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Reconstructive Microvascular Surgery

With Forewords by
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Foreword to the German Edition

The importance of a new operating technique is not judged by the success of one individual case. Only careful observation of the results of numerous operations can show whether the technique may be practised widely and whether the effort expended is justified by the results. Only then, can a new technique take its place in the repertoire of an operative discipline.

The time has come for plastic surgery to avail itself of microvascular surgical techniques and, where there is sufficient experience, the results are good.

Clinical experience has shown that the replantation of amputated extremities can be rewarding when the criteria governing the indications for such surgery are followed rigorously. It is necessary to convey patients quickly to a medical centre which has a clinical organisation specialising in microvascular surgery. Follow-up investigations of the initial successes in replantation of fingers, hands and toes have shown us that such operations are of great importance, not only for the subjective wellbeing of the patients, but for their increased competence to return to work.

Microvascular surgical techniques have also stood the test with regard to free transplantation of tissue; the fundamental advantages being the variable donor-site and a reduced hospital stay.

Indeed, plastic surgery has developed microvascular surgery to an extent where the possibilities offered by this operative technique are inestimable. Certainly, in years to come, the technique will offer new paths for surgeons in many other areas of surgery. One needs little imagination to project the possible rôle of the technique in organ transplantation.

The knowledge and experience of microvascular surgical techniques may belong to every surgeon, but for the plastic surgeon the theory and practice of these techniques are indispensible.

It is to the authors' credit that in this book they not only reproduce their results, but more important, impart their personal experiences and thoughts. Their untiring surgical activity in this field has led to many new discoveries and their book includes everything from improvements in instrumentation and operative strategy to post-operative management and after-care. This book therefore, constitutes a piece of medical history and I am proud that colleagues from my own department have accomplished something so outstanding.

Munich — Prof. Dr. Ursula Schmidt-Tintemann

Foreword to the German Edition

The major breakthrough in microsurgery followed the clinical application of microvascular surgical techniques: the resulting success brought universal recognition. Many years previously, experimental studies had demonstrated the basic requirements of this technique and microsurgery of the peripheral nerves was practised in many clinics. The pioneers in in this new field of plastic surgery in Australia, China, Japan and the U.S.A. had a difficult and onerous start. There then followed, in the first half of the 1970's, increasing disseminated clinical activity which acted as a proving ground for the preceding experiments, and led to countless new possibilities for the application of microsurgical techniques.
Edgar Biemer and Wolfgang Duspiva played a crucial rôle in the development of microvascular surgery in Europe. Through their initiative, a replantation centre was established in Munich in November 1975, alongside the already existing replantation services in Vienna, at the two University Clinics for Plastic and Reconstructive Surgery (from June 1974), and in Hamburg at the "Berufsgenossenschaftliches Unfallkrankenhaus" (from April 1975). The Munich centre soon accumulated a remarkably high number of replantation cases, surpassing the other centres. The authors stand unrivalled with an accumulation of 300 replantations in two years, and a healing rate of 86%. Nevertheless, microvascular surgery is not simply the activity of one or two surgeons. Success requires a team of well skilled microsurgeons, whose unflagging commitment, in conjunction with theatre sisters and anaesthetists, helps to bring these long operations to a successful conclusion. The overall organisation of a unit is strongly influenced by the introduction of microsurgical operations and must adjust to the altered circumstances. Through good collaboration, these problems were happily solved in Munich and the high standard, to which this book testifies, became possible.
Alongside replantation, free tissue transfer with microvascular anastomosis is the realm of the microvascular surgeon. Such operations require planning, and, although not emergency operations like replantations, they are, nonetheless, largescale. Careful attention to the indications for surgery combined with the surgeon's manual dexterity can offer many a patient significant help in his return to a professional working life. Publications in this new field of surgery are essential and the authors, despite their continuing work load, have provided the first comprehensive presentation on microvascular techniques in Germany. In the near future, microsurgical techniques will gain entry into all surgical disciplines, and thereby unleash new methods of treatment.

