VOLUME TWO

CAMPBELL'S OPERATIVE ORTHOPAEDICS

Editors
ALLEN S. EDMONSON, M.D.

A. H. CRENSHAW, M.D.

SIXTH EDITION

VOLUME ONE

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with 5,400 illustrations and 2 color plates

The C. V. Mosby Company

ST. LOUIS • TORONTO • LONDON 1980

SIXTH EDITION

Printed in the United States of America

The C. V. Mosby Company
11830 Westline Industrial Drive, St. Louis, Missouri 63141

Library of Congress Cataloging in Publication Data

Campbell, Willis Cohoon, 1880-1941.
Campbell's Operative orthopaedics.

Includes bibliographical references and index.
1. Orthopedic surgery. I. Edmonson, Allen S.
II. Crenshaw, Andrew Hoyt, 1920- III. Title.
IV. Title: Operative orthopaedics.
RD731.C28 1980 617'.3 80-14731
ISBN 0-8016-1071-0

C/CB/B 9 8 7 6 5 02/A/210

Contributors

L. D. ANDERSON, M.D.

Chapter 10

Professor and Chairman, Department of Orthopaedic Surgery, University of South Alabama College of Medicine, Mobile, Ala.; Active Staff, University of South Alabama Medical Center Hospital; Consulting Staff, Providence Hospital and Mobile Infirmary

OTTO E. AUFRANC, M.D.

Section on Vitallium mold arthroplasty in Chapter 22

Emeritus Professor of Orthopaedic Surgery, Tufts Medical School, Boston, Mass.; Emeritus Assistant Clinical Professor of Orthopaedic Surgery, Harvard Medical School; Emeritus Chief, Fracture Service, Massachusetts General Hospital; Emeritus Chief of Orthopaedic Surgery, New England Baptist Hospital; Honorary Surgeon, Newton-Wellesley Hospital, Newton Lower Falls, Mass.

R. A. CALANDRUCCIO, M.D.

Chapter 22

Clinical Professor of Orthopaedic Surgery and Chairman of Department of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Chief of Staff, Campbell Clinic; Active Staff, Baptist Memorial Hospital, City of Memphis Hospital, LeBonheur Children's Medical Center, and Crippled Children's Hospital

S. T. CANALE, M.D.

Chapter 13 and sections on all joints except knee in Chapter 9 and on ankle in Chapter 22

Clinical Associate Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, LeBonheur Children's Medical Center, Baptist Memorial Hospital, and Crippled Children's Hospital

P. G. CARNESALE, M.D.

Chapter 14

Clinical Assistant Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Baptist Memorial Hospital, and City of Memphis Hospital; Consultant Staff, St. Joseph Hospital, LeBonheur Children's Medical Center, St. Jude Children's Research Hospital, and Veteran's Administration Medical Center; Courtesy Staff, Methodist Hospital

A. H. CRENSHAW, M.D.

Chapters 2 and 7

Clinical Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Crippled Children's Hospital, and Baptist Memorial Hospital; Consultant Staff, Methodist Hospital and United States Public Health Service; Associate Staff, LeBonheur Children's Medical Center and City of Memphis Hospital

ALLEN S. EDMONSON, M.D.

Chapters 1 and 21

Clinical Associate Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Crippled Children's Hospital, Baptist Memorial Hospital, City of Memphis Hospital, and LeBonheur Children's Medical Center

A. J. INGRAM, M.D.

Chapters 16 and 17

Professor and Chairman Emeritus, Department of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Chief of Staff Emeritus, Campbell Clinic; Consultant Staff, Baptist Memorial Hospital, Crippled Children's Hospital, and LeBonheur Children's Medical Center

E. J. JUSTIS, Jr., M.D.

Chapter 15 and review of fractures in Chapter 3

Clinical Assistant Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Baptist Memorial Hospital, City of Memphis Hospital, and Crippled Children's Hospital; Consultant Staff, LeBonheur Children's Medical Center and Arlington Developmental Center; Courtesy Staff, Methodist Hospital

LEE MILFORD, M.D.

Chapter 3

Clinical Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Baptist Memorial Hospital, and City of Memphis Hospital; Consultant in Hand Surgery, United States Public Health Service

J. A. PITCOCK, M.D.

Chapter 14

Clinical Associate Professor of Pathology, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff and Assistant Director of Laboratories, Baptist Memorial Hospital

E. GREER RICHARDSON, M.D.

Review of literature in Chapter 3

Clinical Assistant Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Junior Staff, Baptist Memorial Hospital; Active Staff, Campbell Clinic and University of Tennessee Hospital; Courtesy Staff, LeBonheur Children's Medical Center

F. P. SAGE, M.D.

Chapter 20

Clinical Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic and Baptist Memorial Hospital; Chief of Staff, Crippled Children's Hospital; Attending Staff, City of Memphis Hospital; Consultant Staff, LeBonheur Children's Medical Center and Methodist Hospital

JAMES C. H. SIMMONS, M.D.

Chapter 18 and sections on neurosurgery Chapter 21

Associate Professor of Neurosurgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Chief of Neurosurgery, LeBonheur Children's Medical Center; Active Staff, Semmes-Murphey Clinic

T. DAVID SISK, M.D.

Chapter 5 and sections on knee in Chapter 9, on shoulder in Chapter 22, and on recurrent dislocation of shoulder in Chapter 4

Clinical Associate Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Baptist Memorial Hospital, LeBonheur Children's Medical Center, and City of Memphis Hospital

HUGH SMITH, M.D.

Chapters 6 and 12

Emeritus Clinical Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Staff, Campbell Clinic

MARCUS STEWART, M.D.

Chapters 11 and 19

Clinical Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic and Baptist Memorial Hospital

ROBERT E. TOOMS, M.D.

Chapter 8 and section on knee in Chapter 22

Clinical Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic, Baptist Memorial Hospital, Crippled Children's Hospital, and City of Memphis Hospital; Consultant Staff, LeBonheur Children's Medical Center; Medical Director, University of Tennessee Rehabilitation Engineering Center; Medical Director, Regional Spinal Cord Injury Center

KEITH D. VANDEN BRINK, M.D.

