The History of Technologic Advancements in Urology

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This text is dedicated to the spirit of innovation. To all those that have contributed to technology in medicine and whose creativity and perseverance serve to inspire the next generation of urologists, scientists and inventors.

– Sutchin R. Patel, Michael E. Moran and Stephen Y. Nakada

This text is also dedicated to the memory of Dr. Manoj B. Patel (1967–2017), a dear friend, colleague and inventor.

– Sutchin R. Patel

Contents

Chapter 1
Introduction

Sutchin R. Patel, Michael E. Moran, and Stephen Y. Nakada

We live in exciting times and in our lifetime we have seen tremendous changes in science and technology. These changes have affected all aspects of our life, from communication to transportation to health care.

The field of urology has always been at the forefront of technology in medicine and has been able to adapt to as well as pioneer many of these changes. Advances in optics and Edison's incandescent lightbulb helped lead to the development of better cystoscopes. The work of Clayman and Kavoussi in performing the first laparoscopic nephrectomy ushered in the field of minimally invasive surgery. Chaussy's ingenuity in using shock waves lead to a disruptive technology that changed how we treated stones.

Clio, the muse of history, has a lot to teach us (Fig. 1.1). Understanding the history and evolution of our field is important, as it shows us the big picture, giving us perspective, and allows us to realize the work of those that came before us to give us the tools that we use today. It teaches us that not all new innovations last and that only time will judge which technologies are validated and adopted. It teaches us not to be over confidant, not to become too comfortable and that we must always strive to improve because "change is the only constant in life" (Heraclitus of Ephesus).

Thomas Edison summed up the most important traits in an inventor when he stated "There is a way to do it better—find it." and in one of his most famous quotes "Genius is one percent inspiration and ninety-nine percent perspiration."

In our text we share the stories of how many of the technologies we use today were developed. We hope these stories will inspire you and help you to appreciate

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Fig. 1.1 *Clio, Muse of History*, 1800. Charles Meynier (French, 1768–1832). Oil on canvas; framed: 290 × 192.4 × 6.9 cm $\left(114\,{}^{1}\!/_{8} \times 75\,{}^{11}\!/_{16} \times 2\,{}^{3}\!/_{4}\text{in.}\right)$; unframed: 273 × 176 cm $\left(107\,{}^{7}\!/_{16} \times 69\,{}^{1}\!/_{4}\text{in.}\right)$. The Cleveland Museum of Art, Severance and Greta Millikin Purchase Fund 2003.6.5

the ingenuity, creativity and the countless hours of work and perseverance (which unfortunately we will never be able to fully appreciate) that it took to develop these technologies. Despite the technologic achievements of the past, our field continues to push the envelope in terms of innovation and creativity.

Chapter 2
History of Cystoscopy

Michael E. Moran and Friedrich H. Moll

Introduction

Light allows the physician to peer into the interstices of body cavities, with organs and organ systems [1, 2]. The development of light-guided devices underscores the history and development of the cystoscope [3]. The very beginnings of urology saw the introduction of increasingly sophisticated methods of looking into the lower urinary tract. On May 2, 1868 a little known surgeon who had arisen during the American Civil War to become the Surgeon General of the Navy wrote a seminal work in *The Medical and Surgical Reporter*. Philip S. Wales would go on to devise and develop his own cystourethroscope which he used on multiple occasions in his private practice. He stated, "*the endoscope, from ενδον "within" and the word οχοπεω "I examine" to become an instrument that but recently introduced to the notice of the profession"* [4]. More than one of the founding fathers of the specialty of urology declared that this new and burgeoning technology was the founding stone of the specialty. It is now difficult as a urologist to even imagine a time when we were not able to not only visualize the bladder but have almost complete access to the upper tracts as well, but this was not the case till rather recently. At the dawn of the twentieth century, one early investigator of urologic applications who is better known as the "father of gynecology," Howard A. Kelly demonstrated the potential of endoscopic evaluation of the urinary tract. Kelly and Curtis F. Burnam from Johns Hopkins published *Diseases of the Kidneys, Ureters and Bladder* in 1914 [5].

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On page 270 of his classic textbook, Kelly noted that *"It is our habit in catheterizing ureters in practically all cases to wax the catheter tip before its introduction*". This is the era prior to x-rays, there was no fluoroscopy, and only the hopes for illuminated endoscopes could provide the much needed information for expanding the diagnostic as well as therapeutic potential much need in the primitive specialty. Yet the need for knowledge about what pathology lies within visceral structures existed and the ability of physicians to anticipate pathology rose as autopsies (the word *autopsy* means "personal observation") increased in numbers and were correlated to clinical symptoms. The scratches on the freshly waxed catheters were critical to identify the presence and location of a potential ureteral calculus before other imaging strategies existed.

In this historical sojourn on the development of the cystoscope, we will not recapitulate the histories of the past, but will begin by discussing how the cystoscope impacted the development of urology as a specialty, discuss the earliest beginnings with the founding fathers, and then present the findings of these primordial investigations that led to the twentieth century and an explosion of cystoscopes and the proliferation of modern urology. First we begin with the development of direct and indirect light-guides which forms the basis of all types of urethroscopes followed by cystoscopes. This is followed by the methods for delivering better illumination which is closely related to the improved development of image improvement from the rod-lens systems, to the modern utilization of fiber optics. Next came camera systems which allowed the urologist to multitask which is so fundamental to modern or historically more accurate, current cystourethroscopy [6]. Finally, to simplify this rather complex historical overview- I will present the reader with a simplified outline of the historical development of the cystoscopy, which is a modification of that of Bransford Lewis, 8th President of the A.U.A. and a huge proponent of cystoscopy in early American urology. The history of the writings about the origins of cystoscopy would make an admirable topic unto itself, since most of the major urologic historical authors have attempted this topic and so too has the William P. Didusch Center for Urologic History with one of its first exhibits being this topic. But these writings, like so much of history itself is spread about like the diaphanous web of glimmerings that tempt the historian mightily to seek, to present, to clarify the past and a true and accurate history of cystoscopy would evolve into a mighty tome indeed.

Cystoscopy and Urology

The history of cystoscopy has been largely written about by many authors and historians and there is precious little left to be included in the burgeoning literature. There has been little appreciation of the ability to visualize the lower urinary tract and the truly revolutionary implications that this newfound and precious information allowed urologist and perhaps might have been the key technology that allowed the development of urology as a specialty. The first lighted examinations were external openings to the gastroenteral tract and the female introitus. Early Greek specula have been unearthed that record the foundations of primitive endoscopy. Early practitioners of medicine realized that to view a viscus from the inside should provide valuable information in the management of illnesses and applications were devised for their use in the urethra of both males and females [6]. But before advances in genitourinary medicine and surgery could proceed, the visualization of the lower urinary tract was essential and well recognized by the founding fathers. In Ramon Guiteras's founding remarks at the First Annual Meeting of the American Urological Association held in Saratoga, New York on June 13, 1902 he stated, "*The use of artificial illumination by means of tubes and reflected light was an important step in the advance of modern urology"* [7]. Guiteras continued with a very brief historical overview in the founding document of the A.U.A. It was an early American proponent of cystoscopy that we will next turn for the truly monumental role, then perceived by the cystoscope to come to an appreciation of how revolutionary it was to the nascent profession of urology.

