Beginning in the nineteenth century, technology made great inroads into the practice of medicine. During the 1800's, the medical practitioner could avail himself of many new instruments to aid him in his task: the stethoscope, the ophthalmoscope, the laryngoscope, the clinical thermometer, an improved microscope, and devices designed to administer inhalation anaesthesia. The culmination of the nineteenth-century medical technology boom was the development and employment of X-rays during the 1890's.

Historical analysis of medical technology may be generally classified into five categories. First, the practical or experimental approach centres on the use of historical instruments to determine their technical merits and limitations. Secondly, a more conventional approach is the catalogue of medical instruments. Thirdly, and perhaps most common, are technical narratives of specific instruments. What such works lack in historical interpretation, they usually make up in important technical detail. The fourth approach to medical technology may be termed the analytical or contextual method in which the medical apparatus, instruments or technology in general assumes a secondary role with the primary analysis concentrating on the effects that such devices had upon a particular institution, the medical profession or society at large. The final method may be called the integrated approach, blending the other categories.

Which method is best suited for discussing Canadian medical technology? The analytical/contextual approach might satisfy the purist historian,
but it must first be determined that there is an historical medical technology to place in some context, regardless of what that might be. This research is needed to ascertain the extent to which technology was a component of the Canadian medical scene, specifically during the nineteenth-century. The present analysis, therefore, resembles more the annotated, encyclopaedic catalogue approach to medical technology; the instruments however are, where possible, discussed in a broader medical historical framework. This paper focuses on medical apparatus that was either designed or built in Canada.

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In an era when most physicians compounded their own prescriptions, it is not surprising that specialized pharmaceutical devices were invented. One piece of equipment designed by Joseph J. Lancaster was basically an egg-beater mechanism in which the beaters had been replaced by a pestle, thereby allowing the operator to manufacture powdered drugs by pulverizing gross plant or animal materials. Such a process of trituration was common practice among both homoeopathic and allopathic (that is, "regular") practitioners. Lancaster himself was a successful homoeopathic physician who practised in London, Ontario.6

Another instrument was the "Uterine Medicator" designed by Emily Amelia Tefft, a Toronto physician who patented the device in 1878. It consisted of a two-piece syringe that permitted various fluids to be injected intra-vaginally; no further information is available about the uterine medicator, but one may speculate that the syringe was used in conjunction with a pessary to avoid conception. By injecting, for example, a fluid mixture of cocoa butter, and boric and tannic acids, into the vagina, a contraceptive douche could be prepared. It was considered distasteful, and later it became illegal, to advertise any article intended for preventing conception or causing abortion. Commercial
retailers, druggists and their women clients would quickly perceive the possible true function of the uterine meditator.\textsuperscript{7}

John Brown of Kingston and Chandos Hoskyns of Montreal both felt sufficiently proud and protective of their improved trusses to patent them. Brown claimed in his 1843 patent that his improvement in truss construction resulted from the use of much "soft material" thus obviating the problem of chafed skin for the truss wearer. Such was also the justification for Hoskyns' improved hernia truss of 1845; this truss consisted of an assembly of sliding plates, springs and adjustable screws thus allowing the front support pad "to range to any point within a given circle, either in a perpendicular, horizontal or oblique direction...".\textsuperscript{8}

A Montreal machinist named Midgley, described his "Improved Accoucheur's Assistant" as an invention of a "simple nature," the "great and principle object" of which was to "enable doctors, midwives, and others to confine females in a sitting position". Despite the inventor's claim that the device was a simple one, it consisted of an array of elastic straps and pads that transversed the woman's neck, continued over her shoulders, ran around the small of her back, went around each knee and finally were fastened with buckles on the sole of each foot! Midgley noted optimistically in his 1849 patent description that:

When the instrument or article is fitted on . . . the patient, by pressing forward the knees on the pads, will have the stomach or front part thrown forward by the pad fixed at the small of the back, and which said pad at the same time will act as a support to the back, and thereby add considerably to the ease of the patient and alleviate immensely her suffering.\textsuperscript{9}

An analysis of Midgley's supporter reveals that the only part of the pregnant woman's body not in contact with the device was her hands; such was not the case, however, with John Lloyd's "improved" obstetrical supporter of 1850. In his invention, Lloyd, a Toronto "gentleman", added
hand loops which were connected to the knee loops. Presumably, this modification was intended to alleviate further the sufferings of mothers-to-be.\(^{10}\) A patented variation of Lloyd's supporter was announced in 1854 by Ralph Hoyt. Hoyt incorporated a series of pullies that connected the knee and feet straps, all of which could be "seized by the hands of the user" thereby enabling the pressure of the back pad to be adjusted without the woman having to change the position of her body, legs or feet.\(^{11}\) There can be little doubt that these obstetric aids were designed and probably built in good faith by their inventors, but one wonders perhaps if such equipment was well received by potential users.