Hamburg — Prof. Dr. DIETER BUCK-GRAMCKO

Preface to the German Edition

For many years, the operative manipulation of the most minute structures was frustrated by the limitations of the human eye. With the introduction of the operating microscope by Nylen (1921), fine detailed anatomy was made visible, so that structures could be prepared, presented and manipulated. Nylen used the microscope for treating diseases of the middle ear. In 1946 Perrit in the U.S.A. introduced the operating microscope into the field of ophthalmic surgery. In 1964, Smith, Kunze and Mitchen published reports on their clinical experience using the operating microscope in nerve surgery. Using this technique, it was possible to divide a peripheral nerve into individual fascicle bundles and reapir each bundle precisely.
Following on from these developments, the term "microsurgery" was introduced to cover that branch of surgery which was carried out using the "equiped" eye – either by using loupe spectacle magnification or, more commonly, the operating microscope. The term "microvascular surgery" developed for the operative treatment of small vessels below 2 mm in diameter. Experimental studies for the use of microsurgery in the clinical situation developed alongside its use on small research animals for transplantation models in immunological study. Microsurgical techniques were used in the transplantation of rat liver, kidneys, pancreas, heart and other organs. The clinical application of these microsurgical techniques is nowadays called "reconstructive microvascular surgery". Microvascular surgery, like microsurgery, is not an independent operative discipline, but is purely a technique which may be applied to different specialties, and its use in the future is thereby reinforced. Animal experimental work is an essential prerequisite for the mastery of microvascular surgical technique. In addition to the technical aspects, such experimentation increases the experience of the surgeon by enabling research into suturing and the testing of new developments. Furthermore, regular training is imperative to maintain an optimum standard of safety and confidence for use in the clinical situation.
The first part of the book deals with operating microscopes, instrumentation and microsurgery of vessels commonly used for practice. Methods, documentation and recording of results are presented, and the experimental basis of the techniques involved in microvascular suturing is explained in detail in specific cases. The second part of the book deals with the clinical application of microvascular surgery in replantation and transplantation surgery. The presentations are based on the experience of over 500 clinical cases. The detailed descriptions of the techniques and, in particular, the operating microscopes, instruments and suture materials, do not present a complete picture of all the operative procedures, nor all the available products, but are those with which the authors have had considerable experience.

Acknowledgement

The authors wish to record their special thanks to the many people who supported them and enabled them to gain the experimental and clinical experience on which this book is based. The preliminary work and subsequent laboratory investigations were made possible and encouraged by the support of the Director of the Institute for Experimental Surgery of the "Technische Universität", Munich – Herr Professor Dr. G. BLÜMEL. The countless organisational problems following the clinical application of this new technique, especially in the area of replantation surgery, were expertly handled by the Director of the Surgical Clinic and Outpatients Dept. of the T.U. in Munich – Herr Professor Dr. GEORG MAURER.

Frau Professor Dr. URSULA SCHMIDT-TINTEMANN, Head of the Department for Plastic and Reconstructive Surgery of the T.U., Munich, especially deserves our thanks for her continual support and encouragement throughout our work.

Herr Professor Dr. E. KOLB and his colleagues from the Institute for Anaesthesiology and Herr Professor Dr. H. ANACKER and the Radiological Institute were most helpful throughout the clinical application of microsurgery. The introduction of Xeroangiography by Herr Dr. KRAMANN has proved of great value in assessing the late results of replantation surgery. The authors wish to express their thanks to Herr Professor Dr. DIETER BUCK-GRAMCKO, Senior Surgeon of the Department of Hand Surgery and Plastic Surgery at the "Berufsgenossenschaftliches Unfallkrankenhaus", Hamburg – Bergedorf for providing the Foreword, and in showing great interest in their work.

The clinical application of microsurgery, particularly in the field of replantation surgery, was only made possible by inaugurating a 24 hour stand-by service. The willingness of our colleagues in the replantation team was of immeasurable importance; in addition to their duties in the various surgical units – plastic surgery, thoracic surgery, vascular surgery and orthopaedic surgery – they were ready to take on and perform a considerable amount of work. Those involved in providing this replantation service were: Dr. E. HERNDL, Dr. W. STOCK, Dr. J. HEISS, Dr. K. WERBER, Dr. W. GÖTZ, Dr. K. GLAS, Dr. H. BARTELS, Dr. G. INGIANNI, Dr. G. MEYER-BUSCHE and Dr. H. SCHMÜCK. The outstanding photographic documentation was provided by the Department of Photography of the Surgical Unit of the T.U., Munich. The authors are grateful for the support which they have recieved from the sisters, physiotherapists, occupational therapists and from all personnel in the operating theatres. The authors also acknowledge the help and support of Springer-Verlag and especially Miss TISMER for her considerable efforts in typing the manuscript. Much of the work was supported by the firms of Ethicon – Hamburg, Thomae-Biberach, Aesculap – Tuttlingen and the authors gratefully acknowledge the financial assistance from the Volkswagen Foundation, which made much of the experimental work possible.

