Section of Urology

President J P Mitchell TD MS FRCS

Meeting 25 October 1973

Presidential Address

Optical Criteria of Urological Endoscopes[1]

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Exactly a year ago Mr David Wallace (1973) gave as his Presidential address a superb exposition of the development of endoscopes from Bozzini's lichtleiter, designed in 1806, to the present day. Not only did he show us a picture of this historic instrument, but his eagle eye had spotted a genuine piece amongst some discarded antique relics at the College of Surgeons of Chicago. The instrument has been restored to its pristine state by David Wallace and is exhibited in their museum.

What criteria do we demand from a urological endoscope, and to what extent do modern endoscopes fall short of these standards? The instrument must be capable of viewing the full length of the urethra, all areas of the bladder wall and the bladder neck itself. The development of other endoscopes to view the renal pelvis, calyces and ureter is also imminent.

Panendoscopy
To view the urethra in the past we used the panendoscope fitted with a fore-oblique telescope. This telescope could not be direct-viewing because the wheatear bulb at the tip of the instrument obstructed part of the view and a wide angle was obtained only by rotating the fore-oblique telescope through 360°, but unfortunately this angle of view meant that the instrument had to be advanced along a different line of direction from the line of view. In other words, in order to inspect the urethra with a conventional panendoscope it was necessary to view first, then straighten the line of the instrument and advance it one or two centimetres before viewing again. The beak of the instrument was very liable to damage the mucosa of the opposite wall of the urethra (Fig 1), and the poor view obtained if there was any stenosis of the urethra led to the conventional panendoscope falling into disrepute and being used only on rare occasions. The development of fibre 'light' illumination has permitted the construction of a direct viewing telescope, so that the instrument can now be advanced in the same direction as the view. In recent years this instrument has opened up an entirely new field, in the sense that a structure, very poorly seen until recently, can now be viewed with complete accuracy and detail in both adults and small children. The site, size and length of a stricture can be determined even more accurately than by the urethrogram.

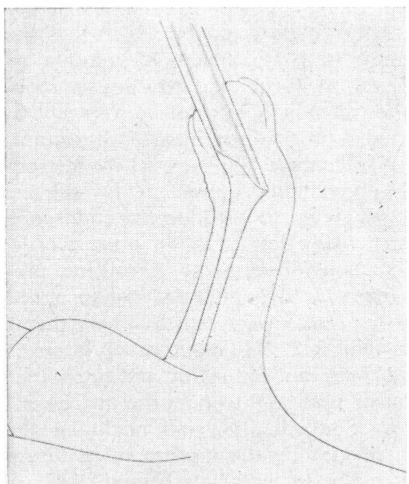

Fig 1 *Using a fore-oblique telescope, the beak of the panendoscope is liable to damage the mucosa of the opposite wall of the urethra*

It is possible to dilate a stricture under direct vision using one of a variety of dilating tips on the

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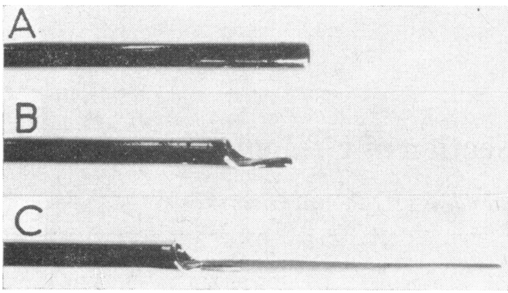

Fig 2 *Three varieties of panendoscope tip.* A, *the direct-vision panendoscope sheath.* B, *sheath with a dilating beak.* C, *sheath with filiform tip attached*

end of a direct-vision panendoscope (Fig 2). The only limiting factor to dilatation under direct vision is that the first split on dilating a stricture may produce too much bleeding, which fogs the view. If the urethra is still strictured proximal to the area dilated, as in the case of a double stricture, then the water flow will not be sufficient to clear the blood in order to see the second stricture.

We have now reached the stage where instruction in endoscopy should consist of training the young urologist always to introduce the endoscope using a direct vision telescope; in other words, carrying out panendoscopy as a routine preliminary to every cystoscopy. I am still surprised at the number of urological centres where this is not routine. The fact that most panendoscopes are supplied with an obturator indicates that many urologists wish still to pass the instrument blind – in other words, they do not take the opportunity of viewing the urethra in its virgin state before any instruments have been passed.

Cystoscopy

After changing the telescope to a right-angle view, most of the bladder can be inspected, but the anterior wall can still often prove inaccessible, even with a hand pressing down the bladder suprapubically. Some degree of retrograde viewing is essential. We have been persuaded by our manufacturers to accept 70° as the angle of view, compared with older telescopes having conventional illumination, which had a 90° angle of view (Fig 3). The theory behind this is that the field of view has been increased sufficiently to cover the same areas we used to be able to cover with our 90° telescopes. Unfortunately, this is not quite true. The reason for the manufacturers' request to accept this 70° angle was the problem of bending the fibres and fitting a diffuser sufficient to give equal illumination to the whole area being viewed. We therefore compromised with a 70° angle which, with a 70° field, gives only 75° of retrograde viewing (Fig 3). An old conventional 90° telescope, with a field as small as 45°, would give us more retrograde viewing.