Bransford Lewis was another of the primordial American urologists and the 4th President of the American Urological Association in 1907. His Presidential Address is most illuminating in the annals of the history of cystoscopy, ***The Dawn and Development of Urology*** [8]. This is worth reading from many historical perspectives, but we will focus upon the comments he made regarding Max Nitze first and then his longer comments that followed, "*…how shall I adequately express the esteem in which the father of cystoscopy, Max Nitze, is held? The one who did more than any other to pave the way to precision in urological diagnosis and therapy as they exist to-day"* [8]. Heady praise indeed, but he is just warming to the topic of the historical significance of cystoscopy. "*If there has been one reason to explain the substantial progress along broad and scientific lines that has been made by this department of medicine in late years, the cystoscope is the reason. It has transferred the study of urinary diseases from an inexact, intangible, shifting basis to one of definite and established proportions. Together with ureteral catheterization, the cystoscope has been the means of bringing within the definite diagnostic reach all of the upper urinary tract- the bladder, the ureters and kidneys. Through this instrument, the world is ours, now, for the taking. A world of diseases and disorders is now placed lucidly before us- conditions that have hitherto been inaccessible and remote, or even unrecognizable. This field has therefore been noted as one of speculation and argumentation, a diagnostic shuttle-cock, dancing from point to point in accordance with the strength or weakness of theoretical contention. It was the mind of Nitze that materialized to practical use the idea of direct inspection of the bladder; his hand guided the growth of this wonderful instrument from its infancy to its maturity; from the cumbersome and dimly-lighted mechanism of the early days to the graceful and effective instrument of the twentieth century; and, fortunately, he lived to see the fruition of his hopes, the world-wide recognition of his instrument, as a blessing to humanity, and its use in all civilized countries"* [8]. Now lest the perceptive reader believe that the cystoscope was the last word on the development of urology as a specialty, let's be thorough in the comments from Hugh Cabot, the 8th President of the A.U.A. just to temper the argument with a just rebuttal, "*The assistant who spends his days with his eye glued to the butt of a cystoscope would probably be admitted to be a specialist, and as such he has my deepest sympathy, for a specialist he must remain to the end, and that of the narrowest type"* [9]. Krotoszyer from San Francisco went even further in his address stating that "*The history of* *urology is best divided into two parts: the pre-cystoscopic and cystoscopic era"* [10]. Hugh Hampton Young was the 5th President of the American Urological Association and he was more enamored with the instruments that followed from the development of the cystoscope stating, "*Truly marvelous are the instruments which followed in steady succession*" [11]. He added that the people who are attracted to training as a urologist should also be interested in the equipment.

Now what is the purpose of all of this investigative knowledge that was pouring out of cystoscopist's findings? How would it make the difference in care and management of urinary troubles? Let's look at several early examples- one in females, one on general endoscopic potential and one from Leo Buerger, one of the founding fathers of American cystoscopy. A truly unheralded work was published in 1872 by a physician in New York City, Robert Newman entitled, *The Endoscope: Considered Particularly in Reference to Diseases of the Female Bladder and Urethra* [12]. He begins apologetically to his audience stating, "*I need not at the present time offer an apology for presenting to this honorable body the recent discovery of an instrument which, added to the repertoire of medical science, promises to be of incalculable benefit to a very large class of sufferers"* [12]. Here we have the allusion to the fact that urinary pathology is common and that people will have benefit from correct diagnoses. Newman waxes philosophical implications to urinary disease, "*…we must hail with enthusiastic welcome any aid by which the veil can be more and more lifted, or the obstacles further removed from a direct and palpable certainty in regard to our treatment of these classes of disease"* [12]. He then demonstrates the Desormeaux device which he utilized in seven cases, and presents the patients' symptoms in which it was used, the findings and therapies. He concludes by stating the obvious, that finding the true pathologic process absolutely relates to the physician's ability to treat it as follows, "*My opinion is not based upon theory, but upon evidence derived from close observation of clinical facts, and is valuable only as the result of careful investigation upon many cases, not only those occurring in my immediate practice, but in the greater field of inquiry and facilities afforded me by hospital practice"* [12].

The findings of cystoscopy were vigorously applied by early urologists. E. Hurry Fenwick was one such practitioner in London who was the President of the Section on Urology at the XVIIth International Medical Congress in 1914. *"With so many ardent disciples of Nitze, the symptomatology of diseases of the lower urinary tract has been entirely reconstructed. Facts have replaced unstable supposition. Each phase in the life-history of each vesical disease has been studied by means of the cystoscope and so accurately described that there are now few bladder or prostatic complaints- if we except those of nerve origin, which are not recognizable to the expert, merely on enumeration of their complexus of clinical features: but in most the final diagnosis is referred to the cystoscope for confirmation"* [13]. At the very same meeting, David Newman from Glasgow presented his findings with photographs of renal and vesical tuberculosis demonstrated by cystoscopy. Newman has several findings summarized as follows: "*(1) when the orifice of the ureter is strictly normal no serious disease exists in the corresponding kidney; (2) when the kidney is normal the orifice of the ureter is also normal; (3) when there is evidence of* *tuberculosis at the orifice of the ureter there is always associated with it tuberculosis of the corresponding kidney; (4) in tuberculosis of the bladder the ureter does not become involved if the corresponding kidney is free from disease"* [14]. His treatise was accompanied by 12 illustrations of the progression of tuberculous lesions by cystoscopy.

Leo Buerger was a prolific urologist at Mount Sinai Hospital in New York City and the major designer of what became the Brown-Buerger cystoscope by Wappler [15]. He wrote extensively about cystoscopy and urethroscopy which now described in many of the findings we take for granted today. In January, 1911 one of his articles discussed the normal and pathologic findings of the posterior urethra and bladder neck. He states, "*In the exposition of my subject I shall devote myself to the following thems: first, anatomical landmarks; second, elementary principles underlying the use of the instrument, and technic; third, the normal pictures of the neck of the bladder and urethra; and fourth, pathological lesions"* [16]. This work was followed by his *Cysto-urethroscopy. A Study of the Normal and Pathological Posterior Urethra* [17]. This was a major paper including 50 illustrated figures on the normal and abnormal urethra. He would later publish works correlating his cystoscopic findings with actual stained pathologic specimens showing clear correlation of anatomy and histology. Modern urologic interventions were on the threshold of achieving everything modern urology could accomplish. One final hallmark contribution cannot be overlooked prior to proceeding with this history, that is the work of the very controversial Abraham L. Wolbarst on his wax models of pathologic lesions in the male posterior urethra which were utilized in training and teaching [18]. Others of course, would develop simulators or phantom trainers that could be utilized to help the neophyte cystoscopist develop proficiency in handling the cystoscope [19].

Light Guides and the Urinary Tract

Vision and sight are humans' most dominant sense and particularly the sense that physicians utilize the most for discerning subtle signs of pathology. Light has long since fascinated mankind, but our ability to manipulate it and refine its intensity is a relatively late event. Sunlight was the dominant source up to and including the nineteenth century, but burning animal fats and vegetable oils were utilized. Since the beginnings of medicine as a profession the ability to utilize light to aid in diagnosis has been documented at least as soon as the Hippocratic period when the speculum was described. Most likely, the first instrument described for peering into the recesses of the human body was a rectal speculum. Hippocrates' treatise on fistulas clearly mentions this technique and later, Galen's *Levicom* refers to the catopter which is an anal speculum [20]. Long-fingered urethral specula were devised and utilized by the 16th and 17th centuries. The limitation only being the amount of sunlight that could be directed into the visual field, usually only for a few centimeters, but innovative urethroscopists devised reflecting mirrors to aid in visualization

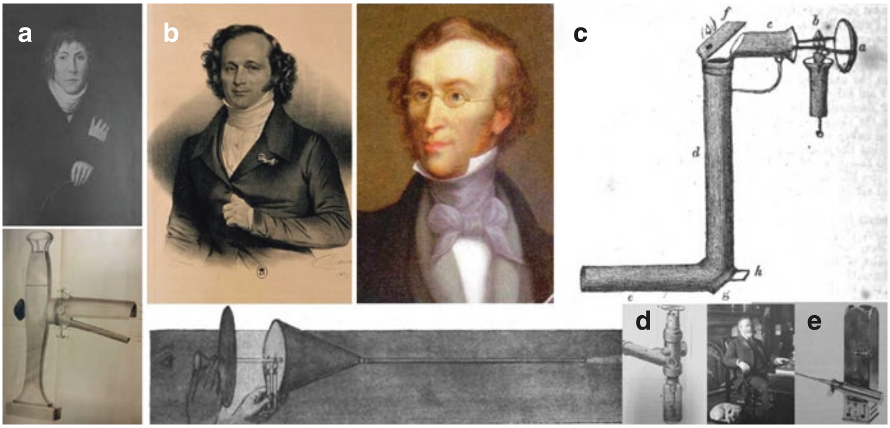

Fig. 2.1 The founding fathers of endoscopy. (**a**) Philipp Bozzini and his Lichtleiter, (**b**) Pierre Salamon Ségalas and his speculum urethra-cystique, (**c**) John Dix Fisher and his early American endoscope, (**d**) Antonin Jean Desormeaux's endoscope (**e**) Francis R. Cruise and his modified Desormeaux scope