Chapter 21 and section on spina bifida in Chapter 17

Clinical Assistant Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic and Baptist Memorial Hospital; Medical Director, Crippled Children's Hospital; Chief of Orthopaedics, LeBonheur Children's Medical Center; Consultant, University of Tennessee Rehabilitation Engineering Center

PHILLIP E. WRIGHT, M.D.

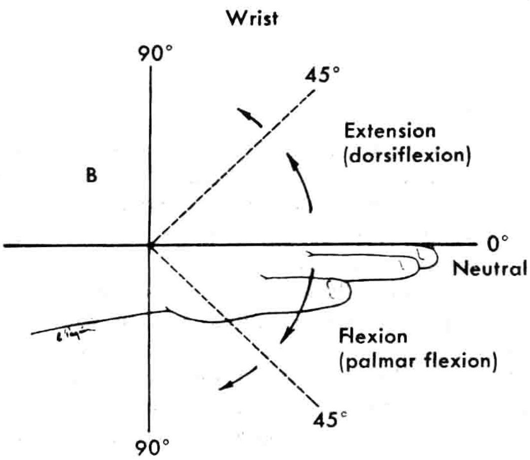
Chapters 4 and 18 and section on microsurgery in Chapter 3

Clinical Assistant Professor of Orthopaedic Surgery, University of Tennessee Center for the Health Sciences, Memphis, Tenn.; Active Staff, Campbell Clinic and City of Memphis Hospital; Associate Staff, Baptist Memorial Hospital; Consultant Staff, LeBonheur Children's Medical Center and Veteran's Administration Medical Center

Preface to sixth edition

The material in this edition of *Campbell's Operative Orthopaedics* has been reorganized in several respects. The result has been the creation of new chapters as follows: infections; miscellaneous affections of bones and joints; affections of muscles, tendons, and associated structures; miscellaneous affections of the foot; and the spine (except for spina bifida, which is retained in Chapter 17). The chapter on care before and after surgery has been deleted because this material is discussed more properly in other works.

All chapters have been at least revised to bring them up to date. To the chapter on the hand has been added a new section on microsurgery. The discussion of traumatic affections of joints, especially those of the knee, has been much enlarged. A section on postnatal cerebral palsy in both children and adults (stroke patients) has been added to Chapter 17. The chapter on arthroplasty has been expanded to include total joint procedures for the ankle, knee, hip, and shoulder; the section on Vitallium mold arthroplasty of the hip has been retained.



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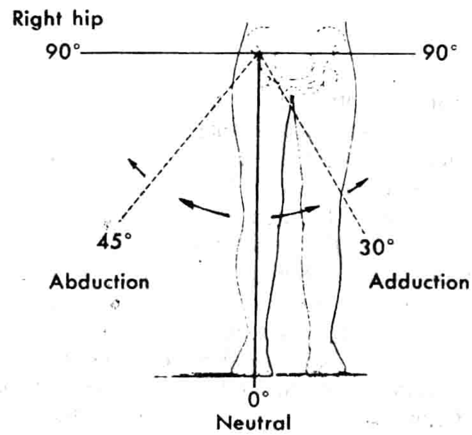

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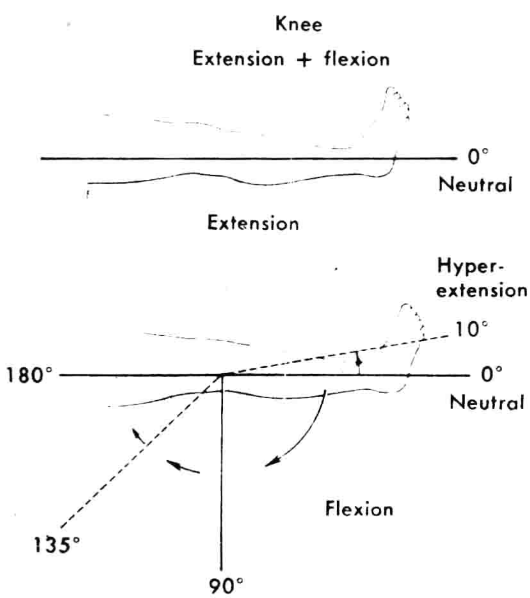

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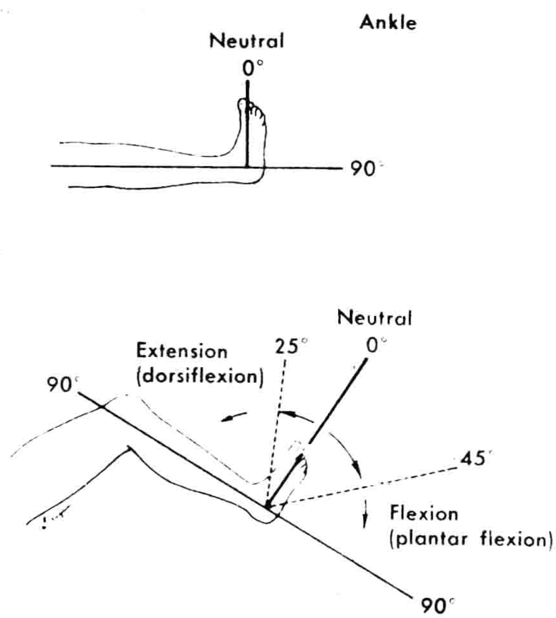

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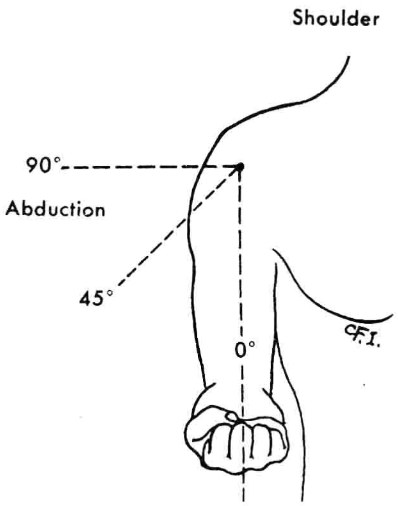