Perhaps of greater utility was another device that attracted the attention of Canadian inventors: the elevating bedstead. Within three years two Canada West residents patented beds to accommodate the needs of the sick or wounded or those who cared for them. In 1851, Joseph Watson, a Norwich Township engineer, described a four-poster bed in which the frame and mattress were constructed in three pieces. These elements were connected to the remainder of the bed by numerous cords and rings which in turn, connected to a roller and crank. Watson's engineering facilitated greater patient comfort and mobility by allowing the bed-ridden to be raised to a sitting position as well as to various other positions by merely turning the crank handle. An additional feature was the incorporation of a hole in the mattress and frame "for the purpose of placing under it a chamber utensil".\(^{12}\) The other bedstead, devised by Jacob Forbes of Haldimand Township, was similar in function, but used cogs and shafts, rather than cords and rings, to raise and lower the mattress.\(^{13}\)

Of the nine pieces of equipment discussed, none can be said to be "high-tech" in construction or function. However, examples of more sophisticated medical instruments are afforded by optical and by electrical appliances. The latter half of the nineteenth century saw the microscope mature into a vital research tool and useful diagnostic aid as well as a
necessary ornament for any gentleman's drawing room. As early as 1846, Dr. Archibald Hall of Montreal used a microscope to detect blood stains on clothing during a murder trial. In that year also Dr. Robert L. MacDonnell of Montreal, acquainted his professional colleagues with the fact that for "some years" he had been "almost in the daily habit" of using his microscope to analyze the urine in cases of suspected diseases of the urinary tract. It would appear, however, that practitioners who wished to purchase an instrument could not readily do so in Canada. An announcement in the Medical Chronicle of 1855, for example, informed its readers that those who required microscopes would be "glad to learn" that they could be purchased from an American company located in Illinois. Thus even by the mid-1850's, there was no domestic supplier or manufacturer of microscopes in Canada. However, during the later period, the Toronto optician, Charles Potter, is believed to have constructed his own microscopes.14

Mention may be made here of Patrick Freeland's "Traversing stage", designed to be attached to a microscope. Freeland was a lawyer and Registrar for the University of Toronto, as well as Recording Secretary of the Royal Canadian Institute.15 It was to the Institute that he delivered a paper in 1857 on the design of his stage.16 Freeland emphasized that easy mobility of the stage plate in every direction was of great importance; to this end, several microscope manufacturers had designed mechanisms whereby a transverse motion could be achieved. Such devices, according to Freeland, were cumbersome and liable to "get out of order"; if a diagonal motion of the stage was required, such could only be achieved by using both hands, when it would not be possible to focus the microscope. To overcome these problems, Freeland had a stage built which, he claimed, possessed three advantages: ease of access by the operator; ease of use with only one hand; simplicity in design resulting in ease of maintenance. In essence, the utility lay in his use of a single lever placed under the stage, running the length of it. One end
of this lever, attached to the stage, acted as a fulcrum; by moving the lever, longitudinal motion of the stage was achieved. Located at the other end was a milled wheel which, when turned, allowed transverse motion of the stage (through an intermediate worm and roller mechanism). Finally, through the simultaneous action of the lever and the milled wheel, which required only one hand, a diagonal motion could be produced.

It is of significance that a lawyer and university administrator such as Freeland was interested in scientific matters. Moreover, unlike the other inventors discussed so far, Freeland made no attempt to patent or derive financial benefit from his device. Indeed, Freeland made every attempt to acquaint others with the details of his stage.

Another example of free exposure of an idea is afforded by the work of A.M. Rosebrugh and his photographic ophthalmoscope. Abner Mulholland Rosebrugh graduated M.D. from Victoria University, Toronto, in 1859; he practised and specialized in ophthalmology and later the therapeutic use of electricity. He was a member of the Royal Canadian Institute where he delivered a paper on the ophthalmoscope and the camera. The novelty of Rosebrugh's 1864 presentation is underscored by his inclusion of extensive background information. Following details of optical theory, Rosebrugh noted that a "camera" was a "darkened box . . . containing one or more convex lenses . . . "; the ground glass screen near the back of the camera could be replaced by a "sensitized" glass plate:

... prepared by the ordinary collodion process. An 'exposure' of about 5 seconds is sufficient. If the 'developing' proves that a good 'negative' has been obtained, it is 'fixed', and used for printing the photographs . . .