which were then applied to general cystoscopes of the late nineteenth century. Bee's wax candles would work when finally mineral oils with additions such as turpentine added to the light intensity with the side-effect of more heat. Finally, heated platinum wires which produced incandescence were investigated following William Hyde Wollastan's breakthrough in isolating and purifying platinum in London almost single-handedly as well as devising methods for generating fine platinum wires [21, 22]. Julius Bruck, who was a dentist, picked up on the potential augmented illumination by the brilliance of incandescent platinum wires to visualize within body cavities, though these early prototypes required complex water-cooled irrigating systems [23]. In 1880 Thomas Edison presented his incandescent electric light bulb and the Scottish physician, David Newman in Glasgow placed and incandescent bulb in the distal end of a rather large cystoscope [24]. Charles Preston followed, an electrician from Rochester, New York devised a 'cold' low amperage mignon bulb in 1898 and Ferdinand Valentine in New York City devised an air-cystoscope that utilized these newest innovations [25].

Waxed candles and mirrors provided the illumination for the first endoscope. Phillip Bozzini (Germany) in 1805 constructed an instrument called "lichtleiter" for the viewing of the openings in the human body (Fig. 2.1a) [26]. Bozzini's insight into the potential for direct visualization of the body is as amazing as the harsh criticism of his peers regarding his endoscopic adventures utilizing his device. Bozzini's light guide consisted of a housing in which a candle was placed. Open tubes of various sizes and configurations could be placed on one side [27]. He then devised a reflecting mirror between the visual tract and the candle light, so that the light would be reflected only toward the targeted organ and not backward into the examiner's eye. The opposite side of the system was the eyepiece. He had published his results in 1806 and began to lecture in 1807 and even tried to have prospective studies of the instrument performed in military hospitals of the time [26, 27]. This development was remarkable in that it was the first use of reflected light as an illumination source. Unfortunately he was censured for his ingenuity since the intended use of the instrument was considered an unnatural act under contemporary mores. Bozzini died at the age of 35 after contracting typhus probably acquired during house calls [26].

In 1824 an ingenious physician in Boston, John Dix Fischer, almost replicated Bozzini's attempts with virtually the same outcomes (Fig. 2.1c). He published his only paper on his endoscope in 1827 as "an instrument for the illumination of dark cavities" [28]. He utilized higher illuminating burning oil as well as integrated telescopic lenses from a periscope. In his paper he even mentions that illumination with a galvanized wire might be possible (incandescence) [28] (Fig. 2.1b). Two years later, in Paris before the Academy of Sciences, Pierre Salomon Ségalas presented his 'urethrocystic speculum' for examination of the urethra and the bladder [29]. Daniel Colladon demonstrated light guiding at the University of Geneva in 1841 [30]. Total internal reflection of light made for a spectacular demonstration and this mechanism was quickly artificially simulated by fellow physicist, Auguste de la Rive using an electric arc light [3]. Jacques Babinet also took the method to use bent glass rods to examine difficult regions of the oral cavity in 1840 [3]. The Paris Opera began to use the same methods for spectacular stage effects in 1849 "*Elias et Mysis*" and again in 1853 for Gounod's *Faust* [3]. In England, John Avery also toyed with a version of a cystourethroscope and apparently Sir Henry Thompson was given a demonstration by 1840. Thompson stated, "*very little could be seen in the bladder.*" Other external illumination sources followed, however the next major innovation was to be the development of an independent light source that could be transported into the body cavity being inspected. Julius Bruck (Poland) in 1860 examined the mouth using illumination provided by a platinum wire loop heated by an electric current within a water jacket [23]. This was the first galvanic endoscope and preceded the invention of Edison's filament globe by 20 years. There were numerous other descriptions throughout the remainder of the late nineteenth century on open tube endoscopy procedures including Kussmaul's description of removal of a foreign body from the esophagus using reflected sunlight. Killian in 1898 employed a tube endoscope with illumination via a reflecting head mirror with the assistance of topical cocaine to inspect the bronchus [31].

Antonin Jean Desormeaux in 1867 developed "open tube" endoscopy for examination of the genitourinary tract and was the first to identify that lenses serve to condense the light source beam to a narrower brighter region that allows for more intricate observations [32] (Fig. 2.1d). He is considered by many to be the father of endoscopy because his work was so influential to the others that followed. In his popular book, he stated triumphantly "Nos quoque oculos eruditos habemus" [32]. Hacken in 1862 and Cruise in 1865 directly picked up the work of Desormeaux and began to investigate small modifications and improvements (Fig. 2.1e). Bevan in 1868 utilized such a device to remove foreign bodies in the esophagus using a ¾ inch diameter, 4 in. length tube with a reflecting mirror [6]. Waldenburg in 1870 lengthened these instruments and referred to them as "telescopes." Furstenheim in Berlin substituted gas for the petroleum light and Andrews then Stein utilized a magnesium light. In 1881, American entrepreneur William Wheeler developed a "light pipe" which he hoped to deliver light to every household, but the incandescent bulb would become his chief rival [3]. The International Health Exhibition held in South Kensington of 1884 displayed a giant "illuminated fountain" created by Sir Francis Bolton [3]. Stoerk in 1887 designed a right angled endoscope to allow greater manipulation away from the ocular [13]. In that same year, Charles Vernon Boys developed a method of creating small stretched almost pure silica fibers that could transmit light [6]. Rosenheim in 1895 employed a flexible rubber obturator for safer introduction and easier handling of endoscopes [6]. Kelling in 1897 designed a true flexible scope with small interdigitating metal rings covered by rubber on the outside [6].

Killian in 1898 first used cocaine anesthesia during bronchoscopy [31]. Nitze in 1879 pioneered the first modern endoscope for cystoscopy [33]. He worked with an optician (Beneche), an instrument maker (Leiter), and a dentist (Lesky) to create a 7 mm. deviating prismed endoscope with a liquid cooled glowing wire of platinum [34]. He followed this later with a separate light source, a miniature electric globe (Mignon Lampchen) [25]. In the United States, Otis designed a new cystoscope with telescopic lenses and a distal electric globe. The instrument maker for this scope was Reinhold Wappler (1900) and clearly became the premier optical system of that time. In 1936 Schindler worked with Wolf (an optical physicist) to design the first working flexible endoscope with steel spiral construction and 48 lenses [6]. As early as 1893, Albert Musehold described an apparatus to photograph the endoscopic appearance of the pharynx [35]. Nitze published the first photographic atlas of the pathology of the urinary bladder in 1893 [36]. On December 30, 1926 Clarence Weston Hansell, an RCA engineer wanted to view images from a distance using fiberoptic bundles [37]. Henning and Keihack published the first color photographic pictures of the stomach in 1938 (Rudolf Schindler developed a rigid, then a semi-rigid gastroscope and Heinrich Lamm tried to reproduce Hansell's findings with fiberoptics as a third year medical student using commercially available optical fiber) [38, 39]. Lejeune produced the first endoscopic motion pictures of the larynx in 1936.

Abraham Cornelius Sebastian van Heel noted that cladding improved the light transfer and image quality of fiberoptics and speculated that it could be used for cystoscopy in a letter he published in *Nature* [40]. Harold Horace Hopkins also published in the same volume of *Nature* with a young graduate student named Narinder S. Kapany, but their fibers were unclad [41]. Basil Hirschowitz (a physician) and Lawrence E. Curtiss (a physics student, later transferring to the American Cystoscope Makers, Inc.) working at the University of Michigan produced a fiberoptic gastroscope which was first tried on Hirschowitz and then presented at the annual meeting of the Optical Society of America in October 1956 in Lake Placid (site of the first digital televised sporting event using fiberoptics) [42]. Numerous modern advances have contributed to our modern arsenal of endoscopic equipment (fiber optic bundles, super-heated halide element light sources, electronic charged-coupled devices, CCD, and others) [43, 44]. The need to be able to visualize and eventually operate with tiny endoscopic manipulators is increasingly apparent [45].

