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The history and evolution of surgical instruments

I Introduction

J R Kirkup FRCS
Consultant Orthopaedic Surgeon, Bath Clinical Area

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Despite obligations to basic science, surgery remains in essence a handicraft requiring manual skill, as ancient derivation of the word indicates (Latin, *chirurgia*; Greek, *kheir* = hand, *ourgos* = working). As with other handicrafts, tools and instruments have evolved to facilitate, extend, and refine practices where hands and fingers alone prove clumsy and inadequate or fall short. Speculation suggests that the first surgical instruments were borrowed from domestic, craft, and perhaps military items and that the earliest problems requiring instrumental intervention resulted from injury, such as gaping wounds, retained foreign bodies, and gross compound fractures. More definite evidence argues that the first planned incisions involved trephining of the skull, either after injury or for epilepsy, and circumcision for ritual or hygienic purposes *(1)*. When such practices commenced is unknown, but certainly they extend far back in antiquity.

Sources of knowledge

ARCHAEOLOGICAL

Prior to the oldest surviving illustrated manuscripts, the most exact knowledge of instrumentation rests primarily on bronze metallic finds, particularly when identified at known medical sites (Fig. 1); secondly, on a few representations in stone and in paint on the walls of tombs or on papyrus; and thirdly, by inference from skeletal remains and the practices of primitive societies still surviving or recently extinct.

MANUSCRIPTS

Unfortunately, the function of ancient instruments is not necessarily obvious by examination alone and further information must be sought in books derived from the manuscripts of Hippocrates, Celsus, Galen, and other early authors.

However, between the demise of the Western Roman Empire in the 6th century and the discovery of printing in the 15th, few instruments have survived and manuscripts supply what little is known of surgery in this period; unhappily repeated copying and translation through many centuries often modify or frankly distort the original meaning, and in those texts illustrated with drawings of instruments or operative scenes, lack of scale and absence of detail often confuse their interpretation (Fig. 2).

PRINTED BOOKS

Illustrated works are clearly more valuable than unillustrated, although the latter may be the only source available or prove vital in amplifying other material.

With the advent of wood-blocks (Fig. 3) and later copperplate engravings, most surgical authors accepted the power of visual display. As Sir Charles Bell emphasises in his *Illustrations of the Great Operations of Surgery* (1821), '. . . where the demonstration is presented to the eye . . . knowledge is most easily conveyed, and especially to those who possess that mechanical and graphic talent, which is so well suited to the Practice of Surgery.'

INSTRUMENT CATALOGUES

By the end of the 18th century, specialist surgical instrument makers had evolved and began to publish illustrated catalogues which ultimately became the principal source of information on surgical instruments.

MUSEUM INSTRUMENT COLLECTIONS

Graeco-Roman instruments apart, very little material dated before the 16th century is available. However, many items of the 17th to 19th centuries have been preserved for study, both in general and medical museums, including an outstanding collection in the Royal College of Surgeons of England *(2)*.

PRESENT INSTRUMENTATION

This will be recorded for posterity in makers' catalogues, in surgical texts, and perhaps in displays yet to be formed. Unfortunately the dis-