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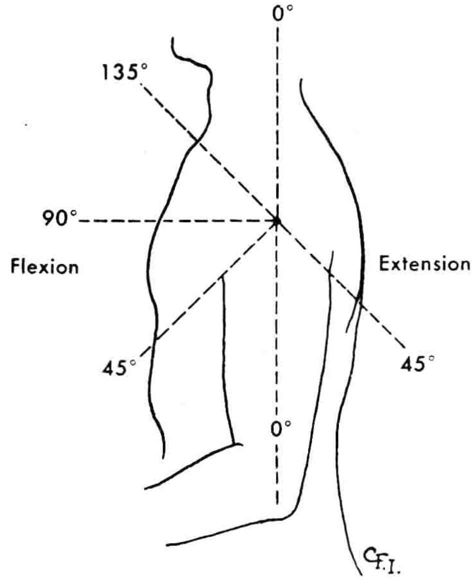

Sketch 6

We have continued to use almost entirely the method of measuring joint motion that has been advocated by the American Academy of Orthopaedic Surgeons. The neutral position is 0° instead of 180° as in the first three editions (see sketches 1 through 4*). For the shoulder, however, the method of the Academy seems too complicated for adoption here. Although the neutral position is 0° as for other joints, the direction of movement in adduction, abduction, flexion, and extension is the same as that used in previous editions (see sketches 5 and 6).

The editors and other members of the staff of the Campbell Clinic are especially indebted to those authors who are not members of the staff: Dr. L. D. Anderson, Dr. Otto E. Aufranc, Dr. J. A. Pitcock, and Dr. James C. H. Simmons. We extend thanks to those orthopaedic chairmen who answered our questionnaire and offered suggestions and comments. We also extend our thanks to the many surgeons who so kindly permitted us to reproduce their illustrative material.

We wish especially to express our appreciation to Mrs. I. C. Harper for her skillful assistance with the manuscript, references, and necessary correspondence, and to our librarian, Mrs. J. M. Daugherty, for her help. We wish also to thank Mr. Jess A. Martin, the librarian of the University of Tennessee Center for the Health Sciences.

Allen S. Edmonson, M.D.
A. H. Crenshaw, M.D.

*Reproduced by courtesy of the American Academy of Orthopaedic Surgeons.

Preface to first edition

The title of this book, *Operative Orthopedics,* is not intended to convey the impression that the chief or most important method of treatment of orthopedic affections is open surgery. Although many orthopedic affections are best treated by operative measures alone, the majority are successfully treated by more conservative means. Further, such measures are often essential adjuncts either before or after operation.

This volume has been written to meet the current need for a comprehensive work on operative orthopedics, not only for the specialist, but also for many industrial and general surgeons who are doing excellent work in some branches of orthopedic surgery, and are making valuable contributions to this field.

The evolution of orthopedic surgery has been exceedingly slow as compared to that of surgery in general. Not until aseptic technic had been materially refined was surgery of the bones and joints feasible. The statement is often made that the World War afforded the experience which made possible the rapid development of orthopedic surgery during the past two decades. The surgery of the war, however, was chiefly the surgery of sepsis; there was little of the refined asepsis which is required in reconstruction surgery. Undoubtedly, the demonstration during the war of the necessity and importance of this field led many able men to specialize in orthopedics, and to them considerable credit is due for its subsequent progress.

No classification of orthopedic affections is entirely satisfactory; consequently, any arrangement of operative procedures is subject to similar criticism. With the exception of the chapters on Arthroplasty and Arthrodesis, operations described in this text are grouped together according to their applicability to a given affection. This involves less repetition as to generalities of etiology, pathology, and treatment than would be necessary in a classification according to anatomic location. Operative procedures appropriate to two or more affections are described in the discussion of the one wherein they are most commonly employed.

To overcome the too widespread conception of orthopedic surgery as a purely mechanical equation, an effort is made in the first chapter of this book to correlate the mechanical, surgical, and physiologic principles of orthopedic practice, and throughout the book to emphasize the practical application of these physiologic principles. A special chapter has been written on surgical technic, for the purpose of stressing certain details in preparation and aftertreatment which vary to some extent from those described in works on general surgery. A thorough knowledge of these phases of treatment is a requisite to success. To avoid constant repetition, chapters have been included on apparatus and on surgical approaches; repeated reference is made to these chapters. The aftertreatment is given in detail for practically all operative technics. This is a most essential, yet too often neglected, factor in the success of any surgical treatment.

In giving the position or range of motion of a joint, only one system has been followed: With the exception of the ankle and wrist, the joint is in neutral position when parallel with the long axis of the body in the anteroposterior and lateral planes. As the joint proceeds from the neutral position in any direction, the number of degrees in which such movement is recorded decreases progressively from 180 to 170, 160, and so on, to the anatomic limit of motion in that particular direction. To illustrate, complete extension of the knee is 180 degrees; when the joint is flexed 30 degrees, the position is recorded as the angle formed between the component parts of the joint, i.e., the leg and thigh, or 150 degrees. Flexion to a right angle is 90 degrees, and full flexion 30 degrees. In the wrist, the joint is at 180 degrees, or in the neutral position, when midway between supination and pronation, and flexion and extension. In the ankle joint, motion is recorded as follows: the extreme of dorsiflexion, 75 degrees; right angle, 90 degrees; and the extreme of plantar flexion, 140 degrees.

In some instances, the exact end results have been given, to the best of our knowledge. So many factors are involved in any one condition, that a survey of end results can be of only questionable value unless the minute details of each case are considered. Following arthroplasty of the knee, for example, one must consider the etiology, pathology, position of the ankylosed joint, the structure of the bones comprising the joint, the distribution of the ankylosis, and the age of the patient, in estimating the end result in each case. Further, a true survey should include the results of *all* patients treated over a period of *many* years, and should be made by the surgeon himself, rather than by a group of assistants, or by correspondence.

In our private clinic and the hospitals with which we are associated, a sufficient amount of material on every phase of orthopedic surgery has been accumulated during the past twenty years or more to justify an evaluation of the various procedures. From this personal experience, we also feel that definite conclusions may be drawn in regard to the indications, contraindications, complications, and other considerations entering into orthopedic treatment. In all surgical cases, mature judgment is required for the selection of the most appropriate procedure. With this in mind, the technics which have proved most efficient in the author's experience have been given preference in the text. In addition, after a comprehensive search of the literature, operative measures have been selected which in the judgment of the author are most practicable.