Early Endoscopic Developments

Maximilian Carl-Fridrich Nitze (1848–1906) was a general practitioner who thought that if an instrument could be introduced with ease, minimal pain, and relative safety that the endoscopes must be smaller [34] (Fig. 2.2d). His idea was to place lenses into the tubes at prescribed distances to focus the image at an ocular. In addition, his early version used a platinum wire in a glass jacket with water cooling methods. He began clinical investigations with this cystoscope in 1877. By 1879, Nitze's design team was aware of Edison's invention of the filament globe and they immediately miniaturized it to fit into the tip of the cystoscopes [46]. But Nitze's reputation not only included his brilliance and dedication to the development of the cystoscope, he was also well known for his dark side, biting sarcasm and intolerance for any modifications that were not his own. In telling statements by Hugh Hampton Young, the fifth President of the A.U.A in 1908, "*And I decided to go to Berlin for study and experience. I spent two months at the clinic of Dr. Leopold Casper who had devised the most practical cystoscope for ureter catheterization. It was not difficult to learn to use his instrument, and I profited greatly by his lectures and the large number of cases I saw at his clinic. Nitze had devised a retrograde cystoscope with a complicated system of lenses and a mirror to look backward and view the neck of the bladder. He had never been successful, because the mirror became clouded. Working with a lensmaker, I constructed a four-sided prism with which we could replace Nitze's mirror. A cystoscope was constructed with a prism in place gave an excellent retrograde view of the bladder. Casper was delighted that I had been able to improve an instrument made by Nitze. When I proposed to take it to the father of cystoscopy, Casper said: 'Don't do it. He will insult you.' Nitze had broken with almost everyone with whom he worked. He brought lawsuits against Leiter, who constructed his first cystoscope, Hartwig who made several others for him, and Heinemann who had also worked with him. When Casper brought out his catheterizing cystoscope, Nitze had sued him for a large sum*" [47]. The first actual use of the Edison incandescent lamp for cystoscopic application was by Newman

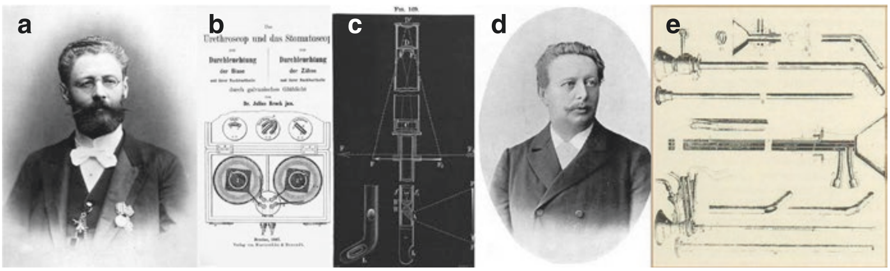

Fig. 2.2 Early modern cystoscopes. (**a**) Julius Bruck, (**b**) Bruck's modification of Wollaston's fine platinum wires for incandescense, (**c**) du Rocher's cystoscope, (**d**) Maximilian Carl-Friedrich Nitze, (**e**) Some of Nitze's first cystoscopes

(Glasgow, 1883), followed by Nitze (1887), Leiter (1887), and Dittel (1887) [25]. Modern methods of cystoscopic development and utilization would now follow the pathway to its current utilization in urology- the extension of the urologist, and now often times by physician-extenders as a diagnostic and therapeutic in everyday practice (Fig. 2.2e). Nitze stated, "*The writing presents only a framework, the complete construction of which will be accomplished over the course of years through the joint work of numerous researchers. We are dealing here with a large new field of work which assuredly harbors untold treasures of knowledge"* [46].

The modern instrument was now only steps away from both development as well as utilization and innumerable workers in the field of urology entered into a frenzied developmental cycle of creation and improvement utilizing now the major manufacturers of instruments in Germany, France, England and the United States. Just following the turn of the twentieth century urology as a specialty was ready for full fledged speciality status. Rapid advances in radiology improved upon the ability of X-rays to image the urinary tract. Listerian antiseptic methods of surgery allowed the virtual unlimited potential of surgery to intervene on the entire genito-urinary system. Anesthesia made tremendous strides for patient management during ever more complex surgical interventions. Now the full potential for the cystoscope was poised to bring the next phase to the complex pathway for the development of modern urology. We will utilize one relatively obscure hospital, not Johns Hopkins, to make this point about the potential of the cystoscope and its profound impact on the direction of urology- the Mount Sinai Hosptial in New York City [48]. This was originally the Jew's Hospital founded in 1852 on West 28th Street by Israel Moses and Alexander Mott. No coincidence was the fact that one of the early specialists in New York City, William Holme Van Buren married Mott's daughter and became one of the first urinary specialists at Bellvue Hospital where F. Tilden Brown would eventually emigrate. A dermatology/venereal disease clinic began at Mt. Sinai in 1890 with Sigmund Lustgarten and Hermann Goldenberg who became chief of urology, when this service was started in the Department of Surgery in 1895 [49]. William Fluhrer took the reigns after joining the Hospital in 1880. The chief of surgery was Howard Lilienthal, himself to bcome famous also practiced cystoscopy. George Brewer was the first to use rubber gloves in surgery in 1899 at Mt. Sinai. Hermann Goldenberg utilized the cystoscope to diagnose and treat urethral polyps [49]. F. Tilden Brown did his internship at Mount Sinai but Leo Buerger became the young urologist of note by 1908, considered the protégé of Emanuel Libman the premier clinician of his time in New York [50, 51]. Buerger developed his own modified cystoscope in 1908 and began extensive investigations and writing from this time onward [51]. Edwin Beer joined the team and developed a pediatric cystoscope in 1911 and then went on to become chief as well as develop new methods of treating bladde cancer by electrodessication and then resection [52, 53]. Maximillian Stern was appointed in 1910 and developed the Stern-McCarthy resectoscope by 1926. He was the Chief of Urology from 1911 to 1937 [54]. Moses Swick joined the house staff in 19924 after working in

Berlin on fellowship funds gifted by Libman to work in Berlin with von Lichtenberg and modern urinary tract radiology developed following the perfection of intravenous pyelography. By the time the Hospital upgraded its primitive cystoscopy suite in 1933, 1800 cystoscopies were performed annually [48]. In 1939 this increased to 2900. In 1935 the urology group was performing about 1000 transurethral prostate resections annually [15]. Modern urology had come into existance.

The Cystoscope

The role that cystoscopy was about to have can also be seen by reference again to Hugh Young, who describes the use of the cystoscope in clinical practice at Johns Hopkins, "*Before long the American Surgical Society met at the Johns Hopkins Hospital. I was invited to appear before the meeting in the amphitheater and to catheterize the ureters of a male patient. Dr. Howard A. Kelly was to do the same in a female. Kelly's patient, under deep anesthesia, was brought in; she was in the knee-chest position. He introduced his cystoscope, which was an open tube with external illumination from a head mirror, but without lens system. The bladder was distended with air; Dr. Kelly quickly inserted a catheter first up one ureter and then up the other amid the applause of the audience. I was nervous when I brought in my patient, who was not anesthetized. Introducing Casper's cystoscope, I too had little difficulty finding the ureters and promptly catheterized them. The audience had their watches out. The contest was close, and each of us required only two or three minutes*" [47].