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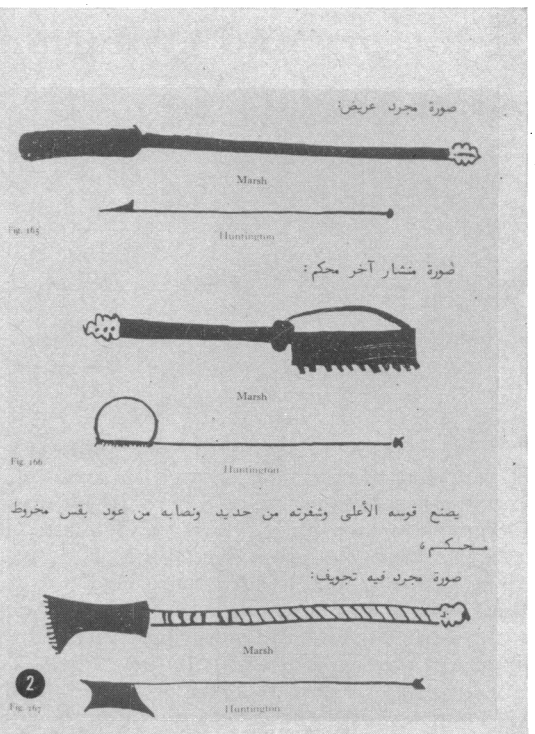
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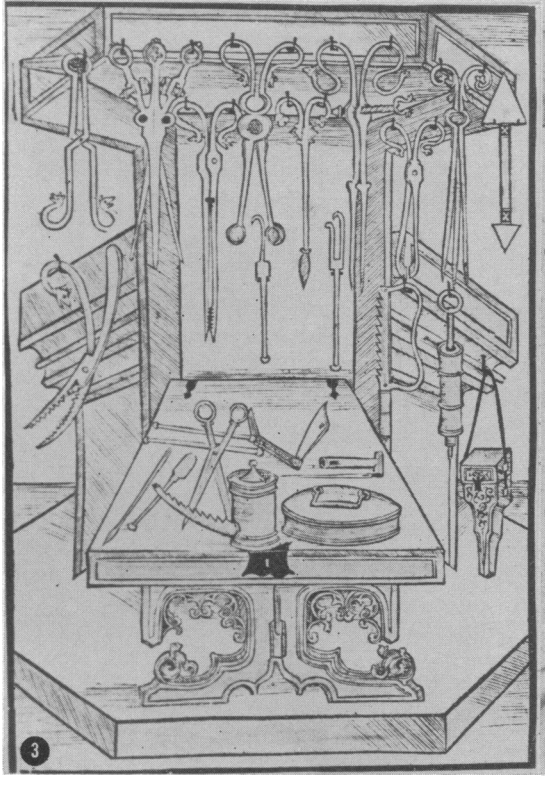
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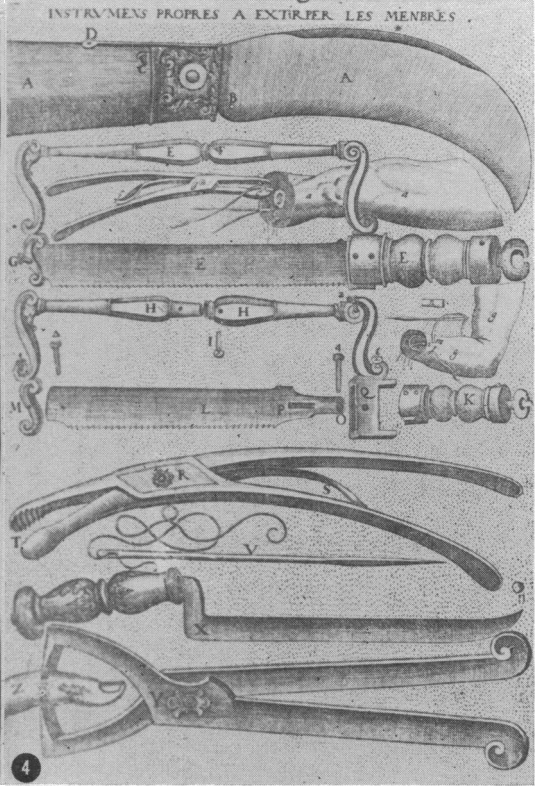
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posable era threatens the conservation of complete instrument collections unless special efforts are made now.

Historical periods

From these sources the following periods of development are proposed.

1) PREHISTORIC

The sophistication of surgical instruments indicated in the Hippocratic writings of 400 BC suggests that their ancestry extends further back through the Bronze Age to at least the New Stone Age. Regrettably few items in this period have been identified with certainty; thus the flint scrapers and borers used in trephination are identical with those used domestically, and the bronze spring forceps or tweezers found in Mesopotamia and Egypt are as much cosmetic and hygienic as surgical *(3)*.