In addition, bending the tips of these fibres has also brought with it unequal illumination of the whole field being viewed. If we test telescopes carefully we often find that the area of the bladder further away from the viewer is better illuminated than the foreground (Fig 4A). This is not at first obvious, as one tends to find the area at the neck of the bladder closer to the lens than the area which is better illuminated (Fig 4B). In practice then, the whole field may prove to be equally illuminated by the inverse square law. However, as soon as the telescope is introduced further into the bladder and all parts of the wall are the same distance from the objective lens, the difference in illumination immediately becomes apparent.

Pyeloscopy

What other areas do we need to view in the urinary tract? Certainly we hope some day to be able to obtain a clear view of the renal pelvis and calyces and, in fact, the whole length of the ureter by means of the pyeloscope.

Here perhaps a word on fibreoptics would not be out of place. If all fibres of a cable are lying in identical relationship to each other at the entry and exit points, then an image can be transmitted.

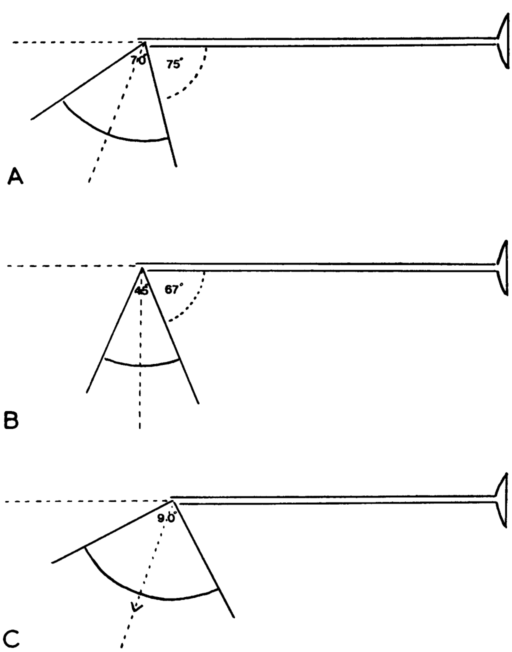

Fig 3 *Wide field telescope (70°) with 70° angle of view* (A) *gives less retrograde viewing (only 75°) than the old conventional telescope of much smaller field (45°) with a 90° angle of view* (B) *which provides 67° retrograde viewing. The wide field telescope (90°) with 70° angle of view* (C) *gives little more retrograde viewing than the old conventional telescope* (B)

The production of a fibreoptic cable is a relatively simple principle (Fig 5): fibres (F) are wound on a wheel (W), with a circumferential measurement equal to the length of the cable required, the fibres are then set in their resin base and sectioned at one point on the wheel. On removing the cable from the wheel the fibre relationship on either side of the cut – that is to say, either end of the cable – is identical (I) and an image can be transmitted.

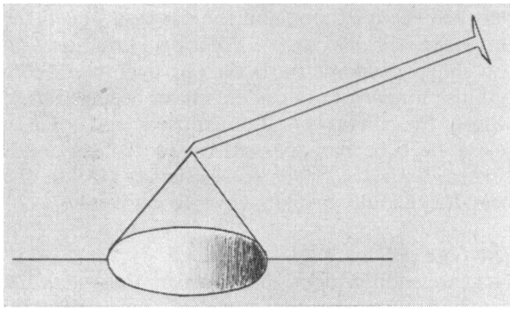

Fig 4A *Poor illumination of the foreground of the field.*

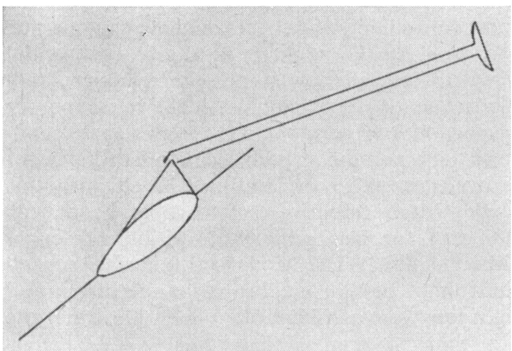

Fig 4B *Poor illumination of the foreground not obvious as the poorly illuminated area is nearer to the objective lens*

Gastroscopes and colonoscopes have fibreoptic systems made up of a vast number of fibres; but the pyeloscope, being of relatively minute calibre, carries comparatively few fibres. The quality of the image is, therefore, still poor, very granular and minute in size. Furthermore, development of fibres to any smaller size is limited by the physical properties of light – in other words, the wavelength of the visible spectrum. The granularity of the image can readily be seen and will be grossly exaggerated in an instrument of so few fibres as the pyeloscope. This minute instrument is still very much in its infancy and no space can be allowed for flow of fluid to distend the structure being viewed. Only by the administration of a diuretic such as frusemide can sufficient urine be produced to distend the area around the objective lens. The direct-viewing pyeloscope should be

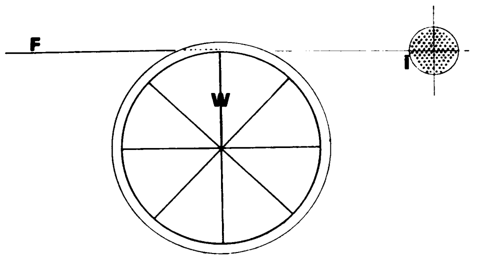

Fig 5 *Construction of a fibreoptic cable (see text)*

useful ultimately for viewing the upper calyces (Fig 6) and full length of the ureter, though at present the difficulty of a medium in which to view is the factor precluding its use in the ureter. For seeing the depth of the calyces the tip must be capable of being angulated to at least three-eighths of a circle (135°) in order to see the lowermost calyces (Fig 7). At present the pyeloscope is limited to a movement of approximately 10–15° on either side of the straight. With this limited movement the instrument's value could be enhanced by using a right-angled view (Fig 8). With this right-angled view and 15° movement either way, most parts of the renal pelvis and calyces could be viewed from the renal pelvis, but not from inside the calyces. I must admit that one has to be something of an acrobat to make full use of the instrument. Poor as our photographs were, it is my feeling that this instrument will be developed to a useful state before long and, for this reason, I try to encourage the young trainee urologists to use the panendoscope whenever the renal pelvis is exposed at open surgery. It is only by using these instruments regularly that we shall learn how to orientate ourselves satisfactorily when the pyeloscope becomes part of the routine armamentarium of the urologist.