Rosebrugh then discussed the ophthalmoscope, an instrument for examining the interior surface of the eye. The original ophthalmoscope was invented in 1851 by Helmholtz; Liebreich's modification soon became the choice of medical practitioners. Rosebrugh's ophthalmoscope was based on this design. It comprised an external light source; a metallic mirror with a
diameter of 1-1/4" and a focal length of 6", which was perforated at its centre with a sight hole of 1/6" diameter; and a double-convex lens with a focal length of 2". The rays of light from the source would be reflected off the parabolic mirror, pass through the convex lens and thus enter the eye, illuminating the fundus, which would then be viewed by the observer through the hole in the mirror. The real ingenuity of Roseburgh, however, lay in his combining of the camera and the ophthalmoscope to produce Canada's first fundus camera:

As yet I have not attempted a photograph of the retina of the human eye, but have confined my experiments to the lower animals, and I have used solar light only in order to shorten the time as much as possible . . . . In photographing the eye of a cat, I found it necessary to put it under the influence of chloroform, but the image of the optic nerve, vessels, etc., upon the ground glass is so very bright and clear that I do not doubt if the most sensitive process be adopted, the impression could be taken instantaneously, thus rendering anaesthesia unnecessary.

Rosebrugh reported the results obtained from his animal subjects:

When the instrument is in its proper position, and the light from the plate glass enters the dilated pupil, the fundus of the eye is brilliantly illuminated, and its reflection passes out of the eye and through the plate glass and lenses, and forms an inverted image upon the ground glass at the back of the camera, where the observer in the rear can see the optic nerve entrance, distribution of the arteries and veins, beautifully depicted, but magnified about 4 diameters. If the details of the image are not perfectly defined, the camera tube is moved backward and forward until the proper focus is obtained.

The manufacturer of this optical device was the Toronto optician, Charles Potter of King Street, from whom the instrument package could be purchased for $10.00.

In sum, Rosebrugh claimed six advantages for his photographic ophthalmoscope, the first of which was its simplicity of construction. The second and third assets centred on the ease of using the equipment. Fourthly, the image of a healthy or diseased fundus could be viewed simultaneously by medical teacher and student. Related to this pedagogic
advantage was another in that artists would be able to prepare "coloured diagrams of the internal eye". Finally, Rosebrugh had demonstrated that detailed photographs of the fundus of the eye could be taken with little difficulty. In his conclusion, Rosebrugh made an enthusiastic plea to his medical colleagues to adopt freely the use of this instrument; it is "even more essential than the Stethoscope".

Thirty years later, in 1896, a wholly new era of medical technology developed through the fusion of photography with electricity. The discovery of X-rays excited scientists and physicians alike, and both groups experimented with the "new photography". In Canada too, practitioners marvelled at the inner body structures revealed by X-rays. Typically, the equipment used by these men were machines of their own making. For example, in early February 1896, John Cox, Professor of Physics in McGill University, and Dr. Robert Kirkpatrick of the Montreal General Hospital, using pieces from the "splendid McDonald collection of apparatus", assembled a complete X-ray machine that allowed them to photograph the bone structure of the hand; these photographs were later displayed to the Montreal Medico-Chirurgical Society. 19

Similarly, Dr. Robert Wilson prepared "radiographs" on equipment that he had constructed; he also exhibited his equipment to the Montreal Medico-Chirurgical Society. Wilson included in his X-ray apparatus a Toepler-Holtz static machine, built by himself:

The two revolving plates of 1/8 in. hard rubber, were 18 ins. in diameter, with six German-silver sectors on the front one. The machine was cased in, containing a tray with 2 lbs. calcium chloride, well dried. The necessary speed (500 to 900 revolutions) was easily obtained by a . . . small waterwheel [operated] from the office water tap. The machine was not intended to compete with a large coil, but gave, with an Edison "medium" high vacuum focus tube, perfect definition of the bones of the extremities, up to the shoulder and pelvis.