FIG. 1 *Bronze Roman instruments from Pompeii: (1) Spring forceps for epilation and dissection. (2) Spring shears. (3) Pivot forceps for crushing piles and uvula; holes in the jaws permit insertion of cord to clamp them fast. (4) Pivot forceps for removing sequestra. (5) Spring forceps with locking slide. (6) Pivot forceps of uncertain use; handles were probably wooden. (7) Scarificator. (From: Meyer-Steinig T, Sudhoff K.* Geschichte der medizin, *1922.)*

FIG. 2 *Instruments of Albucasis copied from Marsh manuscript (1271–2) and Huntington manuscript (1465–6): 165. Broad scraper. 166. Firm (bow) saw, the handle of boxwood. 167. Scraper with concavity. (Reproduced by permission from Spink MS, Lewis GL, eds.* Albucasis on Surgery and Instruments *(5).)*

FIG. 3 *Instrument display showing pivot forceps including cranioclast, dilator, bullet extractors, scissors, polypus and general purpose forceps; also scrapers, hacksaw, syringe, folding knife, probes, needles, spatula, drainage tube, a field-case for small instruments, and on the table a cerate box for ointments. (From: Brunschwig H.* Buch der Cirurgia, *1497.)*

FIG. 4 *Amputation instruments: (A–D) Folding dismembering knife. (E–G) Hacksaw. (H–Q) Parts of saw detached. (R–T) Crow's-beak forceps to catch vessels; note sketch above of forceps in use and spring resistance between handles. (V) Large suture needle; note sketch above demonstrating thread taken through skin and around vessels. (X) Interrosseous knife for cutting between bones of leg or forearm. (Y–Z) Digital dismembering nippers. (From: Guillemeau J.* La chirurgie Francoise, *1594.)*

2) GRAECO-ROMAN

Hippocrates (460–375 BC) describes but does not illustrate knives, needles, spring and toothed forceps, the pivot or uvula forceps, trephines, bone elevators, probes, dilators, and other surgical instruments made of bronze and iron, but their actual shape and dimensions remain uncertain, for pictorial representations are few and no complete armamentarium survives before the hoards discovered in the ruins of Herculaneum and Pompeii, destroyed in AD 97, some 500 years after Hippocrates *(4)* (Fig. 1). Happily the contemporaneous writings of Celsus (25 BC–AD 50) explain the function of many of the 200 different instruments found and reconstruct a picture of operative surgery at this time. Later Roman finds and Graeco-Roman writers such as Soranus (AD 98–138), notably on obstetrics, Galen (AD 130–200), Oribasius (AD 325–403), Aetius (AD 502–575), and Paul (AD 625–690) amplify further a golden age in the development of instruments *(4)*.

3) ARABIC

During the Dark Ages which followed, Islamic scholars kept alive classical learning and added much new knowledge. In medicine the work of Albucasis (936–1013) *On Surgery and Instruments,* in the opinion of Spink and Lewis, '. . . is the first rational, complete and illustrated treatment of its subject' *(5)* (Fig. 2), describing many new operative procedures and instruments attributable to Arabic practice; for example, the tonsil guillotine, the trocar for paracentesis, the syringe, a primitive lithotrite, and possibly the first true scissors with crossing blades controlled by a pivot.

4) MEDIAEVAL

With growing Christian theological dominance of thought and contempt for manual crafts, surgery was largery divorced from academic medicine and its rigid Galenic theories. Despite or because of this, surgical works of the Salerno school (11th–12th century), of Theodoric (1210–98), Saliceto (1210–80), and Mondeville (?1260–1320) displayed initiative in challenging Galenism, although the erudite weight of Chauliac (1300–68) reversed this later *(6)*; if new instruments were devised, little information is available. However, in monographs such as that of Arderne (1307–1380) on fistula-in-ano, rough manuscript drawings of operation scenes with instruments established a new trend *(7)*. That few specimens of the period survive in museums is due partly to the substitution of iron, steel, and wood for more corrosion-resistant bronze. Thompson states that scalpels with wood and