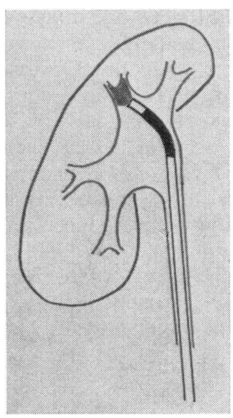

Fig 6 *Pyeloscope viewing the upper calyces*

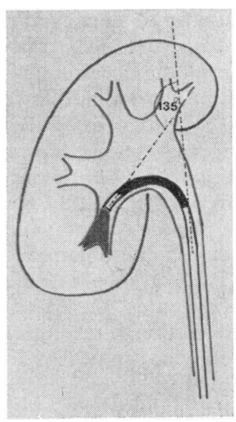

Fig 7 *Need for angulation of pyeloscope tip through three-eighths of a circle*

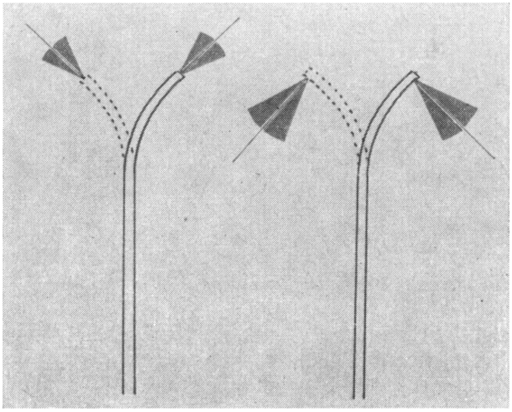

Fig 8 *Left, view from direct vision pyeloscope. Right, views from 90° pyeloscope*

Improvements in the Rigid Telescope

Returning to the rigid instrument, how have these improvements of the last few years been achieved? The three factors are, first, the solid rod lens system designed by Professor Harold Hopkins of Reading University; secondly, improved illumination from fibre-transmitted light; and thirdly, higher standards of manufacture, such as the use of better quality glass, more accurate measurement in the grinding of the micro lenses used, and better quality of blooming. In addition, new cements for the end windows are now being developed to enable the instrument to withstand greater temperature variations in sterilizing processes. The coefficient of expansion of the glass, the metal tube and the old cements were very different.

We are all well aware of the principle of the Hopkins system. Rod lenses have been used for many years, but Hopkins' principle consisted of replacing the air space between the lenses by glass rods. The transmitting system of all telescopes is made up of a series of paired lenses, one imaging and one field lens. The series usually consists of five of these pairs. The same principle of transmitting lenses is followed in the Hopkins system, but only small air spaces exist between each rod.

Newer designs are now on trial, using even longer rods, but the risk of fracture of such long rods is considerably greater, and all are aware of the bending to which these telescopes are occasionally subjected.

The advances achieved by the Hopkins lens system are: increased light transmission, improved image resolution, and the opportunity to use a wider angle lens.

The Eye-piece

In addition to the transmitting system, the telescope requires an eyepiece lens to produce an image at the optimum distance from the eye, which is well beyond the comfortable near point of vision to allow for the occasional presbyopic urologist. This lens also governs the size of the image seen. The eyepiece consists of a simple plain glass window and forms the watertight seal, but it serves yet another purpose – to provide complete insulation over the end of the telescope tube. The black shield of the eyepiece should be constructed of nonconducting material, so that when diathermy is used no spark can be generated between the telescope and the surgeon's eyebrow or, worse still, his cornea. We are all familiar with the sharp pinpoint burn on our eyebrows from old instruments, but accidents have been reported where the metal of the exposed end of the telescope tube has sparked on to the surgeon's cornea, with disastrous consequences. Hence the need for the fully insulated eyepiece cover.

The Fore-oblique Angle

Next we should mention the prismatic system for providing the required angle of view. We need three angles: direct-vision, fore-oblique and right-angle. For operating, we have conventionally settled for a 30° angle of view. This provides the most convenient range over which we can operate. However, the 30° angle tends to give a tangential view to all structures on the bladder wall. Consequently, it is not an ideal telescope for inspection. Furthermore, it is a telescope demanding a fair amount of experience before the operator is accustomed to orientating himself with this angle. More recently, resectoscopes have been designed for use with direct vision telescopes (Mitchell 1972). The 30° deflecting surface proved difficult to design, as chromatic aberration and light loss were considerable. Fig 9A illustrates the