Although no attempt has been made to produce an atlas of orthopedic surgery, an effort has been made to describe those procedures which conform to mechanical and physiologic principles and will meet all individual requirements. In any work of this nature, there are sins of omission; also, many surgeons in the same field may arrive independently at the same conclusions and devise identical procedures. We have endeavored, however, to give credit where credit was due. If there are errors, correction will gladly be made. In some of the chapters we have drawn heavily from authoritative articles on special subjects; the author gratefully acknowledges his indebtedness for this material. He also wishes to thank those authors who have so graciously granted permission for the reproduction of original drawings.

In conclusion, I cannot too deeply express my sincere appreciation and gratitude to my associate, Dr. Hugh Smith, who has untiringly and most efficiently devoted practically all of his time during the past two years to collaboration with me in the compilation and preparation of material, which alone has made this work possible. I also desire to express appreciation to Dr. J. S. Speed for his collaboration on the sections on Spastic Cerebral Paralysis and Peripheral Nerve Injuries; to Dr. Harold Boyd for anatomic dissections verifying all surgical approaches described, and for his assistance in preparing the chapter on this subject; to Dr. Don Slocum for his aid in the preparation of the chapter on Physiology and Pathology; to Mrs. Allene Jefferson for her efficient editorial services, and to Mr. Ivan Summers and Mr. Charles Ingram for their excellent illustrations.

Willis C. Campbell

1939

Contents

CHAPTER 1

Surgical techniques

Allen S. Edmonson

This chapter deals with the management of orthopaedic operating rooms, surgical equipment, and aseptic surgical technique. To avoid repetition in other chapters, a few techniques common to many procedures, such as fixation of tendons to bone and bone grafting, are described here.

OPERATING ROOMS

Ideally the operating suite should be located in an isolated section of the hospital and preferably on a dead-end corridor. An efficient air-conditioning system to control the temperature and humidity and to filter the air is essential. HEPA filters and similar high efficiency air filters have markedly reduced the bacterial count of circulated air in modern operating rooms. The cleaning of the air is further improved by multiple air changes per hour. In ordinary operating rooms, from 25 to 90 changes per hour are usual, and up to 300 changes per hour may be accomplished in special enclosed operating chambers. Air handling systems for horizontal and vertical laminar airflow do not produce dangerous drafts and are highly recommended. Operating rooms should be cool enough to keep the operating personnel comfortable and to avoid heavy perspiration. Temperatures below 21.1° C may lower the patient's temperature so low as to produce significant hypothermia. A rectal or esophageal temperature probe is beneficial in monitoring the patient's temperature.

Separate rooms should be used for "dirty" or contaminated cases; the regular "clean" operating rooms should never be used for these cases. The rooms assigned for contaminated cases may also be used for routine plaster work. Plaster equipment should be brought to the "clean" operating room only at the end of an operation when a cast is required, and plaster equipment from the "dirty" operating rooms should never be used in a "clean" room.

The operating rooms should be of ample size, with all cabinets, roentgenogram view boxes, etc., recessed into the wall to reduce the number of objects that will catch dust. For the same reason, only essential equipment should remain in the operating room; all accessories should be stored in a separate but conveniently located room. The operating rooms should be cleaned thoroughly with an antiseptic solution daily. In addition, it has been our practice for many years to thoroughly clean the operating room floor with an antiseptic solution between all cases, even though a study by Weber et al. reported no statistical difference in infection rates in operating rooms when the floor was not so cleaned. It is time-consuming, but we have not changed our cleaning practice.

No one should enter the "clean" operating room, even when surgery is not in progress, without changing to operating-room attire and putting on cap or hood and mask; shoe covers should also be included if street shoes are worn.

The lighting equipment should provide both general illumination and special illumination for the operative field. Though spotlights are often necessary for work on the extremities, the use of hot spotlights at close range may result in tissue damage from heat and drying, especially when the operation is done under tourniquet ischemia. Special spotlights employing fiberoptics can be sterilized so that they can be used effectively in the wound and do not add a significant hazard of heat.

SURGICAL EQUIPMENT

No attempt is made here to describe in detail all the surgical equipment necessary for orthopaedic operations. Good equipment is, of course, one of the first requisites of good surgery.

Operating tables. A fracture table often serves a double purpose, being used also as an operating table. Thus transferring the patient from an operating table to a fracture table for the application of a cast after operation is unnecessary.

Many fracture tables now are designed for use with image intensifier television fluoroscopy and consequently may not be used to apply a spica cast. For this reason three separate tables may be necessary for a well-equipped orthopaedic operating room: (1) a standard operating table with a special radiolucent top to allow roentgenogram cassettes to be slipped in beneath the patient during surgery, (2) a special table suitable for use of the image intensifier for hip and femur nailings, etc., and (3) a standard fracture table suitable for application of a spica cast.

Tourniquets. Operations on the extremities are made easier by the use of a tourniquet. The surgeon and all operating room personnel must realize that the tourniquet is a dangerous instrument that must be used with proper knowledge and care. In some cases a tourniquet is a luxury, whereas in others it is a necessity. In delicate operations on the hand, it is imperative. The pneumatic tourniquet is safer than the Esmarch tourniquet or the Martin sheet rubber bandage.

A pneumatic tourniquet with a hand pump and an accurate pressure gauge is probably safest (Fig. 1-1), but an automatic-pressure type of tourniquet, if properly maintained and checked, is quite satisfactory. Several sizes of pneumatic tourniquets are needed for the upper and lower extremities. The tourniquet should be applied with care by an experienced person and not be delegated to someone who does not understand the tourniquet's use.

The upper arm or the thigh is wrapped with several thicknesses of cotton cast padding applied smoothly. All air is expressed from the sphygmomanometer or pneumatic tourniquet, which is then applied to the extremity smoothly and evenly. If this is not done, wrinkles will appear during inflation, pinch the skin, and cause blisters. When a sphygmomanometer cuff is used, it should be wrapped with a gauze bandage to prevent its slipping during inflation.