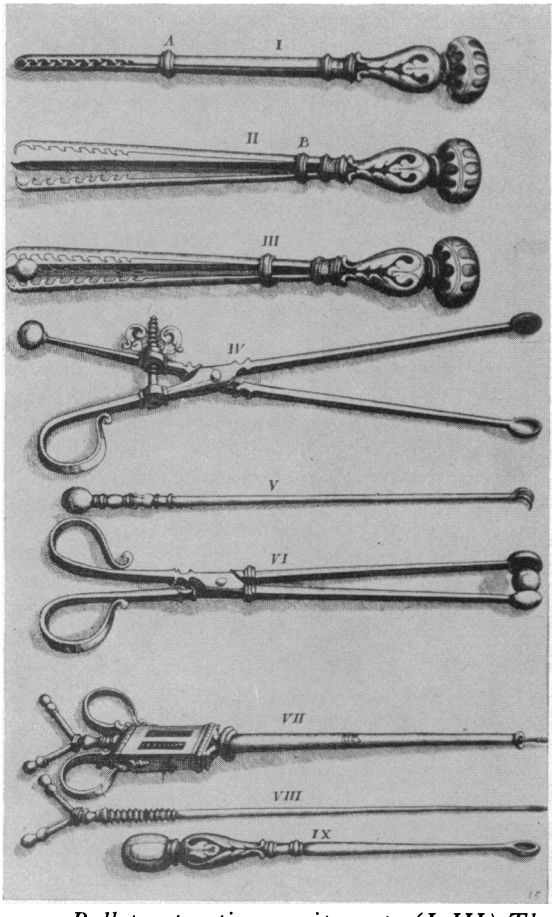

FIG. 5 *Bullet extraction equipment: (I–III) The Alphonsinum bullet extractor controlled by sliding ring. (IV) Goose-billed bullet forceps controlled by transverse screw. (V) Extraction hook. (VI) Goose-billed forceps without screw. (VII) Bullet probe with central screw thread to engage lead bullet. (VIII) Central screw detached. (IX) Bullet scoop. (From Scultetus J.* Armamentarium chirurgicum, *1655.)*

bone handles became evident in the 14th century *(8)*; however, Albucasis describes a wooden-handled saw (Fig. 2) and it is probable that hot iron cauteries, one of the commoner instruments of mediaeval surgery, were insulated with wood from Graeco-Roman times.

5) RENAISSANCE

The first accurate printed texts, allied to rediscovery of ancient classical authors and the challenge posed by gunshot wounds, stimulated innovation. Thus special instruments were designed for bullet extraction (Figs. 3 and 5), and emergency amputation became a common procedure effecting changes in technique, particularly the introduction of the crow's-beak forceps (Fig. 4) and ligature for haemorrhage by Paré (1510–90) *(9)*. Other 16th-century inventions included working the crown saw by brace to compose the trepan, the thumb lancet for bleeding, spring scarificators for wet cupping *(10)*, the suture cannula, and the employment of spring resistance between the handles of pivot forceps (Fig. 4).

H Brunschwig's profusely illustrated *Buch der Cirurgia* of 1497 includes an assembly of some 25 instruments (Fig. 3). Though no scalpels, lancets, spring forceps, or trepanning equipment are shown, we observe the first comprehensive collection of instruments and obtain an idea of their comparative dimensions. Apart from Paré, other important contributors illustrating instrumentation were Gersdorff (fl. 1500), Ferri (c. 1500–80), Croce (1500–75), Ryff (c. 1500–62),