Munich

E. BIEMER
W. DUSPIVA

Contents

Part 1

Technique of Microvascular Surgery and Preliminary Experimental Studies

I. Development of Microvascular Surgery

The well proven technique of continuous vessel suture which gives excellent results in larger vessels under the naked eye, unfortunately proves difficult when dealing with vessels with an outer diameter of less than 2 mm: under the naked eye the vessel lumen can no longer be safely identified. It is easy with such suturing techniques to suture the back wall of the vessel or, by inverting the suture, create a stenosis at the suture site. The problem of uniting smaller vessels with an outer diameter of 0.3–2 mm has largely been solved in the last two decades with the development of microsurgical operative techniques. The advantage of these techniques lies in the optical enlargement, which permits much better identification of the lumen of these thin vessels than can be achieved with the naked eye. The vessel stumps are easily identified and, using fine suture material and instruments, can be repaired exactly, so that no constriction or distortion occurs at the site of anastomosis. Magnification on a small scale is possible using loupe-spectacles (up to times 6, see Fig. 1), and larger scale magnification is possible using the operating microscope. There are certain disadvantages using the operating microscope: these must be taken into consideration, especially the reduction in the field of vision.
A wide variety of techniques for joining small vessels has been attempted in the last few years, e.g. pure sticking plaster, sticking plaster in conjunction with holding sutures, rings, small capillary tubes, clips and various suture devices (Johns 1947; Swenson and Gross 1947; Bikfalvi et al. 1953; Samuels 1955; Androsov 1956; Inokuchi 1958; Carter and Roth 1958; Nathan 1960; Urschel and Roth 1961; Nakayama et al. 1962; Hafner et al. 1963; Mozes et al. 1963; Ballinger et al. 1963; Gonzales and Nathan 1963; Sigel and Acevedo 1963; Williams and Takaro 1963; Chase and Schwartz 1963; Stirling 1964; Takaro 1964; Padula et al. 1965; Smith 1966; Blümel and Gottlob 1968; Kalkowski et al. 1970; Östrup 1976; Matras et al. 1977; Pearl et al. 1977). The majority of these techniques which have been used in animal trials rely on cannulisation of the vessel lumen and for the most part can be performed with the naked eye. Many of these methods, however, have common disadvantages e.g. media necrosis caused by the sticking of the foreign material, reduced tensile strength, lumen constriction, the presence of a permanent foreign body in the lumen and, in particular, the restriction of the techniques because of the size of the materials used. Nevertheless, new methods are constantly being developed and it is possible that many of these techniques e.g. sticking with "Fibringlue"[1] may gain acceptance, when used in conjunction with the operating microscope techniques in the future, similar to the techniques used in microsurgery of nerves (Matras et al. 1973; Duspiva and Biemer 1976; Kuderna 1976).
Very good results can be achieved in suturing of nerves with an outer diameter of 0.3–2 mm, using simple sutures of fine nylon under operating microscope control. The greatest variation in technique is in the suturing of arteries, veins, and vein transplants by end-to-end and end-to-side anastomosis. Equilibrium can be achieved up to a certain degree and even vessels of an outer diameter of only 0.3 mm can still be anastomosed with comparative safety (O'Brien 1977).
Microsurgical suture techniques in small vessel surgery have greatly developed in the last two decades since the work of Jacobson et al. in 1960. Buncke 1965 and 1966 reported the first series of replantations of amputated parts in experimental animals. The first successful replantation in a human was performed in Japan (Komatsu and Tamai 1968) where microsurgical techniques were used to replant a totally amputated thumb. About the same time, there appeared in the literature the first reports concerning free tissue transplantation using microvascular anastomosis in animal

1 Fa. Immuno, Vienna, Heidelberg

trials (Krizek 1965). The first clinical cases were reported by Daniel and Taylor (1973) and O'Brien et al. (1973b).

There has been continuous development and improvement of operating microscopes, instruments and surgical techniques, and new clinical applications for microsurgery have followed. As in the German-speaking nations, there are presently many centres throughout the world where replantation and free tissue transplantation using microvascular techniques are routinely performed.