Every effort should be made to save tourniquet time; the extremity is often prepared and draped before the tourniquet is inflated. The extremity is then elevated for 2 minutes, or the blood is expressed by a sterile sheet rubber bandage or a cotton elastic bandage. Beginning at the fingertips or toes, the extremity is wrapped proximally to within 2.5 to 5 cm of the tourniquet. If a Martin or elastic bandage is applied up to the level of the tourniquet, the latter will tend to slip distally at the time of inflation. The tourniquet should be inflated quickly to prevent filling of the superficial veins before the arterial blood flow has been occluded. The correct pressure will depend upon the age of the patient, his blood pressure, and the size of the extremity. The average adult arm requires a pressure of 300 mm Hg (about 6 pounds) and the thigh 500 mm Hg (about 10 pounds). Children and thin patients require less pressure. In applying solutions to the skin, one must be careful to prevent any of the solution from running beneath the tourniquet, lest a chemical burn result. Rarely a superficial slough of the skin may occur at the upper margin of the tourniquet in the region of the gluteal fold; its etiology is not clear.

Pneumatic tourniquets should be kept in good repair, and all valves and gauges must be leakproof. The inner tube should be completely enclosed in the casing; otherwise, the tube may balloon through an opening, allowing the pressure to fall or there may even be a "blowout." Care must be taken not to puncture the tourniquet with a towel clip while draping.

Tourniquet paralysis may result from (1) excessive pressure, (2) insufficient pressure, resulting in passive congestion of the part, with hemorrhagic infiltration of the nerve, (3) keeping the tourniquet on too long, or (4) application without considering the local anatomy. There is no rule as to how long the tourniquet may be safely inflated. The time may vary with the age of the patient and the vascular supply of the extremity. We prefer, in the average healthy adult under 50 years of age, not to leave the tourniquet inflated on an arm more than 1 hour or on a thigh more than $1^1/_2$ hours. If the operation requires more time, the tourniquet is deflated for 10 minutes. During this time, hemostasis should be secured. Safe limits after reinflation are unknown.

The Esmarch tourniquet is the safest and most practical of the elastic tourniquets. It is never used except in the middle and upper thirds of the thigh. This tourniquet has a

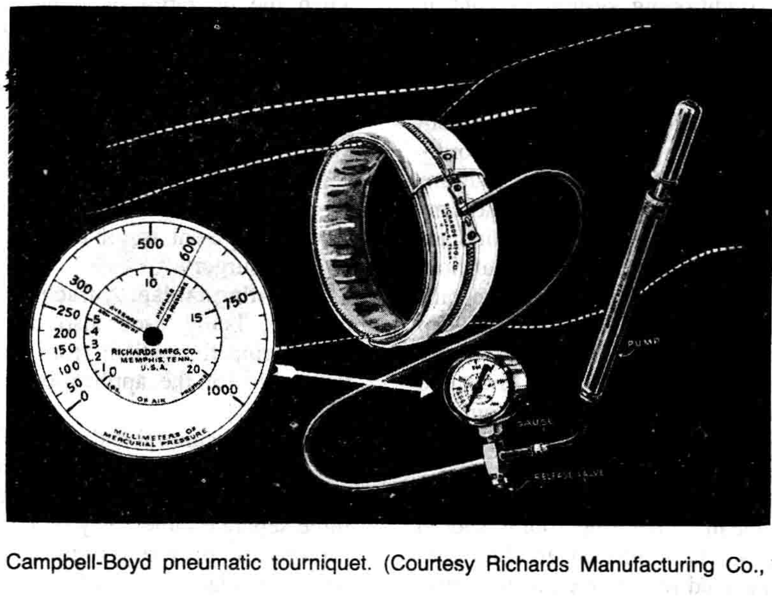

Fig. 1-1. Campbell-Boyd pneumatic tourniquet. (Courtesy Richards Manufacturing Co., Memphis, Tenn.)

definite although limited use in that it can be applied higher on the thigh than can the pneumatic tourniquet. The Esmarch tourniquet is applied in layers, one on the top of the other. Since as much pressure is required to occlude the vessels at a given level over a wide surface as over a narrow surface, a narrow band produces less tissue damage than a wide one.

The Esmarch tourniquet should not be applied until the patient is well anesthetized; otherwise, persistent adductor muscle spasm may cause the tourniquet to be too loose after the muscles have relaxed. A hand towel, folded lengthwise in four layers, is snugly wrapped as high as possible around the upper thigh. The tourniquet is then applied over the towel as follows. The chain end is held over the lateral surface of the thigh with one hand; the other hand is passed under the thigh and grasps the rubber strap near the chain and pulls it taut. The strap is allowed to slip between the thumb and fingers as the hand is brought under and around the thigh; properly performed, this slipping produces a singing sound from friction. When it completely encircles the thigh, the tourniquet is overlapped layer on layer, with no skin or towel caught between the layers. This is repeated, keeping constant tension on the strap, until its application is complete. The hook on the end of the strap is then caught in one of the links of the chain. Care must be taken that excessive tension is not built up gradually as the tourniquet is applied.

Gowns. The gown of the surgeon should be made with a double flap down the entire back. While our original gowns were designed by Dr. C. N. Carraway of Birmingham, Alabama, many models of surgical gowns now provide sterile coverage of both the front and the back of the surgeon (Fig. 1-2).

Sponges. To avoid errors, it is probably best to restrict the sponges used in orthopaedic surgery to those that contain radiopaque markers. Regular gauze sponges smaller than the standard 4 × 4 inches are rarely if ever necessary. Heavier gauze strip sponges and "lap packs" should not be used unless there is a wide radiopaque strip built into the sponge and a tag for attaching a hemostat or other surgical clamp when it is used inside a large wound. When one end of the sponge is left protruding from the

Fig. 1-2. Double-flap gown designed by Dr. C. N. Carraway; back as well as front of gown remains sterile.

wound with a hemostat attached, it is unlikely to be overlooked when the wound is closed.

Towels. The towels ordinarily used for abdominal surgery are too small for surgery of the extremities. Towels should be of sufficient length and width to cover the distal end of either the lower or upper extremity and overlap several inches. Large towels make draping easier and reduce the danger of contamination of the surgeon.

Gloves. Regular surgical gloves are used in most orthopaedic operations. Light-colored gloves have an advantage because blood that leaks into the glove through an unrecognized perforation can be easily seen. Since orthopaedic operations frequently require forceful manipulations as well as dexterity, tears and perforations of surgical gloves are more common than in general surgery. In addition to routine gross examination of surgical gloves by the scrub nurse prior to application, the wearing of double gloves, at least empirically, diminishes the possibility of wound contamination.