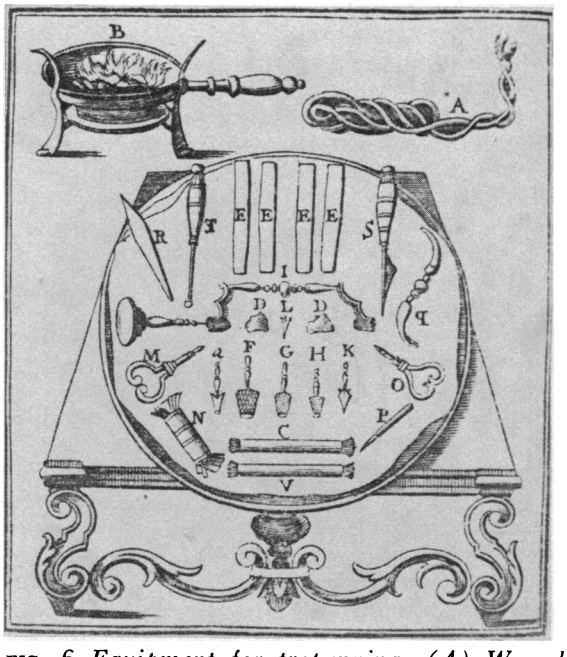

FIG. 6 *Equipment for trepanning: (A) Waxed cord candle. (B) Brazier for warmth. (C) Lint swab. (D) Cotton to plug patients' ears. (E) Wound edging swabs. (F–H) Crown saws to fit into (I) Trepan brace. (K) Perforator. (L) Removable centre pin of crown saws. (M) Key for removing centre pin. (N) Fine brush to remove bone dust. (O) Gimlet. (P) Point for searching depth of saw cut. (Q) Elevator. (R) Myrtle leaf to elevate bone disc. (S) Lenticular. (T) Lenticular. (V) Lint swab. (From: Dionis P.* Cours d'opérations de chirurgie, *1708.)*

Botallo (c. 1564) *(11)*, and Paré's most distinguished pupil, J Guillemeau, whose *La chirurgie Francoise* of 1594 is the first work devoted to operative surgery with, as the author states, instruments intentionally drawn to scale to enable their accurate reproduction by skilled smiths (Fig. 4).

6) SEVENTEENTH AND EIGHTEENTH CENTURIES

Before this period many instruments were made by armourers, braziers, blacksmiths, needle and razor makers, but in the 17th century pewterers, silversmiths, and cutlers advanced to prominence. Decoration now assumed importance (Fig. 5) and ebony, ivory, and tortoiseshell gradually replaced wood, bone, and horn. Silver for catheters, probes, cannulae, and tracheostomy tubes became standard and minor instruments were put up in elegant shagreen pocket cases or boxes *(12)*.

Notable illustrated works in the 17th century came from Ab Aquapendente (1533–1619) *(13)*, Hildanus (1560–1634) *(14)*, Woodall (c. 1569–1643), who introduced the modern form of skull trephine *(15,16)*, and above all J Scultetus, whose magnificent *Armamentarium chirurgicum*, printed posthumously in 1655, was the first book illustrating virtually all known instrumentation as well as operative scenes; further, the instruments were drawn to scale in relationship to each other (Fig. 5) and many operations depicted step by step, as seen in a modern book. Translated into English in 1674 as *The Chyrurgeons Storehouse* and into other languages, it remains a rich source of information.

