femur ending in trochanteric region.
FIG. 100

Post-mortem specimen of hip of patient aged 80 years who died five months after internal fixation. Top: On gross and histological examination the specimen is avascular. The nail has been driven into the foveola. Bottom: The radiograph shows a band of radiolucency at the site of the not yet united fracture.
FIG. 101

Femoral head of woman aged 74 years, 3½ months after internal fixation. In the original specimen the dark zone indicating revascularization was red.
Histological section of same case as in Fig. 101. There is creeping substitution of a dead trabecula by living osteoid.
Radiograph of the hip of a woman whose fracture was pinned when she was 82 years old. Twenty nine months after operation the neck has disappeared and the head is dense. The nail is in the fovea yet somehow this femoral head has become revascularized.
Left hip of patient aged 78 years nailed one month after injury. The radiograph shows that the pin has cut out of the femoral head which appears abnormally dense.
FIG. 105

Simplified model of hip joint. $F$ is the load forcing the acetabulum against the femur. $P_1, P_2, P_3$ are the principal stresses.
Principal stress trajectories for $p_1$ and $p_2$, and the zero stress isobars for $p_2$ and $p_3$. Full lines represent direction of compressive stresses and broken lines directions of tensile stresses. Note that in Zone A the three principal stresses are all compressive. In Zone B they are compressive on four surfaces of a cube and in Zone C on two surfaces of a cube. (Figs. 105 and 106 copied from Zarek and Edwards, 1963)
FIG. 107

Action, but not orientation of stresses on small cubes in Zones A (top), B (middle) and C (bottom) of Fig. 106.
FIG. 108

Bottom left: Contact area viewed from above. \( p_2 \) and \( p_3 \) as in Figs. 105 and 106. The signs of these two stresses are different.

Top right: Shearing stresses caused by \( p_2 \) and \( p_3 \).
FIG. 109

FIG. 110

Compressed football headed by Jeff Astle. (Copied from Amateur Photographer, 22nd March, 1967, page 415)
FIG. 111

Radiograph of pelvis of man aged 72 years. His right hip was painful. Notice the Judet's prosthesis on the left side.
FIG. 112

Coned view of the right hip of Fig. 111. There is minor flattening of the femoral head.
FIG. 113

Same hip as in Fig. 112. Within a month the femoral head has become crushed. Notice the ghost-like appearance of the trabecular systems.
FIG. 114

Histological preparation of femoral head shown in Fig. 113.
Dead bone found in femoral head as shown in Fig. 114. (H and E x 100)
FIG. 116

Active repair in same slide as Fig. 114. (H and E x 100)
FIG. 117

Metaplastic cartilage found in same slide as Fig. 114. (H and E x 100)
FIG. 118

Radiograph of ununited fracture of man aged 32 years.
FIG. 119

Biopsy of fracture shown in Fig. 118. Dead bone is present. (H and E x 150)
FIG. 120

Regenerating bone in same slide as Fig. 119. (H and E x 100)
FIG. 121

Metaplastic cartilage in same slide as Fig. 119.
(H and E x 100)
Radiographs of right hip of woman aged 81 years.

Top: Soon after fracture.
Bottom: Six weeks later.
Radiograph of left hip of woman aged 79 years. Top: Soon after fracture. Bottom: Three weeks later. The lateral trabecular system is deficient laterally.
FIG. 124

Radiograph of right hip of woman aged 88 years two years after internal fixation.
FIG. 125

Radiograph of left hip of woman aged 53 years nine years after an anterior dislocation of left hip in a road traffic accident.
FIG. 126

Same hip as in Fig. 125 six months after total replacement by Mr. W. G. France.
FIG. 127

Schema of the trabecular systems of the femoral head and neck: (1) Medial system. (2) System rising from lesser trochanter. (3) Trochanteric group of trabeculae. (4) Lateral trabecular system. (5) System rising from medial aspect of outer cortex opposite (2).
Radiograph of left hip of woman aged 70 years. A solid segment of the femoral head has become detached and is slightly displaced outwards.
FIG. 129

Radiograph of left hip of patient suffering from S-C haemoglobinopathy. Notice the saucer-shaped depression.
FIG. 130

Radiograph of right hip of woman aged 53 years a few days after internal fixation of her femoral neck fracture. Notice the valgus impaction and the insertion of the tip of the pin into the foveola.
Radiograph of the same hip as in Fig. 130, 27 months after internal fixation. The pin has been removed. There is superior segmental collapse.
Radiograph of right hip of patient aged 77 years demonstrating superior segmental collapse, shortening of the neck, a pin track and displacement osteotomy.
FIG 133

Biopsy trephine with adjustable collar.
FIG. 134
Typical biopsy specimen
FIG. 135

Dead bone obtained from the hip of a man aged 78 years. Note the absence of osteocytes and the dead marrow space. (H and E x 100)
FIG. 136

Hip from which biopsy shown in previous Fig. was taken three years after internal fixation. The line of the fracture is still visible. The patient had no disability.
FIG. 137

Viable bone obtained from the hip of a female patient aged 88 years. (H and E x 110)
Diagram explaining how the specific gravity of a bone biopsy is determined. S. Specimen. Full bottle plus specimen on left equal bottle containing specimen on right plus volume of water displaced by specimen. Both bottles are filled to the mark with water.
FIG. 139