II. Technical Equipment

1. Operating Microscope

Much of the preparatory work in microvascular surgery can best be performed using loupe-spectacles (see Fig. 1). The magnification varies from 2 to 6 times and allows a greater view of the operative field than can be achieved under the microscope. For the actual microvascular suturing, it is necessary to employ greater magnification, which is supplied by the operating microscope (see Fig. 2). At the present time, there are a variety of models of operating microscopes, which are suitable for microvascular surgery. The authors' experience lies mainly with microscopes manufactured by Zeiss. For experimental work, the OPMI 6 (see Fig. 5) and the wall-mounted OPMI 9 with appropriate attachments are generally used. In the clinical situation, stereoscopic double microscopes with fibre-optic illumination, such as the OPMI 2 and the OPMI 7 D are used. Such microscopes enable the assistant to perform his duties accurately. For practical courses in microsurgery, the OPMI 1 U7 (see Figs. 3 and 4) on a table

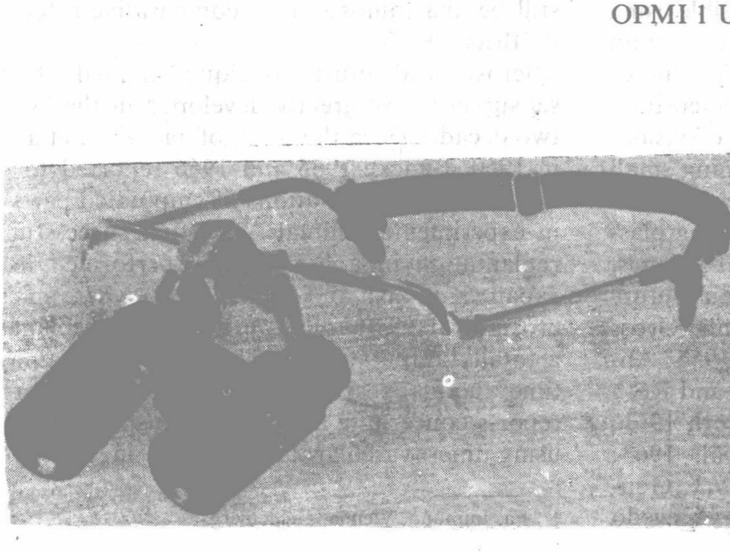

Fig. 1. Loupes (Zeiss)

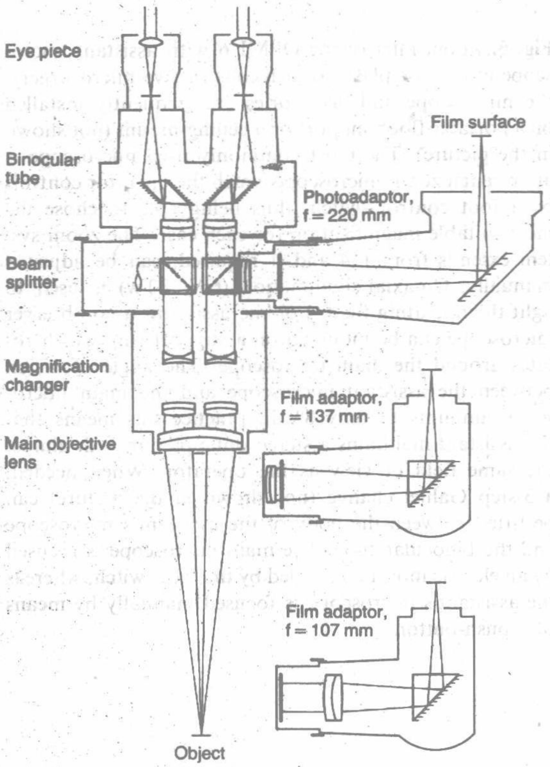

Fig. 2. Schematic diagram of an operating microscope (courtesy of Zeiss)

Fig. 3. Table microscope in use during an instructional operating course

stand has proved reliable and allows a large number of participants to operate independently.

The technical details, the mounting and control mechanisms of the many operating microscopes that are available on the market can be found in the appropriate instruction manuals produced by the manufacturers. In this Chapter several of the operating microscopes produced by Zeiss are illustrated and described in detail.

Particularly important when using the operating microscope, is to obtain precise focusing at the highest level of magnification, since only then can an exceedingly long operation be performed without fatigue. Great care should be taken with the operating microscope and, when not in use, it should be carefully covered.