Throughout this time, urologists have managed to extend the limits of visualized access to the recesses of the urinary tracts though early cystoscopes were expensive and did not give an adequate view (Fig. 2.3a). There have been improvements in optical imaging systems, both rod-lens and fiber optic. Illumination systems provided unprecedented color and brightness secondary to halide lamps. Minimization of the trauma of access is the result of smaller and smaller endoscopes. Finally, by moving the surgeon's eye away from the ocular, video camera

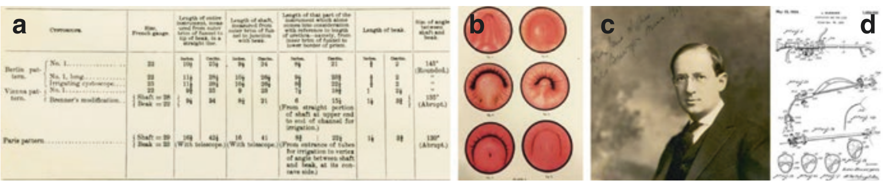

Fig. 2.3 First commercial cystoscopes. (**a**) Comparison from Willy Meyers chapter on "Cystoscopy" from Prince Morrow's textbook, *A System of Genito-Urinary Diseases* 1893, (**b**) Luy's colored illustration of cystoscopic view of the verumontanum, from *A Treatise on Cystoscopy and Urethroscopy*, C.V. Mosby, St. Louis 1918, (**c**) Leo Buerger from about 1934, (**d**) One of several of Buerger's patents for cystoscopes

systems allow the urologist the freedom to control complex endoscopic interventions. Electronics is now the key to many of these newer innovations. The charged coupled device was invented by George Smith and Willard Boyle at the Bell Laboratory on October 17, 1969 for electronic video recording. This was rapidly applied to fiber optic technology initially by Welch Allyn in 1983. Japanese makers Olympus, Fuji and Pentax all introduced video-endoscopy in the early 1980s [55]. The digital cystoscope that are now almost universally utilized by many modern urologists makes the performance of this task even easier on our patients. Though initially perceived as having a longer learning curve than rigid cystoscopy, the fact that skilled secondary medical providers are now capable of performing some routine cystoscopic tasks probably represents the future. Virtual reality cystoscopy is undoubtedly possible by newer imaging modalities, but the lower urinary tract remains complex and there is some distinct probability that some sort of direct imaging system might still need to be deployed for compete visualization for some time to come [56].

This has been a revised history of the cystoscope primarily focusing upon the technology itself and the impact that this technology has had upon the burgeoning field of urology. It would be fitting to conclude with a nearly forgotten saga that so typifies history, yet serves as the punctuation to conclude this tale as it involves one of the major players, Leo Buerger. As we have seen, the Mount Sinai Hospital in New York City, heralded some of the very first innovations in urology at the turn of the twentieth century [48, 51, 57] (Fig. 2.3c). Sarah Bernhardt was at the peak of her international reputation considered by many to be the first superstar diva of the modern era who bridged between the stage and early silent films. She was touring the U.S. when she became ill with obstructive pyohydronephrosis just following her appearance for the 4th of July festivities in New York City. Ms. Bernhardt was admitted to Mount Sinai under the care of Dr. Emanuel Libman, whose archives at the National Library of Medicine are indebted for maintaining the records of this specific encounter. Leo Buerger, the urologist was asked to see and evaluate the starlet and he proceeded to operate upon Ms. Bernhardt on Saturday July 14th and he recorded that a "*large amount of pus washed out from left kidney.*" Her vital signs during the ensuing post-cystoscopic period reflect that she remained unwell. She had five attending physicians including her own private French physician that met again on the evening of Tuesday, July 17th when her condition had become critical enough to warrant emergent open surgery. Buerger again records, "*Incision was made into the kidney and six ounces of foul smelling pus obtained. Large irregular calculus in the pelvis, which was removed.*" Her post-operative records revealed that her hospital vital signs showed rapid improvement. With no available antibiotics it is almost miraculous that she survived. She adopted Buerger's only daughter, Yvonne and as her godmother became close to Germaine Schnitzer, Buerger's wife. Of the five attending physicians who cared for Ms. Bernhardt, she kept in contact with both Buerger and Libman in her final years [58]. She was a dynamo of activity working on another silent movie in her final year, dying on March 26, 1923 in Paris. Dr. Buerger's life apparently fell to pieces following this surgery, becoming a footnote only in the history of urology.

Cystoscopy rapidly expanded with the development of newer and cheaper endoscopes in the arly part of the twentieth century as did the specialty of urology with rapid progression, in fact, this explosion of technology is quite complex to fully chronicle since so many investigators were involved [59] (Figs. 2.4 and 2.5). The cystoscope has changed to include both flexible cystourethroscopes as well as digital flexible cystourethroscopes. Already histories of these flexible cystoscopes are becoming rapidly antiquated by even more advanced technologies [60]. No longer does it appear necessary that the urologist be the person performing the cystoscopy, at least in non-complex situations [61]. Capsular endoscopy has also been developed for GI utility and it is probable that such technology can and will be adapted for cystoscopy in the future [62]. The ability of radiographic imaging to better visualize the lower urinary tract might also result in "virtual cystoscopy" [63].

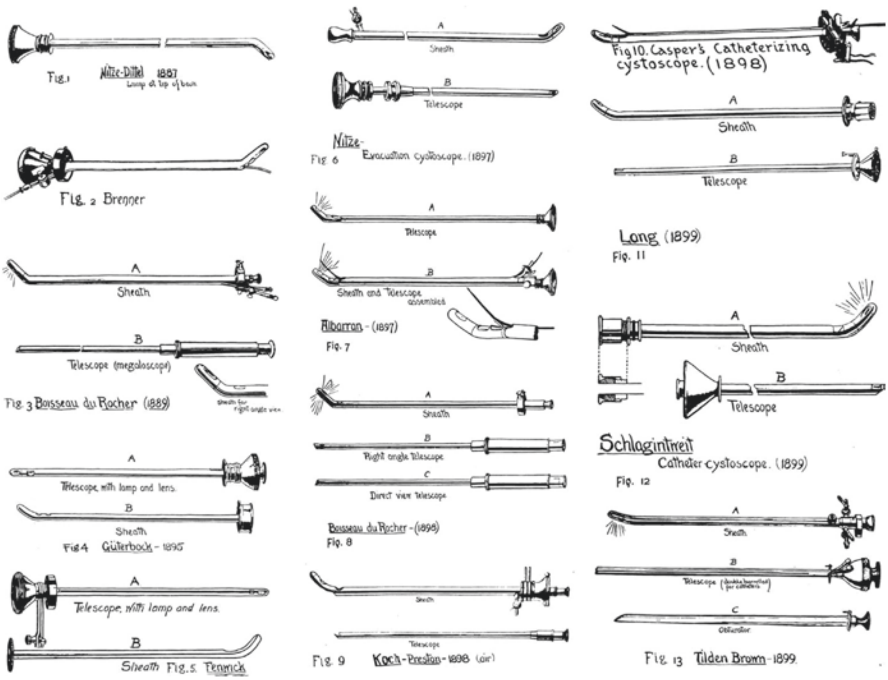

Fig. 2.4 Summary of modern cystoscopes via Bransford Lewis's ***Illustrated Résumé*** from his 1908 paper (Illustrations 1–13)

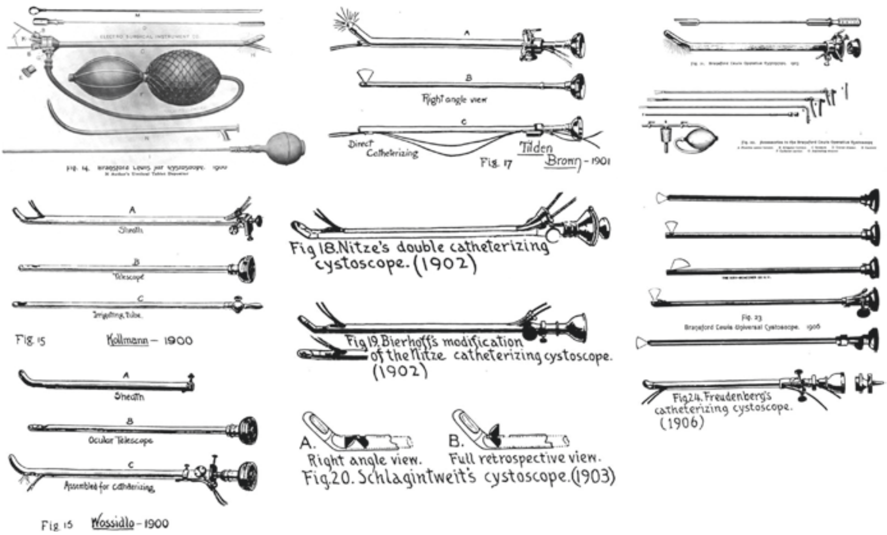

Fig. 2.5 Summary of modern cystoscopes via Bransford Lewis's ***Illustrated Résumé*** from his 1908 paper (Illustrations 14–24)