Masks. Disposable masks are strongly recommended and should be worn for one operation only. All facial and cranial hair should be covered completely. This may mean that hoods must be worn rather than operating caps and masks. In addition, some studies have shown that extensive talking increases the likelihood of contamination.

Surgical suction. Surgical suction to remove blood from the immediate operative field is commonly used in spinal, hip, and shoulder surgery since a tourniquet obviously cannot be used. The diameter of the suction tip and the sterile tubing must be sufficient to allow the surgeon to see the operative field clearly. The sterile tubing should be attached to a sterile trap bottle with volumetric graduations so that the amount of blood loss can be monitored simply by observing the level in the bottle. Although we have apparently had no problem with extensive use of surgical suction, a study by Meals and Knoke reported bacterial contamination in 60% of cultured tips in their study, apparently from the air drawn into the tube. None of their patients developed a wound infection, and the wound cultures at surgery grew organisms different from those grown from the suction tips.

Surgical Instruments

An ample supply of special instruments, all in good working order, is essential. In our experience the finest surgical instruments are the most economical. As Boyes has emphasized, the instruments should be commensurate in size with the part to be operated on. The instruments used for open reduction of the femur cannot be used for suturing nerves and tendons in the hand.

Scalpels. A wide variety of sizes and shapes of scalpels should be available to meet the demands of any case. Operating knives with removable razorlike blades are suitable only for skin or soft tissue incisions. They should not be used for prying inelastic soft tissue structures from the bone or for dissection at the junction of soft tissues and bone, since thin blades break relatively easily. Good-quality periosteal elevators, sharp gouges, and sharp osteotomes or other heavier cutting instruments should be used instead.

At this clinic we have long supported the opinion that a separate scalpel and blade should be used for incising the skin and a second "clean" knife used for dissection of deeper structures. A report by Ritter et al. does not support this concept.

Soft tissues may be incised also by electrocautery or a laser beam. Reports by Link et al. and Madden et al. confirm a significant increase in wound infections when these are used rather than the standard steel blade. The advantage of less blood loss and a bloodless field apparently is gained at the expense of increased tissue necrosis and delayed wound healing.

Hemostats. Small and delicate instruments such as the Halstead and Kelly clamps should be reserved for inducing hemostasis. Clamps used for manipulating bones or exerting tension on nonresilient or nonelastic soft structures must, of course, be of heavier construction.

Chisels and osteotomes. Chisels and osteotomes are similar to instruments used by a woodworker but are usually made entirely of metal, preferably stainless steel. A chisel has a cutting edge with a straight side and a tapering side, while both sides of an osteotome taper equally to the cutting edge. The cutting edges vary in width from 3/16 to 2 inches (4.7 to 50 mm). Whenever possible, chisels and osteotomes should have shafts 5 or 6 inches (12.5 or 15 cm) long and large knurled handles similar to those popularized by Cobb for scoliosis gouges and elevators (Fig. 1-3).

Gouges. A gouge differs from a chisel in that its cutting surface is curved from side to side and frequently also from before backward (Fig. 1-3). Since the sizes and shapes of gouges vary, they may be used for cutting grooves of different depths or for curving flat surfaces. Gouges must be kept sharp and their contours must not be altered during the sharpening process. Since a dull gouge or other bone-cutting instrument requires more forceful blows with the mallet or more powerful effort when used by hand, the safety of the bone-cutting or shaping operation is diminished not only by the necessary use of greater force, but also because this effort fatigues the surgeon and diminishes his skill.

Mallets. Mallets should be of metal because it is durable and easily sterilized. For heavy duty the Meyerding mallet, which resembles a potato masher, is preferable. Lighter mallets are suitable for use on the small bones, such as those of the fingers and wrist. Mallets with lead-filled heads quickly lose shape, and wooden mallets are too light and split or crack after being sterilized a few times. We have used mallets with a thick layer of plastic over the striking surface. They diminish the noise in the operating room and cushion the shock of the mallet blow from the hand of the surgeon, but they sometimes are not durable. We still prefer metal-to-metal contact.

Drills and drill points. Drills may be either hand-powered or motor-driven. The motors are either electric or operated by compressed air or other gases. Ease, speed, and security of attachment of drill points, reamers, etc. are important design features of the best hand- and power-driven drills. Drill points are made in numerous diameters measured in both fractions of an inch and millimeters. Whereas drill points are used to cut holes, reamers are used to enlarge holes; both must be kept sharp not only

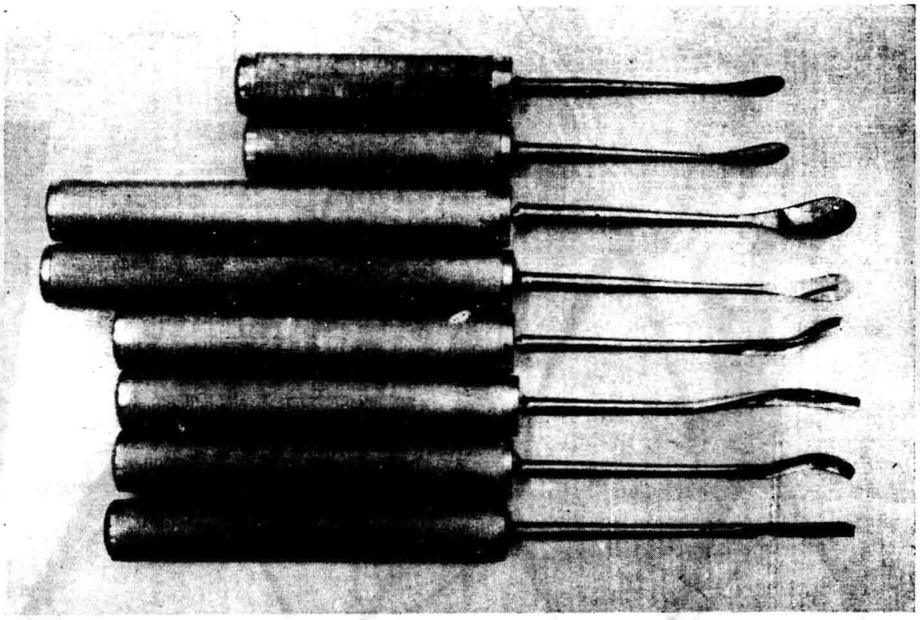

Fig. 1-3. Gouges and periosteal elevators designed by Dr. J. R. Cobb for spine fusion.

for speed of cutting but also to diminish the effort and force required for the cutting operation. Especially when power drills are used, irrigation must be used at least intermittently to cool the drill point and the bone to minimize damage to the bone and the metal of the cutting instrument.