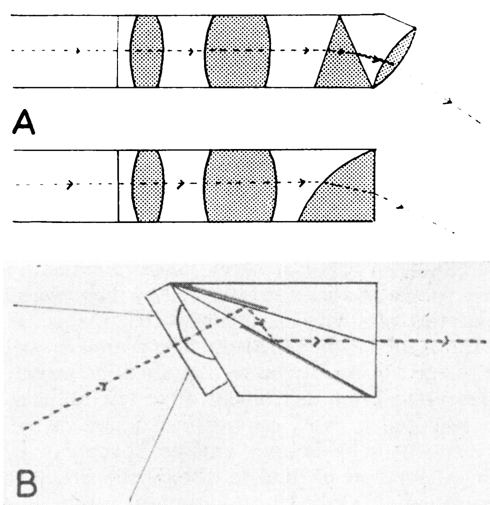

Fig 9 A, *simple principle for angulating to a fore-oblique view.* B, *McCarthy's triple prism with double reflecting surfaces*

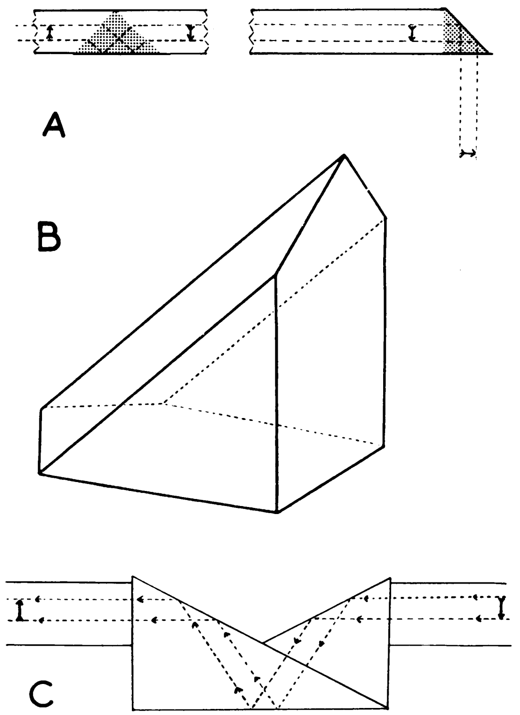

Fig 10 A, *simple inverting wedge.* B, *the Amici prism.* C, *the K prism*

simple principle of angulating the lens and prisms which has been incorporated in many earlier telescopes. In 1923 McCarthy claims to have presented the triple prism, with its double reflecting surfaces (Fig 9B).

Inversion of the Image
Finally, every instrument must be fitted with a corrective device to adjust the inversion which occurs in all transmitting systems, so that we can see the image the correct way up.

Although we could obtain a perfectly adequate view without this corrective device, it would be extremely difficult to orientate and to operate. The earliest was a simple inverting wedge (Fig 10A). Later, the inverting system was incorporated in the objective prism of the cystoscope, which not only inverted the image, but also gave the right-angled view; this is the Amici prism (Fig 10B). Today, a more sophisticated device, the K prism, is used to invert the image (Fig 10C).

Image Resolution
The resolution of the image must be considered at the varying distances from which we view. At the neck of the bladder and on the trigone we may be as close as 2 mm from the objective lens. In viewing the lateral wall, in particular the vault of the bladder, we may be as much as 5 cm distant. The varying depth of focus is purely a matter of accommodation by our own eye and, therefore, to some extent, the question of the age of the consultant performing the endoscopy. For the purposes of testing it is imperative, therefore, that we test at varying distances of, say, 3 mm up to 5 cm and only by testing over this range can we be certain that the instrument is achieving the degree of resolution to be expected. Specific graticules should be visible at certain distances. It is surprising how much the eye will accept and try to compensate for poor resolution.

The Wide-angled Field
As regards the field of view, the provision of a wider angle has the tremendous advantage of extending the area seen but, in itself, produces new problems. In the first place, there is loss of magnification as compared with the conventional telescope when the object is viewed from the same distance (Fig 11A). In order to obtain the same degree of magnification, the object must be viewed at a very much closer range, thereby filling the whole field (Fig 11B). Viewing at such a close distance can, of course, give rise to some degree of distortion due to extreme variation in depth of focus. This is comparable to portrait photography, when you have a choice of using a portrait attachment, with shallow depth of focus, or taking the same photograph from a further distance, using a telephoto lens. The latter will give a much greater depth of focus.

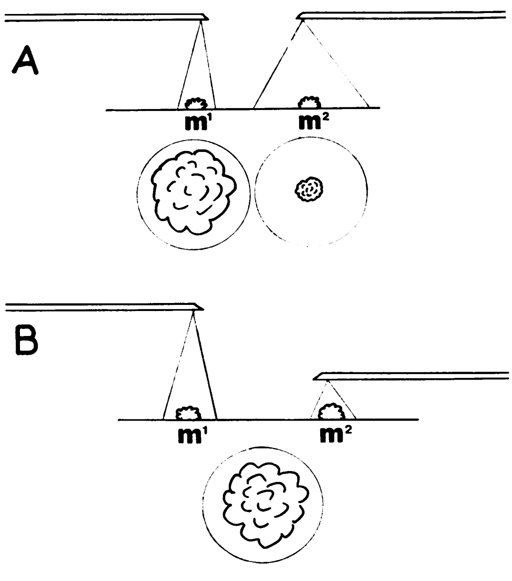

Fig 11 A, *loss of magnification in the wide-angle telescope.* B, *compensation of loss of magnification by viewing at closer range.* m^1, *image viewed by a narrow field telescope.* m^2, *same image viewed by wide-angle telescope*

This loss of magnification is only one of the problems introduced by the wide-angle lens. Another problem is the peripheral distortion that can occur, again comparable to the use of a wide-angle lens in photography. The picture of two tall buildings with a wide-angle lens produces the effect of the buildings toppling over towards each other. The same thing will occur at endoscopy with the use of a wide-angle lens and this can be demonstrated by the curious dome effect when chart paper is viewed (Fig 12).