An important contributor early in the eight-

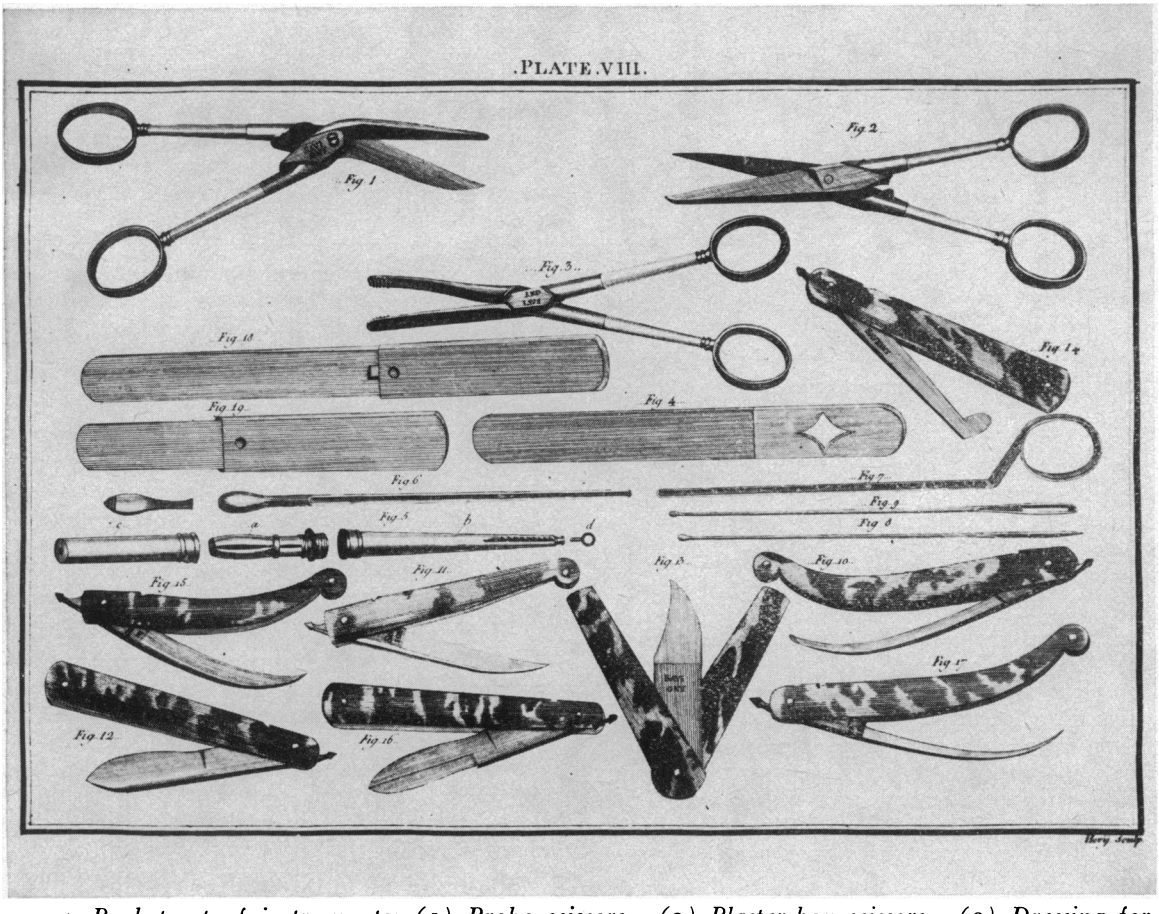

FIG. 7 *Pocket set of instruments: (1) Probe scissors. (2) Plaster-box scissors. (3) Dressing forceps. (4) Spatula. (5) Caustic case, dismantled. (6,7) Grooved directors. (8,9) Probes. (10) Curved bistoury. (11) Straight bistoury. (12) Lithotomy scalpel. (13) Abscess lancet. (14) Gum lancet. (15) Curved bistoury. (16) Double-edged bistoury. (17) Curved bistoury. (18) Extending spatula open. (19) Extending spatula closed. (From: Savigny J.* A Collection of Engravings. . . *1798.) (Photograph by Medical Illustration Support Service Ltd.)*

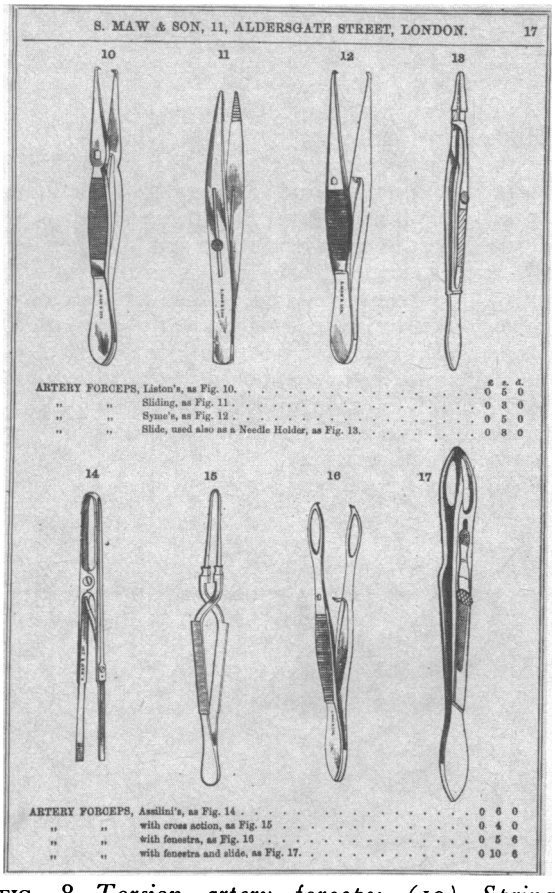

FIG. 8 *Torsion artery forceps: (10) Spring catch. (11) Collar stud sliding catch. (12) Spring catch. (13) External slide catch, jaws grooved for needle holding. (14) Offset pivot with closing spring. (15) Cross-action. (16) Spring catch. (17) Internal slide catch. (From: Maw and Son* A Catalogue of Surgeons Instruments, *1866.) (Photograph by Medical Illustration Support Service Ltd.)*