In our experience, the foot-pedal switches can cease to function if they should become encrusted with blood during an operation. Our current practice is to protect the foot pedal switch during use by placing it in a plastic

Fig. 4. The OPMI 1 U7 type of microscope on a table stand, for use in an instructional operating course. An f = 175 mm interchangeable objective is used and the instrument has complete sterilizable attachments for manipulating the microscope. There is a built-in Galilei alternator with 5 levels of magnification and attachments for a variety of adaptors. 3 lighting variants are possible: standa d lighting with 6 ' lamps, high performance lighting using halogen lamps 12 V (OPMI 1/H) or fibre-optic lighting (OPMI 1/F)

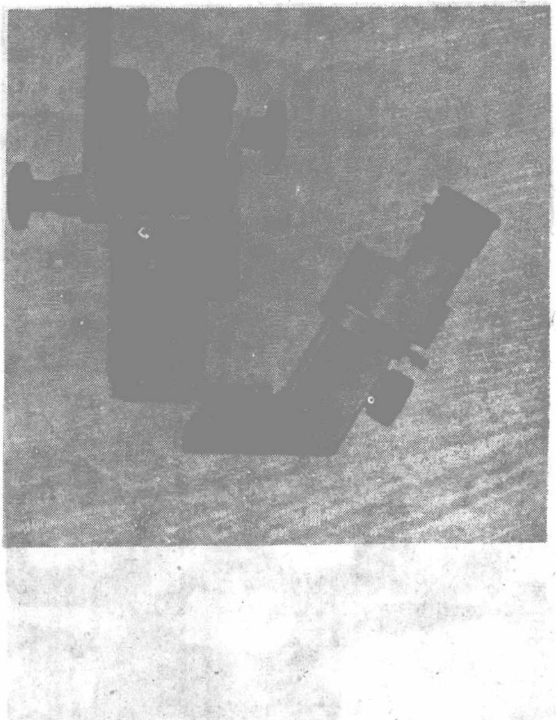

Fig. 5. Zoom microscope OPMI 6 with assistant microscope at 8°. For plastic and reconstructive microsurgery, the microscope and accessories are frequently installed on a portable floor support or a ceiling-mount (not shown in the picture). The most commonly used microscope is at present a zoom microscope which the operator controls by a foot control switch, thus being able to chose the most suitable magnification for each case. The zoom system extends from 1:4 and if required, can be adjusted manually. Co-axial illumination (6 V, 30 w) is used to light the operating field. For the assistant, a co-observer microscope can be mounted on a support ring which rotates around the main microscope. The angle of vision between the assistant microscope and the main microscope amounts to only 8°. In practice this means that the assistant maintains a stereo-optic picture with almost the same field of view as the operator. When needed, a 3-step Galilei change (not shown in the picture) can be fitted between the body of the assistant's microscope and the binocular tube. The main microscope is focused by an electric motor controlled by the foot switch, whereas the assistant's microscope is focused manually by means of a push-button

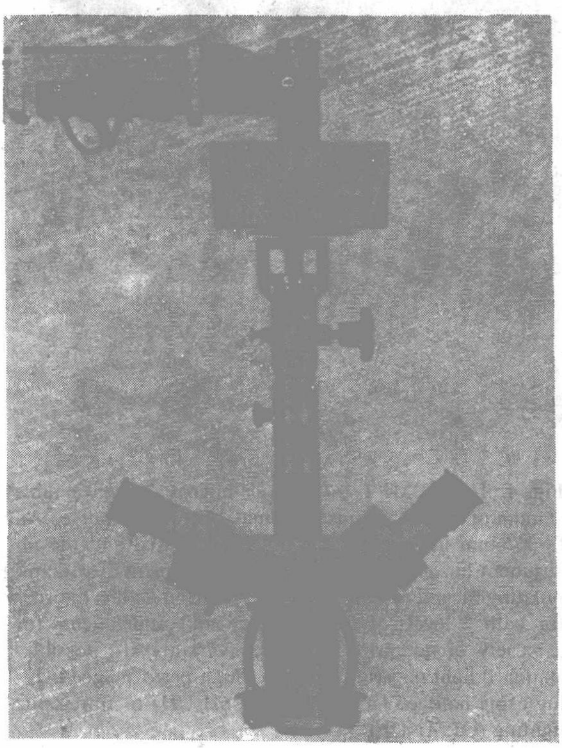

Fig. 6. OPMI 7D, with coordinated coupling. The coordinated coupling, sometimes referred to as the XY coupling is useful for fine adjustment of the microscope. It is controlled by an electric motor and allows displacement in a horizontal direction of about 50 mm, with an adjustment speed of 3.5 mm per second. This is so calculated to allow prompt positioning of the microscope, even at relatively high magnification. The main microscope is a zoom microscope, permitting continuous magnification change within a range of 1:5. There is a stereo beam splitter on which two straight binocular tubes with appropriate eye-pieces are mounted. This arrangement enables both the operator and the assistant to have exactly the same angle of view and the same stereo optic advantages with regard to the operating field

bag. Damage to the cables, by kinking or running over while transporting the microscope, can lead to the loss of individual functions and great care should be taken when transporting the microscope within the hospital.