Bransford Lewis Tabulated History (Modified) [64]

1806	Philipp Bozzini of Frankfurt presents Lichtleiter to Josephine Academy
1824	John Dix Fisher wrote about his telescopic endoscope but it was published in 1827
1826	Pierre Salamon Ségalas presents his "Speculum urethra-cystique" to Academy of Sciences of France
1826	M. Bombolzini an illuminated speculum supposedly utilized on the urinary bladder
1853	Antonin J. Desormeaux- presented to Imperial Academy of Medicine in 1855 utilizing spirit lamp; first real descriptions of bladder pathology; published book in 1865
1862	August Haken- used dilation and direct vision scope in women's urethra and bladder, head mirror
1865	Francis R. Cruise utilizes a modification of Desormeaux's device
1867	E. Andrews modifies Desormeaux's device but uses magnesium wire incandescence for urethroscopy
1867	Julius Bruck- platinum-wire glow-lamp
1868	Philip Skinner Wales- publishes on endoscopy Figure 2.6c. and d.
1870	Furstenheim substituted combustion from gas to illuminate urethroscope
1872	Robert Newman- New York presented modifications and expanded series Figure 2.6a. and b.
1874–1876	Grünfeld- endoscopic inspection of bladder; introduction of ureteral catheter outside and along the endoscope, first successful endoscopic ureteral catheterization; external mirror illumination (rapidly modified by Steurer and then Klotz)
1875	Gustav Simon- first ureteral catheterization, "fishing method" via anatomical landmarks and touch
1876	Rutenberg, Vienna, used forced air-inflation for distension of bladder
1877	Maximilian Carl-Friedrich Nitze- first application of telescopic lenses for cystoscopes, uses Bruck's glow-lamp (incandescent platinum filament), wrote book on cystoscopy in 1889

1880	Dittel- applied glow-lamp to tip of beak
1883	David Newman- first to use incandescent lamp in cystoscopy
1885	Boisseau du Rocher- incandescent lamp with indirect-view with megaloscopic lenses
1886–1888	Karl Pawlik- air-distension, knee-chest cystoscopy in females and ureteral catheterization, external illumination
1887	Max Nitze- application of Edison bulb to two models of cystoscope, direct and indirect views with telescopic lenses, Lehrbuch der Kystokopie 1889
1887	Leiter- indirect-view telescopic lens cystoscope (similar to Nitze 1)
1887	Dittel- application of incandescent lamp to tip of beak, indirect view
1889	Alexander Brenner- addition of single ureteral catheter channel to Nitze's direct-view cystoscope (James Brown, 1st urologist at Johns Hopkins uses his scope to catheterize a male's ureter)
1889	Boisseau du Rocher- composite cystoscope; first of sheath-and-telescope plan; first to give synchronous double ureteral catheterization through two channels; two models for direct and indirect views
1891	F. Tilden Brown develops a bivalved-wire urethral speculum, indirect illumination (first a mirror then developed an electric light delivery system)
1891	W. K. Otis modifies Leiter and Nitze's instruments for urethroscopy, in 1892 calls it the 'perfected urethroscope"
1892	E. Hurry Fenwick also modifies Nitze device called aero-urethroscope
1893	Howard A. Kelly- air-distension, direct-view, similar to Pawlik's (complains that Nitze device though ideal for males is too "*elaborate, delicate and expensive for examining females*")
1894	Leopold Casper- first model of catheterizing cystoscope, indirect-view
1894	Friedrich Nitze- single tube ureter-catheterizing cystoscope, indirect-view
1895	Güterbock- sheath-and-telescope, both lamp and lens on telescope, indirect-view, non-catheterizing, irrigation through sheath
1896	E. Hurry Fenwick- sheath-and-telescope, both lamp and lens on telescope, indirect-view, non-catheterizing, irrigation through sheath, writes Electric Illumination of the Bladder and Urethra in 1904
1897	M. Nitze- evacuation cystoscope, sheath-and-telescope, indirect-view, non-catheterizing, free irrigation for evacuation through sheath
1897	Joaquin Albarrán- sheath-with-telescope, indirect-view, irrigation and ureteral catheterization, movable lever-system to direct catheter
1898	Boisseau du Rocher- improved 2nd system, multi-telescopes for direct and indirect views, irrigation
1898	Koch-Preston- cold lamp, air cystoscope, sheath and multiple telescopes, for direct and indirect-views, extra tube for ureteral catheter
1898	Leopold Casper- double catheterization cystoscope
1899	Lang- sheath-and-telescope, indirect-view, non-catheterizing
1899	Schlagintweit- evacuation, sheath-and-telescope, indirect view, non-catheterizing
1899	F. Tilden Brown- sheath-and-telescope, double catheter channel, direct view
1900	Bransford Lewis- air cystoscope, fixed ureter catheter channel (first single, then double)
1900	Kollmann- sheath-and-indirect telescope, irrigating, non-catheterizing
1900	Wossidlo- sheath-and-indirect telescope, double catheterizing, non-irrigating
1900	F. Tilden Brown- composite sheath, multiple telescopes, direct and right-angle view, double catheterizing, irrigation, lamp at tip of beak (Dittel's plan)
1902	M. Nitze- double catheterizing cystoscope

1902	Bierhoff- modified Nitze, sheath-and-scope
1903	Schlagintweit- retrograde cystoscope by movable lens, non-catheterizing
1903	Hugh H. Young- retroscpective fixed-prism cystoscope
1903	Bransford Lewis- operative air-distension cystoscope
1903	Le Für posterior urethroscope
1904	Kolischer-Schmidt- sheath-and-telescope, distal window, direct-view, double catheterizing using Casper's arrangement
1904	Follen Cabot- composite cystoscope, direct-view, double catheterizing, lamp on beak, irrigation
1904	Bransford Lewis- set globular-lens for retrospective view
1904	Baer- universal cystoscope, sheath-and-multiple telescopes, catherizing, irrigation, and operative features
1904	Freudenberg- direct-view double catheterizing (altered in 1906)
1904	Georges Luys- direct-view, air cystoscope for females only
1905	G. Luys- direct-view, air cystoscope for males, textbook A Treatise on Cystoscopy and Urethroscopy translated into English by Abraham Wolbarst in 1918
1905	Cathelin- direct-view air cystoscope
1905	W. K. Otis- sheath and close-fitting telescope, wide-angle indirect-view, non-catheterizing
1906	Goldschmidt irrigation cystoscope
1906	Bransford Lewis- universal cystoscope, sheath with multiple telescopes, double catheterization, irrigation, protected inverted lamp
1906	Freudenberg- seath-and-telescope, double catheterizing, irrigation, movable-cath lever
1907	Freudenberg- multiple sheaths, single telescope, indirect-view, non-catheterization, irrigation
1907	Kreissl- sheath, direct-view, double catheterizing
1909	Leo Buerger- modified Goldschmidt, Brenner and Brown's instruments and makes device with Reinhold Wappler (Wappler Electric Co, NYC) Brown-Buerger cystoscope

Fig. 2.6 Early cystoscopes. (**a**) Robert Newman's 1872 modification of Desormeaux's scope, (**b**) The Endoscopist, (**c**) General Philip Skinner Wales of Washington, DC, (**d**) The Wales cystoscope