eenth century was P Dionis, whose *Cours d'opérations de chirurgie* of 1708 first portrayed complete sets of instruments for each operation (Fig. 6). Heister (1683–1758) *(17)* and Petit (1674–1750) *(18)* also wrote important textbooks finely illustrated with plates demonstrating many new instruments, and in 1782 J A Brambilla assembled virtually all known equipment into a large folio volume, *Instrumentarium chirurgicum.*

As the 18th century reached its close the numbers and complexity of instruments increased, stimulating the appearance of the first surgical instrument makers' catalogues.

A significant early publication is *L'art du coutelier expert en instruments de chirurgie* by J J Perret of Paris in 1772, illustrating instruments full size and also manufacturing methods and machinery. The first catalogue by a surgical instrument maker giving himself this title is *A Collection of Engravings Representing the Most Modern and Approved Instruments Used in the Practice of Surgery with Appropriate Explanations* by J H Savigny of London in 1798 (Fig. 7).

7) NINETEENTH CENTURY

Even before the stimulus of anaesthesia in 1846, specialist makers became indispensable to surgery; of outstanding ingenuity was Charrière (fl. 1820–60) in Paris, whose work included conversion of simple dissecting forceps or tweezers by means of a spring rachet catch and by cross-leg action into quickly applied self-holding haemostats *(19)* (Fig. 8); the former has not survived, but cross-action persists today in several forms of towel clip and the 'bulldog' artery clamp. Towards the middle of the century, application of the rack catch to lock pivot forceps by controlled compression produced the modern form of haemostat and needle holder which, allied to Lister's antiseptic system, revolutionised operative technique. This simple, almost trivial, device remains the hallmark of today's pivot forceps in its many forms. The lithotrite, primitive endoscopes, mechanical saws, and the tonsil guillotine were among countless 19th-century refinements of instrument makers such as Weiss, Maw (Fig. 8), and Arnold of London, Robert, Collin, and Mathieu of Paris, Jetter and Scheerer of Tuttilingen and Berlin, and Nyrop of Copenhagen, who all published a series of comprehensive catalogues. Other significant illustrated works included the massive *Armamentarium chirurgicum* in 1838 by A W H Seerig and *Précis iconographique de médicine opératoire et d'anatomie chirurgicale* in 1848 by C Bernard and C Huette, the latter depicting the first comprehensive coloured presentation of instruments.

8) ASEPTIC

The thermal sterilisation of instruments, established between 1885 and 1910, proved destructive to equipment handled in ebony, ivory, and tortoiseshell and necessitated the manufacture of all-metal instruments which initially were nickel- or chrome-plated. After 1925 stainless steel gradually superseded all other metals except silver for tracheostomy tubes and various alloys and titanium for prostheses retained in the body. Space forbids even a selective list of novel instruments in this fertile period; it is sufficient to recall that the abdomen, pelvis, brain, chest, bones, and joints enjoy extensive specific armamentaria largely devised since asepsis was accepted *(20)*.

Today and tomorrow

The constant advance of surgical ingenuity poses mounting problems for conservation; many instruments are transient tools and rapidly become redundant; prostheses now exist in enormous numbers, each with specific instrumentation; a growing proportion of scalpel blades, needles, cannulae, syringes, catheters, specula, and even dressing forceps and sigmoidoscopes end brief lives in the incinerator; and already solid scalpels, eyed needles, glass syringes, etc. are oddities.

Yet the cutting revolution may be on the wane as drugs, endoscopy, cryosurgery, lasers, nuclear medicine, and future non-invasive techniques short-circuit open surgery. As these trends evolve, will the 21st century witness fewer elective wounds necessitating fewer instruments devoted to incision and excision, hitherto the very doyens of the surgical instrument cabinet?

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In connection with this series of articles it is hoped that a display of historic books and instruments will be mounted in the College in the near future.