2. Accessories and Documentation

Different attachments for the microscope are important in building up a comprehensive system (see Figs. 8 and 9): fibre-optic lighting, electronic flash-gun, co-observer tubes (Fig. 7), dual microscope, beam-splitter with possibility for photography (Super 8 mm and 16 mm) and colour T.V. adaptor. The assistant microscope – 8° – acts as an independent microscope, being secured on a carrying ring which allows rotation round its own and the main microscope's axis. In the middle of the carrying ring, an operating field magnifier ×2, can be mounted and it can be used simultaneously with the assistant's microscope. Beam-splitters, 50 and 70, permit accessories for co-observation and documentation to be simply and quickly mounted. Beam-splitter 50 is particularly suited for co-observer tubes, supplying the same amount of light to the tube and to the main microscope. Beam-splitter 70 directs more light to the attachments and is more advantageous for the recording accessories. With co-observer tubes, the assistant can see the operating field at the same angle as the surgeon. The monocular as well as the stereo co-observer tubes can be used

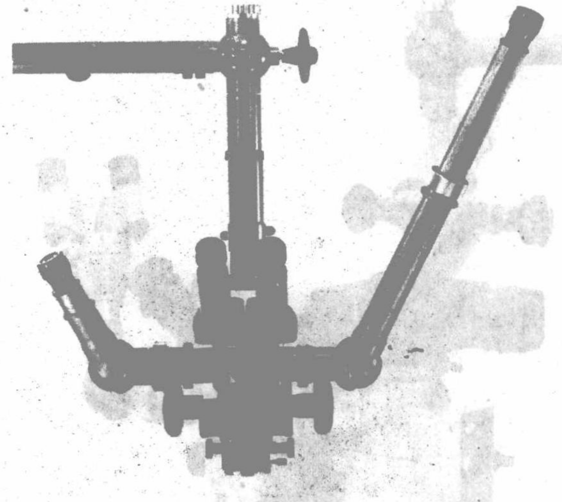

Fig. 7. Short and long co-observer tubes mounted on the microscope

in differing directions and, with the extended observer tube, the operating field can be observed without disturbing the operating team.

The photo-adaptor, f = 220 mm, fits on one of the beam-splitters and can be used with all objectives on the main microscope. With Galilei exchange and a ×2 lens attachment, a ×10 magnification can be obtained for each lens. The photographic attachment is used with the microscope lenses f = 125 mm and f = 200 mm. In addition, three photographic lenses (125/1, 125/2, 200/1.25) can be used with this attachment or combined with ×2

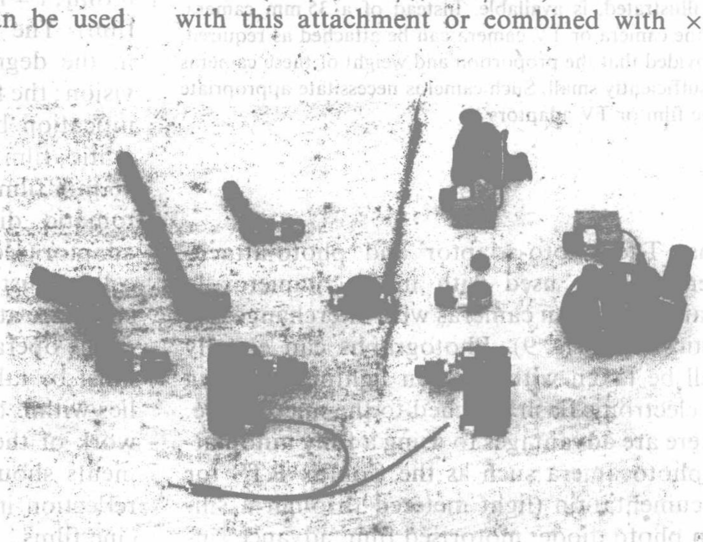

Fig. 8. Accessories for co-observation and documentation: cine, photo and TV cameras, co-observer tubes and adaptors