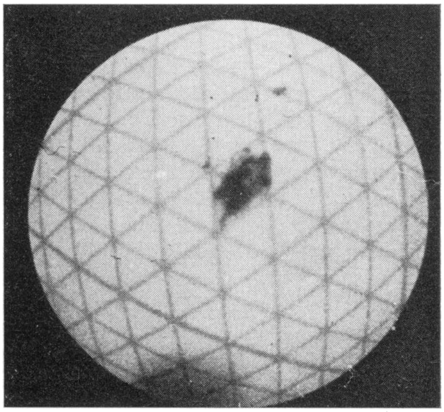

Fig 12 *The dome effect*

These problems with the wide-angle lens become much more apparent when using the 70° or 90° telescope than when using the direct vision instrument, as magnification can be adjusted readily by moving the instrument along its own axis—in other words, if there is too much magnification the instrument can be withdrawn, and if there is too little magnification the instrument is moved in its own line towards the object being viewed. With a 70° or right-angle telescope, the distance of the object from the objective lens is to some extent predetermined by its position on the bladder wall.

With the fore-oblique telescope, the application of a wide-angle lens has introduced yet another problem. With the increased field the edge of the sheath of the resectoscope where the loop disappears has had to be cut back, otherwise the edge of the sheath will obscure part of the foreground of the field of view. By cutting back the leading edge of the sheath, the tip of the telescope comes closer to the point at which the loop finishes each cut (Fig 13). Consequently the loop is still active when it is within 1 mm of the end of the telescope and, at this distance, an arc can jump from the loop on to the telescope resulting in damage to the telescope, the lens mounting and even the lens itself. This is why most resectoscopes designed for use with wide-angle telescopes have a rim of sheath showing. This is a safety factor to

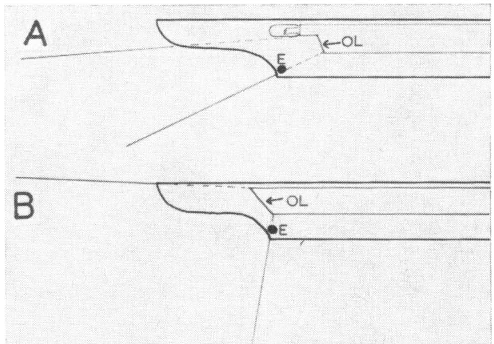

Fig 13 A, *with a narrow field the lens* (OL) *is nearly 1 cm proximal to the edge of the sheath as the loop* (E) *is retracted.* B, *using a wide-angle lens the loop as it retracts is only* 1–2 *mm away from the lens and therefore can short on to the telescope itself, damaging the objective window*

preserve the tip of the telescope. Multiplying the measurement by πr^2 it will be found that it obscures more than one-sixth of the field. Is it then not more advantageous to use a narrower field of view when operating, say 70°, with the intention of preserving the tip of the telescope?

Sparking to the telescope can also be overcome by using an all-metal sheath, to which the spark will jump from the loop in preference to the telescope.

I have also experimented in this work with a rotatable direct-vision all-metal resectoscope (Mitchell 1972) which, of course, has no beak and no damage to the urethral mucosa has been seen at subsequent panendoscopy. Furthermore, the end of the cut is very clean and leaves no tags. Another advantage of an all-metal sheath is its further reduction in size to 22 Charrière, which is less than the conventional viewing cystoscopes.

Finally, concerning magnification, with a 30° angle the 90° field gives the impression of considerable distance between the two points (Fig 14): the object at 0.5 cm appears very much larger than

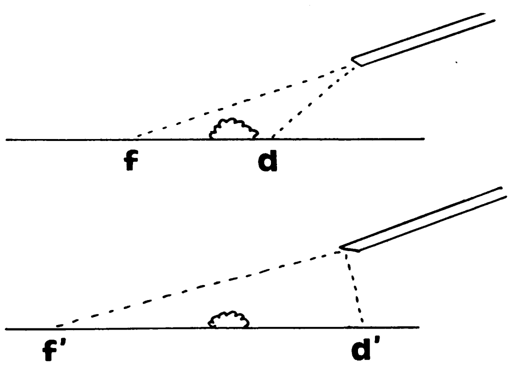

Fig 14 *Impression of distance in the depth of field;* fd *is the depth of viewing with a 45° field;* f'd' *shows the much greater depth using a 90° field of view*

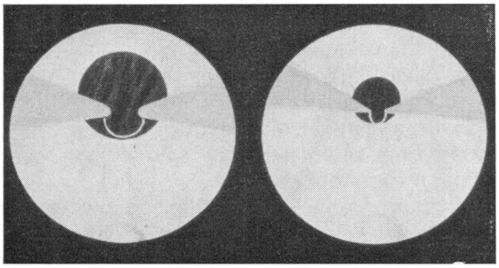

Fig 15 *Comparative view between 55° telescope (left) and 90° telescope (right)*

the object at a distance of 3 cm. This becomes extremely apparent in the traverse of the loop which, when fully extended, appears to be in the far distance as compared with, say, the 50° or 70° field, where the loop in its full extent of traverse still appears to be within a reasonable distance (Fig 15).