The most satisfactory hand-powered drill is made with a wheel and gear of high ratio; this assures smooth action and diminishes the risk of breaking the drill point by side-to-side motion. Hand-powered instruments should always be readily available as a backup to complete the operation if there is a failure of powered equipment.

Instruments to smooth rough bony surfaces. Round, flat, broad, and narrow rasps as well as files with broad or tapering points are useful instruments for smoothing or shaping bone edges and surfaces. Many specialized shapers, reamers, and large burrs are manufactured for particular operations, many of which are arthroplasties. These are included in the discussions of the various operations to which they apply.

Bone-cutting forceps and rongeurs (Fig. 1-4). Bone-cutting forceps are constructed on the same principles as wire cutters. Compact bone of large circumference is more easily cut with double-action forceps, whereas single-action forceps are used for cutting smaller and less dense bone. Rongeurs, which are similar in action to bone-cutting forceps but have jaws resembling those of curettes, are used to cut out small sections of bone the size of the jaws. These also are obtainable with double or single action.

Bone-holding instruments. Instruments used primarily to manipulate bony fragments must be of heavy construction, with jaws wide enough to conform to the diameter of the bone (Fig. 1-5). Large Ochsner forceps are suitable for holding the smaller bones, and the larger Lane bone-holding forceps for bones such as the femur and humerus. Smaller Lane bone-holding forceps (Fig. 1-6) are made for smaller bones such as the radius, ulna, and fibula. When modified to be self-retaining, these forceps are useful for holding a plate or similar appliance across a reduced fracture.

Power saws and bone-cutting instruments. Electrically powered and air- or gas-powered saws are widely used. Most have an oscillating design for safety. Rapidly spinning air or gas turbine-driven drills or burrs are also very efficient for cutting bone, and most are easily maintained for sterile conditions. Heat buildup must be controlled, usually by intermittent or constant irrigation with sterile isotonic fluids. The Stryker electrically powered saw (Fig. 1-7) widely introduced the oscillating principle. This saw oscillates at high frequency (28,000/minute) through a small arc ($^1/_8$ inch or 3.1 mm). Thus it cuts bone but not the adjacent soft tissue unless the soft tissue lies between the blade and the bone or another hard surface. A variety of cutting blades including bone-plug cutters are available.

Special instruments. Instruments for special operations are described or illustrated as much as possible in the sections where the operations are described.

Material for internal fixation of bones

Internal fixation of two bony surfaces may be accomplished by a variety of apparatuses and materials. Techniques of internal fixation are described in the chapter on fractures. The most popular materials are bone and metallic appliances of 18-8 S Mo stainless steel or Vitallium.

When both osteogenesis and stability are required of the same agent, autogenous cortical and cancellous grafts from the tibia as used in the onlay bone graft procedure are the best material. If the use of autogenous bone is impractical, homogenous bone may suffice.

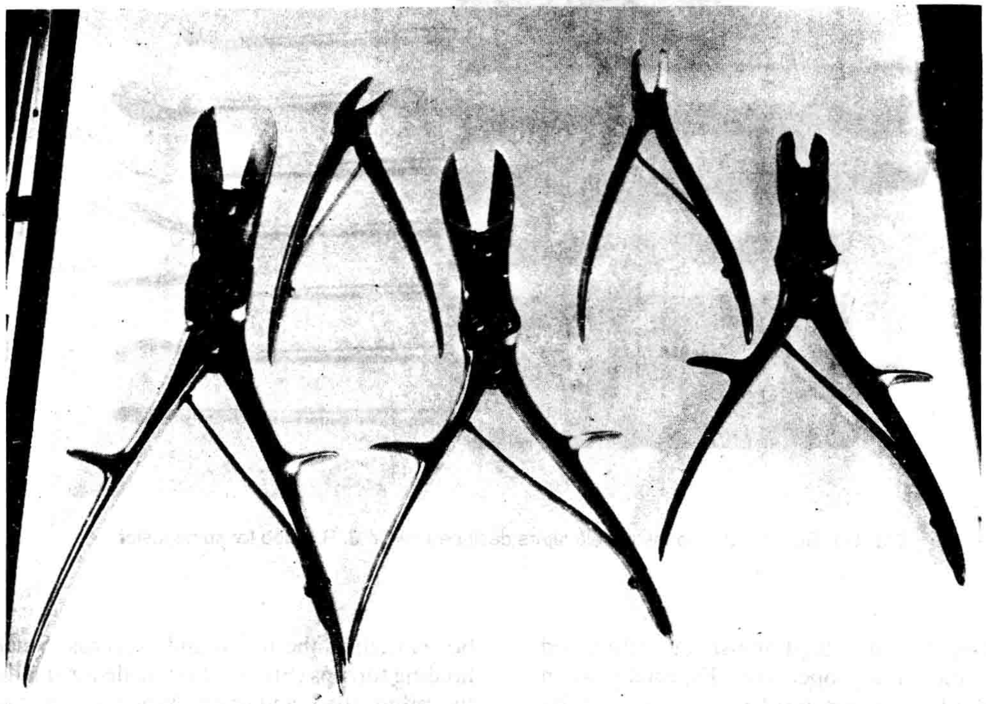

Fig. 1-4. Single and double action rongeurs and bone-cutting forceps.