References

1. Moran ME. The law of accelerating returns. J Endourol. 2006;20(6):1–8.
2. Bragg W. The universe of light. New York: Macmillan Co.; 1933.
3. Hecht J. City of lights: the story of fiber optics. New York: Oxford University Press; 1999.
4. Wales PS. Instrumental diagnosis. Med Surg Rep. 1868;18(18):377–81.
5. Kelly HA, Burnam CF. Diseases of the kidneys, ureters and bladder. New York: D Appleton & Co.; 1914.
6. Moran ME. In: Monga M, editor. History of ureteroscopy. Ureteroscopy: indications, instrumentation & technique. New York: Springer; 2013. p. 3–12.
7. Guiteras R. The evolution of urology. N Y Med J. 1902;76(15):617–22.
8. Lewis B. The dawn and development of urology. Trans Am Urol Assoc. 1907;1:9–19.
9. Cabot H. Is urology entitled to be regarded as a specialty? Trans Am Urol Assoc. 1911;5:1–20.
10. Krotoszyer M. Urology-past, present, and future. Am J Urol Sex. 1911;10:292–6.
11. Young HH. The Renaissance of urology. South Med J. 1916;9(2):146–53.
12. Newman D. Cystoscopic appearances of renal and vesical tuberculosis in the early stages demonstrated by the projectoscope. Am J Urol Vener Sex Dis. 1914;10(8):401–10.
13. Fenwick EH. Presidential address to the section on urology of the XVIIth international medical congress in London. Am J Urol Vener Sex Dis. 1914;10(8):355–68.
14. Newman R. The endoscope: considered particularly in reference to diseases of the female bladder and urethra. Albany: Weed, Parson & Co.; 1872.
15. Brendler H, Ferber WLF. Early days of urology at Mount Sinai. Urology. 1974;3(2):246–50.
16. Brueger L. The normal and pathological posterior urethra and neck of the bladder. Am J Urol Sex. 1911;7(2):1–10.
17. Buerger L. Cysto-urethroscopy. A study of the normal and pathological posterior urethra. Trans Am Urol Assoc. 1911;5:130–68.
18. Wolbarst AL. Demonstration of wax models of pathologic lesions observed in the posterior male urethra by means of the posterior urethroscope. Trans Am Urol Assoc. 1915;9:470–5.
19. Fenwick EH. A handbook of clinical electric-light cystoscopy. London: J&A Churchill; 1904.
20. Peters L. The evolution of modern cystoscopic instruments and methods. Am J Obstest Dis Women Child. 1906;54:486–501.
21. Wollaston WH. The Bakerian lecture: on a method of rendering platina malleable. Philos Trans R Soc Lond. 1829;119:1–8.
22. Wollaston WH. A method of drawing extremely fine wires. Proc R Soc Lond. 1800;1:455–6.
23. Bruck J. Das Urethroscop und StomatoscopDurchGalvanischesGluhlict. Breslau: Marushke and Berendt; 1867.
24. Newman D. Lectures to practitioners on the diseases of the kidney amenable to surgical treatment. Glasgow Med J 1883;131.
25. Moran ME. The light bulb, cystoscopy and Thomas Alva Edison. J Endourol. 2010;24(9):1395–7.
26. Figdor PP. Philip Bozzini: the beginnings of modern endoscopy. Tuttlingen: Verlag Endo-Press; 2002.
27. Bozzini P. Lichtleiter, eineEnfindungzurAuschschauunginnere Theiler und Krankheiten. J der PractischenArzneykunde und Wunderartzneykunst. 1806;24:107–24.
28. Fisher JD. Instruments for illuminating dark cavities. Phil J Med Phys Sci. 1827;14:409.
29. Segalas PR. Un moyend'eclairer 'uretre et la vessie de maniere a voirdansl'interieur de ces organs. Revue MedicaleFrancaise et de L'etrangere. 1827;1:157–8.
30. Colladon D. On the reflections of a ray of light inside a parabolic liquid stream. Comptes Rendus. 1842;15:800.
31. Killian G. ZurGeschicnte der Oesophago und Gastroskopie. Deutsche Zeitschrift fur Chirirgie. 1900;59:499–512.
32. Desmoreaux AJ. The endoscope and its application to the diagnosis and treatment of affections of the genitourinary passages. Chicago Medizinhist J. 1867;24:177–94.
33. Nitze M. Eineneue Beleuchtungs und Untersuchungs method fur Harnrohre, Harnblase, und Rektum. Wiener Med Wochen. 1879;24:649.

34. Nitze M. Beitragezur Endosckopie der mannlichen Hamblase. Arch fur KlinishceChirurgie. 1881;36:661–732.
35. Musehold A. Stroboskopische und Photographische Studien. Ann des Mal du Larynx Jan 1893.
36. Nitze MCF. Kystophotograpischer atlas. Wiesbaden: JF Bergmann; 1894.
37. Sircus W, Flisk E, Craigs Z. Milestones in the evolution of endoscopy: a short history. J R Coll Physicians Edinb. 2003;33:124–34.
38. Brittain JE. Scanning the past. Hansell, CW and Carter, PS. Proc IEEE 1996;84(4).
39. Henning N, Keilhack H. Die gezielteFarbenphotographie in der Magenhohle. Deutsche Med Wschr. 1938;64:1392–3.
40. van Heel ACS. A method of transporting optical images without aberrations. Nature. 1954;173:39.
41. Hopkins HH, Kapany NS. A flexible fiberscope, using static scanning. Nature. 1954;173:39–41.
42. Hirschowitz BI. A personal history of the fiberscope. Gastroenterology. 1970;36:864–7.
43. Kieser CW. Introduction of cold light endoscopy. Aktuelle Urol. 2008;39(2):130–4.
44. Vilardell F. Digestive endoscopy in the second millennium: from Lichleiter to endoscopy. Madrid: Thieme; 2006.
45. Lang P. Candles to computers: the story of minimally invasive procedures. UWOMJ. 2011;80(1):34–6.
46. Newell OK. The endoscopic instruments of Joseph Leiter of Vienna and the present development of endoscopy. Boston Med Surg J. 1887;117:528–30.
47. Young HH. A Surgeon's autobiography. New York: Harcourt, Brace & Co.; 1940.
48. Aufses AH Jr, Niss B. This house of noble deeds: the Mount Sinai hospital, 1852–2002. New York: New York Univ Press; 2002.
49. Lilienthal H. The Mount Sinai hospital and its surgeons of the middle eighties; a few recollections. J Mt Sinai. 1937;3:229–40.
50. Brown TH. The cystoscope and ureteral catheter in the diagnosis of surgical disease of the kidney and ureter. Med News. 1905;86:442–4.
51. Buerger L. A new indirect irrigating observation and double catheterizing cystoscope. Ann Surg. 1909;49:225–37.
52. Beer E. Cystoscopy and utereral catheterization in young children. Am J Surg. 1911;25:79–81.
53. Beer E. Removal of neoplasms of the urinary bladder: a new method, employing high-frequency (Oudin) current through a catheterizing cystoscope. JAMA. 1910;54:1768–9.
54. Stern M. Minor surgery of the prostate gland; a new cystoscopic instrument employing a current capable of operation in a water medium. Int J Med Surg. 1926;39:72–7.
55. Samplaski MK, Jones JS. Two centuries of cystoscopy: the development of imaging, instrumentation and synergistic technologies. BJU Int. 2008;103:154–8.
56. Schultheiss D, Machtens SA, Jonas U. Air cystoscopy: the history of an endoscopic technique fromt the late 19th century. BJU Int. 1999;83:571–7.
57. Buerger L. Intravesical diagnosis and treatment. N Y Med J. 1913;8:57–62.
58. Moran ME. Obstructive pyohydronephrosis and life saving intervention of the greatest starlet of all time- Sarah Bernhardt. Abstract presented at 2017 American Urological Association Annual Meeting, Boston.
59. Reuter MA, Reuter HJ. The development of the cystoscope. J Urol. 1998;159:638–40.
60. Radhakrishnan S, Dorkin TJ, Johnson P, Menezes P, Greene D. Nurse-led flexible cystoscopy: experience from one UK Centre. BJU Int. 2006;98(2):256–8.
61. Wuilleumier J, Point D, Fooks H, Zaslau S. The history of cystoscopy in urology. Internet J Urol. 2015;14(1):1–8.
62. Gomella LD. From the Lichleiter to capsule cystoscopy. Eur Urol. 2009;55:1034–6.
63. Karabacak OR, Cakmakci E, Ozturk U, Demirel F, Dilli A, Hekimoglu B, Altug U. Virtual cystoscopy: the evaluation of bladder lesions with computed tomographic virtual cystoscopy. Can Urol Assoc J. 2011;5(1):34–7.
64. Lewis B. Résumé of progress in the development of modern cystoscopes. Trans Am Urol Assoc. 1908;2:215–24.