Light Transmission

To measure the amount of light being received at the eyepiece end of the telescope would seem at first to be a simple measurement to make with a photo-electric cell. All that appeared necessary was to have the cell at the prescribed distance from the eyepiece, to shine a light of constant intensity down the telescope and to see what was measured on the meter. In practice, however, the size of the receiving area of the photo-electric cell and whether the light from the telescope filled the area made standardization difficult. If one telescope illuminated a wider area of the photo-electric cell than another telescope, then a higher reading could be obtained. This is, therefore, part of a much larger test programme for telescopes on which our physicists are now engaged under the guidance of Mr Tony Makepeace at the Bristol University Department of Audio-visual Aid.

Illumination of the Field

Lastly, the accuracy of the area illuminated has to be assessed. Fig 16 shows three tracings in which the dark rings represent the field of view of the three respective telescopes, and the light areas outline the maximum illumination. As can be seen in each instance, the maximum illumination does not coincide with the field of view. As already mentioned, this is partly due to the manufacturing difficulty in angulating the tips of the glass fibres and also due to the problems of diffusing the light from its point source at the end of the fibres.

In addition, it is important to ensure that the correct cables are used. In Fig 17 the upper three tracings show the area of illumination from a 2 mm fibrelight cable via three different manufacturers' telescopes; the three lower tracings represent the illumination from a 4 mm cable via the same three telescopes. In other words, in order to compare the illumination transmitted down two telescopes, it is necessary to ensure that the cable matches the distribution of the fibres at the pillar of the telescope.

The Non-rotating Pillar

The problems which fibre illumination has introduced are: uneven illumination of the field being viewed, the need to match cable and telescopes, and the angle of the fibre tips for which a 70° view is our compromise today. With fibre illumination we are committed to a fixed pillar and this causes certain inconveniences both with inspection and with endoscopic surgery. The large fixed pillar obstructs the lateral movement of the instrument by impacting against the thigh making it difficult to view the opposite side of the bladder wall and prostatic cavity. Richard Turner-Warwick has made the helpful suggestion that the pillar should be reversed to the opposite side of the telescope. This in itself, however, introduces further problems with certain types of mechanism, where the thumb-piece can foul the pillar. I have

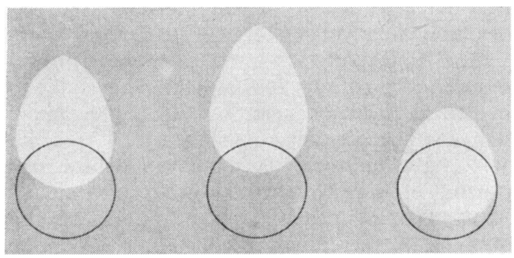

Fig 16 *Failure of maximum illumination to cover the exact field of view*

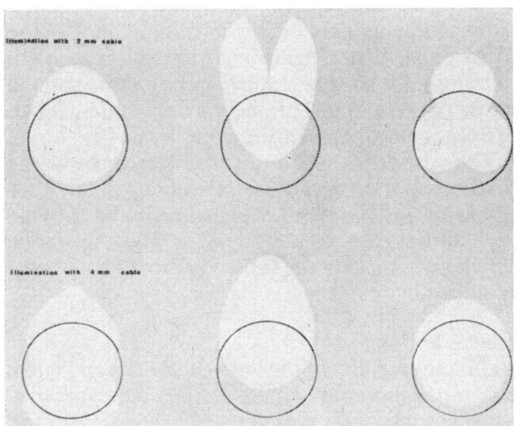

Fig 17 *Upper three tracings show area of illumination from a 2 mm fibrelight cable via different telescopes; lower three tracings show area of illumination from a 4 mm cable via the same three telescopes*

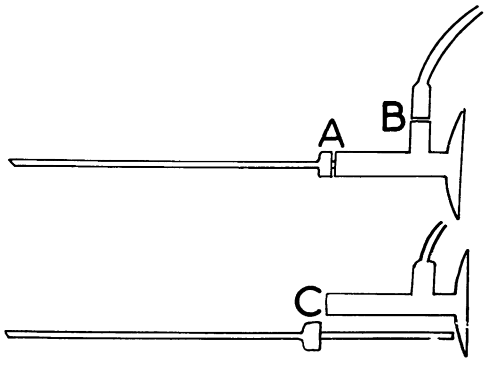

Fig 18 A *and* B *are the two interfaces of fibres on a rotating pillar.* C *shows cable incorporated in detachable eye-piece*

had constructed a lateral pillar at right angles to the vertical axis of the telescope, so that when looking at the right lateral wall of the bladder, or the right side of the prostatic cavity, the pillar is directed upwards, and when looking to the left side of the bladder and the left wall of the prostate, the pillar is downwards. This, in my hands, has proved most valuable. Attempts have been made to develop a rotating pillar but this inevitably involves a second interface of fibres (Fig 18 A, B). At each interface there is, unfortunately, at least 50% loss of light. This is due to the fact that the fibres cannot be made to appose each other accurately. One fibre may transmit 100% light, another 50%, and yet a third may transmit none at all, with the net result that less than 50% of light is, in fact, transmitted across an interface. If, therefore, a second interface on the rotating collar is introduced, this reduces the illumination by more than 75%. Yet another suggestion, at present under construction for me, is to fix the cable to the eyepiece, incorporating the eyepiece as part of the cable (Fig 18 C). The eyepiece is then attached to the telescope on a running joint so that the telescope can be rotated inside the eyepiece. This means only one interface of fibres and, therefore, only one area of light loss.