Radiograph of hip of woman aged 55 years, 27 months after internal fixation and six months after removal of the pin. Notice the superior segmental collapse.
FIG. 140

Radiograph of hip of woman aged 88 years. The pin was centrally inserted in the lateral view as well.
FIG. 141

Radiograph of same hip as in previous Fig. 140. The pin has cut through the femoral head.
FIG. 142

Simple method used with first specimen tested.
FIG. 143

Method subsequently adopted. Four guide wires were driven through the femoral head roughened in many places. Acrylic cement was then moulded round the wires, the specimen and the non-tightened jaws of the vice for secure fixation.
Specific gravity of the samples plotted against fixing moments. The line of best fit was calculated. There is a 95% correlation.
Specific gravity plotted against calcium concentration. The line of best fit was calculated. There is a 91.7% correlation.
Calcium concentration plotted against fixing moments. There is an 81.4% correlation.
Analysis of method used for determining fixing moment.

The femoral head on left is embedded in cement. Load L is attached to the end of the pin. The reactive forces inside the femoral head are R1 and R2. a is the length of the pin inside the femoral head and b the length outside.
FIG. 148

Radiograph of femoral head of case 7 in Table XI. Notice the poor mineralization of the pelvis, the wide femur and the narrow cortex.
FIG. 149

Radiograph of left hip of man aged 36½ years, 18 months after unsound pinning.
FIG. 150

Radiograph of right hip of woman aged 44 years. A Minneapolis prosthesis has been inserted. There is evidence of a healed osteotomy.
FIG. 151

Radiograph of impacted vertical femoral neck fracture. Specimen in Museum R.C.S.
FIG. 152

Radiograph of undisplaced vertical femoral neck fractures.
Specimen in Museum R.C.S.
FIG. 153

Radiograph of displaced vertical femoral neck fracture.
FIG. 154

Radiograph of transverse impacted femoral neck fracture.
FIG. 155

Radiograph of transversely disposed femoral neck fracture without displacement.
FIG. 156

Radiograph of displaced transverse femoral neck fracture.
FIG. 157

Tracing of radiograph of same case as in previous figure after reduction.
Femoral head of man aged 29 years, who committed suicide. A trifin nail was driven $\frac{7}{8}$" into the centre of the specimen. Ample cushioning was provided. The specimen was transfixed with wires and embedded in acrylic cement as described in Chapter XI. After the experiment the resin was nibbled away to expose the crack produced by hammering in the pin. The hole below the pin track represents the donor site of the material sent for laboratory examination.
Radiograph of right hip of woman aged 56 years, eight years after trifin nailing. Osteoarthritis has developed.
Radiograph of left hip of woman aged 35 years with gross coxa vara.
Radiograph of same hip as in previous figure after valgus osteotomy.
Rationale of operation shown in previous figure. For symbols see text.
Sketch of osteotomy in Fig. 161. Distance C'P equals distance CP in previous figure. The lower transverse line represents the latus rectum on which the original point C has been marked.
FIG. 164

Post mortem specimen of left hip of woman aged 85 who died 58 days after pinning of a vertical undisplaced femoral neck fracture. There is bony union.
Radiograph demonstrating a Thompson prosthesis in upper end of left femur of a patient aged 84 years. The prosthesis is loose and has migrated downwards.
FIG. 166

Austin Moore prosthesis removed from a patient's hip on account of infection. A substantial amount of the cement used has come away with the implant.
FIG. 167

Tracing of displacement osteotomy for ununited femoral neck fracture.
FIG. 168

Tracing of abduction osteotomy for ununited femoral neck fracture.
FIG. 169

Radiograph of hip of 16 year old girl. The four wires have snapped. There is non-union.
FIG. 170

Sketch showing wedge excised in cuneiform osteotomy.
Sketch showing situation after closure of gap created by cuneiform ostectomy. The fracture line is more horizontal.
Radiograph of same hip as in Fig. 169 six months after osteotomy as described. The fracture line is horizontal but its lateral portion is obscured by a cervical fragment secured with two small pins.
FIG. 173

Radiograph of high femoral osteotomy for Perthes' disease. A Coventry screw-plate has been used. Courtesy of Mr. C. P. Monty, M.D., F.R.C.S.
FIG. 174

Radiograph of left hip of woman aged 83 years. An impacted vertical fatigue fracture is present.
FIG. 175

Radiograph of pelvis of girl aged 15 years suffering from polyostotic fibrous dysplasia. Notice the pathological fracture of the left femoral neck.
Radiograph of the same left hip as in previous figure two years after internal fixation with an autogenous tibial bone graft.
Radiograph of right hip of girl aged twenty years. The femoral neck has been destroyed by a simple bone cyst.
Radiograph of same hip as in previous picture after insertion of an implant with a stainless steel stem inserted into the femoral shaft. The upper portion of the stem is surrounded by acrylic resin which does not show up in the radiograph.
Radiograph of left hip of patient aged 69 years. There is destruction of bone by a carcinomatous deposit. A pathological fracture is also present extending upwards from the lesser trochanter.
FIG. 180

Radiograph of same hip as in previous figure two years after prosthetic replacement. Notice the acrylic cement.
FIG. 181

Radiograph of hip of 44 year old woman three months after radical mastectomy for mammary carcinoma. An extensive secondary deposit is present.
Radiograph of same hip as in previous figure taken four months later after deep X-Ray therapy.