Chapter 3
History of Optics in Endourology

Kimberly A. Maciolek and Sara L. Best

Optics is the branch of physics that studies the behavior and properties of light, including its interactions with matter and the construction of instruments to detect it. From its earliest days, physicians have found the urinary tract to be a tempting target for intervention since it lies so tantalizingly close to the surface and has a natural aperture. This accessibility allowed urologic procedures to be among the earliest attempted by practitioners, with interrogation of the bladder first occurring thousands of years ago. While lithotomists made their diagnosis based on history and the transurethral "sounding" of the bladder to identify bladder calculi, the actual surgery was traumatically transperineal as the technology to *see* in the urethra and bladder did not yet exist.

The birth of endoscopy, or the ability to see inside the human body, did not occur until the nineteenth century. Dr. Phillip Bozzini in 1806 points out that in the study of the internal workings of the human body, "it is necessary that (1) a sufficient amount of light be introduced; and (2) the light rays be reflected back to the eye" [1]. Thus Bozzini, the father of endoscopy, succinctly defines the "problem" facing the developers of technology. The rest of this chapter will describe the innovations developed to address these problems.

First-Generation Endoscopy: Extracorporeal Light Sources

Bozzini began designs for his "lichtleiter," translated to "guided light," in the early 1800s (Fig. 3.1). In his 1806 publication, Bozzini describes a "vase" containing a wax candle. The tube had two apertures, one through which the user could look and

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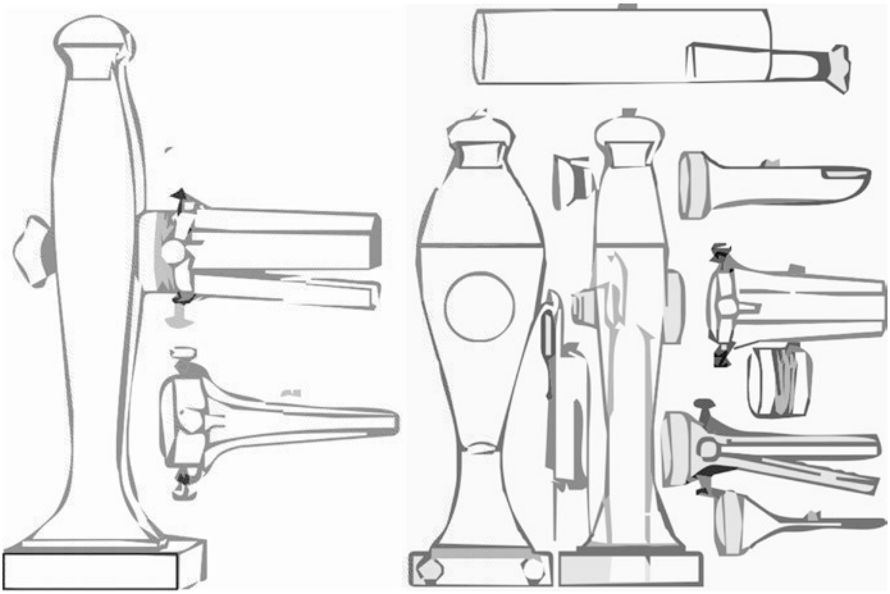

Fig. 3.1 Bozzini's Lichleiter with one aperture for the user and one for light conductors (By Philipp Bozzini (1773–1809) [Public domain], via Wikimedia Commons; By Countincr at en.wikipedia (Transferred from en.wikipedia) [Public domain], from Wikimedia Commons)

the other to which a variety of sizes of "light conductors" could be attached, some of which are strikingly similar to modern specula. The light would pass through the conductor into the target anatomy and allow the physician peering through the eyepiece to see inside [2, 3]. With this device, Bozzini successfully observed a stone within the bladder of a female cadaver. The litchtleiter, however, had limited urologic utility as it only allowed inspection of a small area of bladder mucosa and illumination was poor with weak extracorporeal lighting. Bozzini and the lichtleiter became the victim of medical politics of the day and his untimely death shortly thereafter left his invention forgotten. Despite this setback, future investigators would go on to find numerous ways to solve the bi-fold problem of endoscopy, namely to deliver light to the internal cavity and to return a useful image to the human eye [2, 3].

Decades would pass before the literature revealed new forays into the endoscopy problem. Two physicians, Pierre Salomon Segalas and John Fischer, are generally given credit for simultaneously and independently improving Bozzini's cystoscope. Segalas introduced his invention, the "urethro-cystique" in 1826, which incorporated a double lens system and mirror to improve the lighting and black coating on the viewing tube to reduce light scatter [4]. Fischer used the same principle as Segalas but used hollow tubing with two right-angled turns to form a Z-shape to visualize the urethra and bladder [5]. Like Bozzini's lichtleiter, Segalas and Fischer's inventions improved visualization but similarly failed to enable effective inspection of the bladder due to limited delivery of light.

The term ‘endoscope’ was coined in 1853 by French urologist Antonin Desormeaux. He reported the use of *gazogène* (a mixture of alcohol and turpentine) instead of a candle to illuminate his “l’endoscope” device based on Bozzini’s lichtleiter. This new light source provided a much brighter yet clearer flame than candlelight. He also adjusted the angle of his lenses to better focus the light, providing a clearer image [4]. Désormeaux used his device to perform the first endoscopic surgery, an endoscopic excision of a urethral papilloma, and is heralded as the “father of cystoscopy.” Unsurprisingly, the major complication of his procedure was burns [4]. Despite this improvement, Desormeaux’s endoscope was only able to inspect a very narrow field of view and still lacked sufficient illumination [6].

Second Generation Endoscopy: The Advent of Electricity, Intracorporeal Light Sources, and Increased Field of Vision

Advances in the techniques of illumination were intimately coupled with the discovery of electricity. Bozzini’s successors concentrated primarily on visualizing the urethra and bladder via speculum examination and an external light source. The next major breakthroughs came with German urologist Maximilian Nitze (Fig. 3.2). Nitze was uniquely credited with achieving a sweeping revolution in the diagnosis, treatment and photographic documentation via cystoscopy and is appropriately titled the father of modern urology [5, 7].

Nitze is credited with the first use of intracorporeal electric light sources. Aware of the limitations plaguing endoscopes of the time, Nitze is famously quoted stating that, “in order to light up a room one must carry the lamp inside” [7]. Nitze was inspired by the early works of Julius Bruck, a young dentist in Breslau, to overcome “insufficient illumination of objects” [8]. Bruck used incandescent platinum wires,

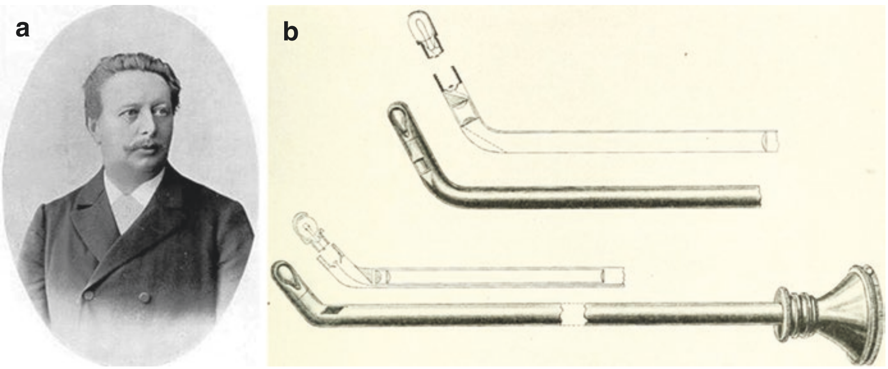

Fig. 3.2 (**a**) Maximilian Carl-Friedrich Nitze (1848–1906). (**b**) Prototype of Nitze’s cystoscope including the hot platinum filament at the tip (By Internet Archive Book Images [No restrictions], via Wikimedia Commons)