The introduction of a direct-vision resectoscope overcomes the problem of the fixed pillar altogether as in this type of instrument the moving part and sheath rotate round a fixed telescope which gives exactly the same view in all rotational positions.

The Light Cable

At first the rigidity of the light cable was a problem but, today, fibrelight cables can be so flexible they wrap around one's thumb without fracture of the fibres.

Cables can become hot at the light source end, so much so that nurses, in order to avoid grasping the hot metal plug, tend to pull on the cable when detaching it from the light source. This can result in the cable being pulled out of its metal socket, particularly in a spring clip type of plug and socket (Fig 19). Some cables have been fitted with a heat shield which can be held comfortably even after the light source has been working for an hour or more.

Overheating of the cable end can readily occur if the cooling fan breaks down. Some more powerful light sources have twin fans, both of which must be functioning. Unfortunately my ear was not attuned to the sound of two as opposed to one fan, with the expensive loss of a highly flexible light cable, as the ends of the fibres were fused beyond repair.

Finally, there are the numerous cable attachments at present on the market, few of which seem to accept the standards recommended by the British Standards Institution, with the result that matching cables, the telescope pillars, and the light source sockets can be not only frustrating but frankly exasperating.

It will therefore be seen that the introduction of fibre illumination has presented a number of problems, and it is for these reasons that it would seem possible that we shall ultimately return to some form of distal illumination, when bulbs of smaller size, better light generation and more reliable life can be designed. This would also offer increased light transmission along the optical system, and dispensing with glass fibres would permit an increase in the diameter of the telescope lenses themselves.

Endo-photography

Photography via endoscopes is considerably simpler than would be anticipated, provided adequate illumination is available. Much is said about matching the camera to the endoscope. The critical factors quoted are, first, the distance of the object from the objective lens and, secondly, the distance of the virtual image from the eyepiece lens: but in practice the aperture of the eyepiece lens in relation to the camera lens is so small that it is to all intents and purposes a pin-

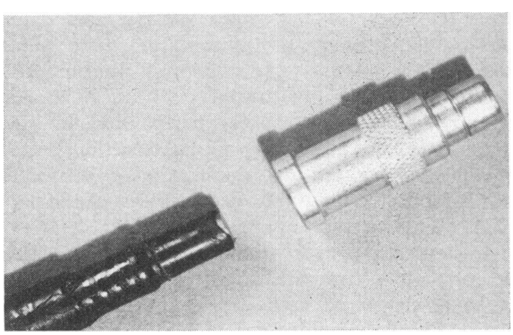

Fig 19 *Light cable pulled out of its metal socket*

hole camera with little problem of focusing. With a single lens reflex camera the image can then be focused accurately.

Attaching the camera to the eyepiece of the telescope can be an awkward manœuvre, but the magnetic coupling designed by my colleague in Bristol, Mr Tony Makepeace, has simplified this problem considerably. But could we not have a uniform size of eyepiece without any irregularities so that coupling would be very much easier?

The major problem is that of filling the area of film on a 35 mm camera. In the standard camera, with a 55 mm lens, only one-quarter of the film is occupied by the image. To increase the area of film used requires some form of telephoto lens.

Colour rendering, of which many of us have become conscious since the first fibrelight instruments were introduced, is of even greater importance in photography. We have noted that fibre-illumination fails to transmit blue light adequately. This is presumably a property of the glass used for drawing the fibres, probably combined with the effect of the wave-length of the blue end of the spectrum. This is at present under investigation by physicists in Bristol and elsewhere.

Ghost images are similar to the overlapping pictures sometimes visible on television screens. In Bristol any complaints of television ghost images are immediately explained as being due to the proximity of the new Severn Bridge, which absolves the television mechanic from any further attempt to correct the fault. However, at endoscopy, ghost images are rare.

The distance of the virtual image is surprisingly variable from 3 ft to 7 ft (1–2 m). For perfect photography this should be measured accurately for each telescope.

Flare can be a real problem in certain instances, when features of highly contrasting illumination are being photographed but, on endoscopy, the fault usually resolves into one of uneven diffusion from the light fibres or reflection off the chrome tip of the endoscope sheath. One word of warning: isotonic fluids, such as glucose or glycine, have different refractive indices from plain water, which is the preferable photographic medium.

Ciné photography, and to some extent still photography, can best be performed via some form of teaching attachment, which has of necessity to be flexible and is, therefore, usually based on the principle of fibreoptics. The result, however, is a somewhat granular appearance, and it is hoped that a new design of teaching attachment by Professor Harold Hopkins, based on the principle of jointed periscopes, will give considerably better resolution and eliminate the granularity due to the fibres.

The use of the teaching attachment for the purposes for which it was designed has, on the other hand, proved somewhat frustrating as it fails to convey the practical difficulty of orientation. However, it is an invaluable asset in a department of urology, both for photography and for the instructor to watch what the trainee is doing.

Ciné pictures can be taken by direct application of a camera to the resectoscope telescope without the aid of any teaching attachment. This method of resecting, however, cannot be recommended, as assessment of the accuracy of resection via the viewfinder of a ciné camera can be nerve-racking for the surgeon.