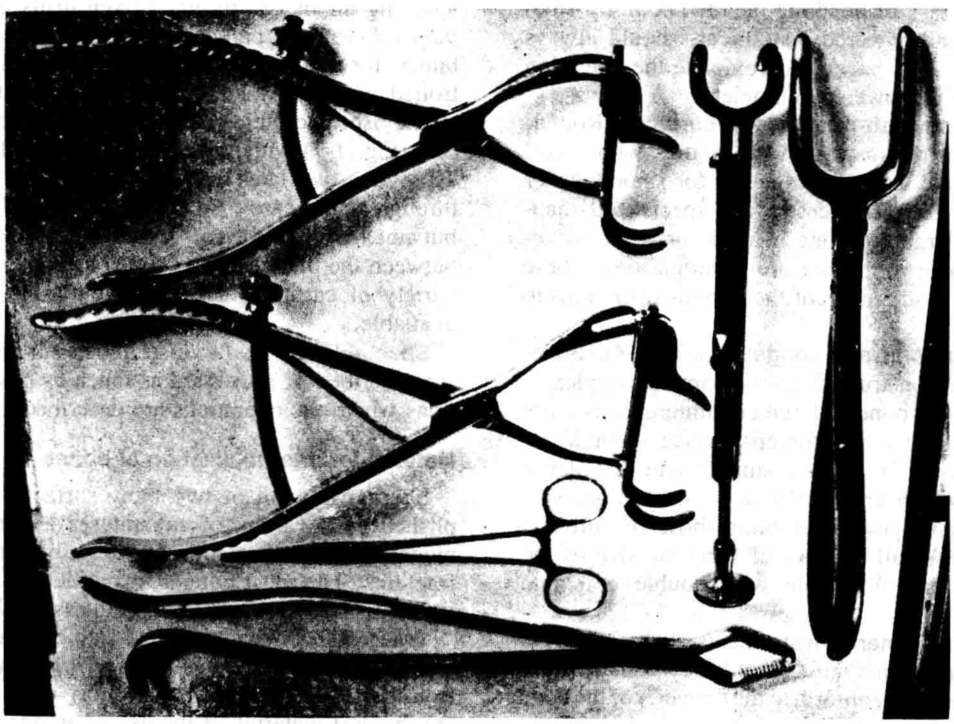

Fig. 1-5. Bone-holding instruments of Rush, Lane, and Albee, and Ochsner clamp.

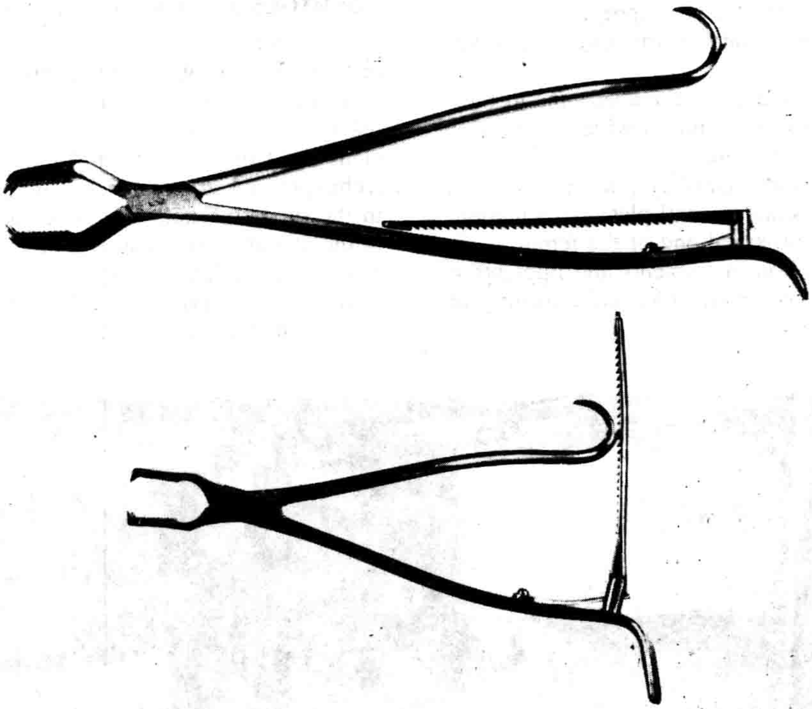

Fig. 1-6. Self-retaining Lane bone-holding forceps, two sizes. When self-retaining feature is not being used, it lies out of the way against handle.

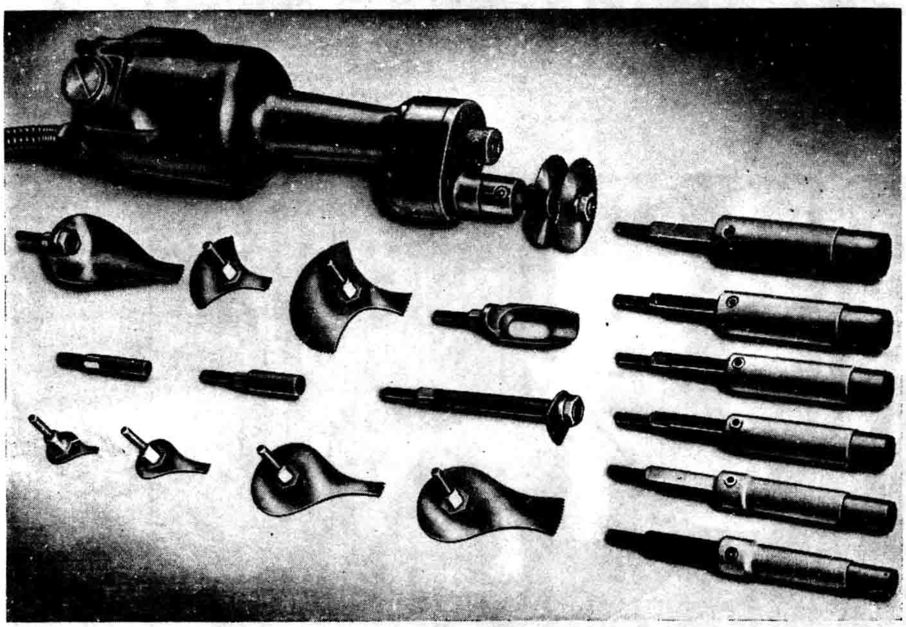

Fig. 1-7. Stryker saw. (Courtesy Orthopedic Frame Co., Kalamazoo, Mich.)

Apparatus or implants for fixation that have the widest application are desirable. A large number of expensive gadgets of limited use is usually unnecessary. The following standard fixation devices should meet most requirements.

1. Stainless steel wire in several sizes.
2. Kirschner wires and Steinmann pins in at least three diameters each, both smooth and threaded. These may be cut into the desired lengths for use as pins or may be used for skeletal traction, guide pins, or medullary pins for fixation of small bones.
3. One complete set of multiple sizes and types of