Telescopic Coverings

Returning to the telescopes themselves, may I give a final word on the non-optical features of the instrument. The length and calibre need little comment: the longer the telescope, the more space there is to fit moving parts for operating. The calibre should now allow the viewing adult cysto-panendoscope to be no more than 17 Charriere. The insulation of the eyepiece has already been described.

Under the heading of durability, may I make a plea for specially trained staff to handle these instruments. That includes not only the nurse who assists at endoscopy, but the staff who clean, check, repack and sterilize the instruments. A post of curator of endoscopes is long overdue in our hospitals and would be a great financial economy to the National Health Service.

Sterilization

As regards sterilization, in Bristol we still favour low pressure steam as being the safest bacteriologically and, of all heat processes, the least traumatic to telescopes. Steam at ½ an atmosphere pressure develops at 80°C. The cycle takes 17 minutes from dirty to clean trolley, and the instruments are stored in a sterile box ready for immediate use.

One must remember to check that the low pressure steam autoclave is not overheating, and not to put telescopes previously sterilized in alcohol, chlorhexidine or gluteraldehyde through the low pressure steam autoclave, as the lens mountings may have been weakened. The boxes should be kept clean, otherwise bitumen will be deposited on the surface of the instrument as a brown, irregular, adherent film. We have found that, if used correctly, low pressure steam is less traumatic to the endoscopes than cold sterilizing fluids.

Testing Telescopes

Finally, a simple instrument (Fig 20), constructed by one of our hospital engineers, can give us a very elementary test of new telescopes. The grip for the telescopes can be rotated from 90° to 0°,

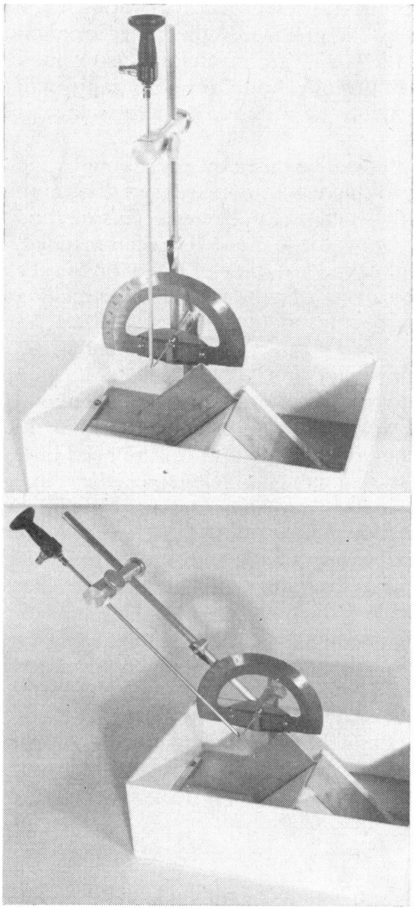

Fig 20 *Simple telescope testing device*

and the wedge platform for viewing in water can be raised from 5 cm up to 2 mm from the objective lens. A photo-electric cell can measure the light transmitted through the optical system from a source of given power. A similar simple testing device has been designed by Mr J F R Withycombe at Cambridge.

Further refinements in assessing criteria of telescopes must remain in the hands of the physicists, but a simple device such as this could be available at trade exhibitions, for us to be able to compare one exhibit with another. Finally, let us hope that the criteria of a satisfactory telescope will no longer be assessed by the view the theatre superintendent has of the window at the end of the corridor.

Endoscopy Groups

Much can be learned from discussion with others engaged in the art of endoscopy. In Bristol we have a small club made up of one representative from each discipline employing endoscopy. Our neurosurgical member has shown us the appearance of the ventricles and we have encouraged him with small instruments to view the spinal cord in detail. One plastic surgeon has demonstrated inspection of the soft palate from inside the nose during speech. The rheumatologist has shown us the inside of joints and, of course, the gastro-enterologist has shown us his field. The possibility of forming a national society on similar lines is now being considered.

Probably one of the most interesting realms is industry, where endoscopy of engines is a long-established method of routine inspection, and amongst my many visits to the Bristol Aeroplane Company and to Rolls Royce, Bristol, I was permitted to inspect the Concorde's turbo-jet engines for damage to the blades from ingested birds.

In the local University veterinary department comparative endoscopy is still a closed book. The rigid endoscope can only be used in female animals. To carry out cystoscopy on a bull demands a flexible instrument over 3 feet (1 m) long, and none of my colleagues will agree to his colonoscope being used for cystoscopy and panendoscopy on a bull, however valuable the bull may be.

Acknowledgements: To optical physicists I apologise for apparent over-simplification, and hope they have been able to bear with me, as I have tried to steer a middle course between the complexity necessary for accuracy and simplicity of terminology to maintain interest.

I wish to thank Tony Makepeace for his help with the ciné photography and for the many interesting discussions we have had together on the optical physics of photography. This is also an opportunity to give my very sincere thanks to Jim Gow, David Wallace, Richard Turner-Warwick and John Withycombe for all the enthusiastic support they have given on the BAUS Endoscope Development Committee. Also to Professor Harold Hopkins FRS of Reading University, and his colleague Mr Steve Dobson, for his advice, encouragement and the pipedreams of future developments. At the same time we wish him success with his new teaching attachment, which looks most promising.

Finally, I must thank my colleagues in Bristol and, in particular, Norman Slade and Michael Roberts, for their unlimited patience with tests on ever-changing new pieces of endoscopic equipment.

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