Wilson's X-ray machine also included a "home-made" 6" by 8" calcium
tungstate fluoroscope. Wilson commented that the whole apparatus cost $25, but a "similar outfit could be placed on the market for $50". Wilson might have had plans to manufacture Canadian-made X-ray outfits; however, nothing more appears to have come of his idea.²⁰

In Ontario too, X-ray equipment was being built. The University of Toronto's team of J.C. McLennan, C.H.C. Wright and J. Keele demonstrated the properties of cathode rays using a combination of an induction coil and Crookes tube.²¹ Dr. Frank Price, a Toronto dentist, constructed his own X-ray outfit; later he also devised protective clothing for X-ray operators, such as aprons made of a rubber-lead mixture.²²

Evidence of indigenous medical technology may also be found in other electrical appliances. The relationship between electricity and medicine has been, for the most part, a curious one. The accepted theory of one generation becomes the anathema of the next. While some might consider physicians employing electricity to be valiant experimentalists hoping to relieve suffering, others might say that they were dupes caught up in a medical fad, subjecting their patients to cruel and useless treatment. Regardless of the merit of electro-therapy, Canadians were aware of this field and did contribute to its technology.²³

The first truly Canadian electro-medical device appears to have been a portable battery built and patented by a London, Canada West, resident named Palmer. The most complete description of Palmer's device is available in the British American Journal (BAJ),²⁴ whose editor described the battery as "exceedingly simple in its construction" consisting of forty-two or more tubes which could be "put into action" by dampening them with dilute acetic acid or weak saline solution. The purpose of this battery was the "transmitting through any portion of the body a continuous stream of galvanism" — a task which it appeared to perform admirably, for the BAJ editor further remarked that:

The current thus evolved is continuous and unremitting, and when
the little battery is enclosed in its card case, it will continue
to generate the excitement for a considerable time without redamping
. . . The current possesses sufficient force to overcome the resistance
of the bodies of six or more persons in contact . . .

This device was cheap ($6-$8); it was small enough to fit in a waistcoat
pocket, a "striking contrast with the cumbersome and troublesome intermittent-
current batteries" then in common use. Moreover, the intensity of the
current could be varied, thus accommodating different therapeutic needs.
For example, using moist sponges as electrodes, it produced a sensation
"by no means unpleasant". Similarly:

By placing the silver points, which accompany also the instrument,
upon the skin previously dried by a little powdered rice, a slight
amount of irritation is at once induced. A higher amount of irritation
may be caused by previously breathing upon the skin; while damping
the part with the salt water, the most intense pain is at once
perceived, amounting in a few moments to actual vesication.

Thomas J. Hayes, Resident Medical Officer of the Toronto General Hospital,
attested to the fact that he had used Palmer's battery on several patients
with satisfactory results. He cited the case of a female patient who
was in a "state of high nervous excitement" but who became perfectly
calm after five minutes' treatment, and within fifteen, fell into a
quiet sleep.25 Similarly, Dr. Robert Craik of the Montreal General
Hospital reported that he used the battery in several "painful cases"
and had "no hesitation in declaring the beneficial effect to be more
rapid and complete than after any of the methods formerly in use".
Craik described how a woman, suffering from severe muscular pain in the
right arm and shoulder, could move her arm freely after five minutes' 
treatment; after forty-eight hours, she suffered no pain at all.26 The
most informative testimony came from Dr. William Hingston of the
St. Patrick's Hospital, also in Montreal.27 Hingston reported details of
five cases where electricity had been used therapeutically. Typical of
Hingston's comments are the following:
[9th May 1861]

No. 29 ... severe pain in epigastric region .... Needles were applied to seat of pain, and sponge saturated with salt water in hand. Vesication in 1-1/2 minutes, with great relief. 10th still feels better.

No. 71 ... Painful affection of the limbs of many months duration. Positive pole to hand, and needles to lumbar plexus, continued for two minutes. Expresses herself much relieved and desires a repetition. Negative transferred to cervical region, and pain long felt in left arm is relieved. Says she has not felt so well for months. 10th less free from pain than yesterday, yet feels much easier than before the use of the battery. Repeated again to-day, but although polar current was continuous, the quantity was not so great.

It was evident that electro-therapy was employed in cases of neuralgic and muscular disorders; the voltaic therapy did appear to be successful. However, there were exceptions: Hingston, for example, reported that electro-voltaic treatment proved ineffectual in the following case:

No. 69 ... Suppression of the menses for eight years in a plethoric but hysterical girl. Positive by means of a sponge isolated in a glass tube to uterus, and negative to cervical region. 10th. Great pain in lumbar region. Repeated on 11th with increase of pain.

It is clear that this mode of therapy could increase patient discomfort, and also that treatment was not limited to external application but might include electrical stimulation of internal organs as well.

Another use of batteries in mid-nineteenth century medicine was the attempted revival of unconscious patients. As early as 1774, electricity had been used to resuscitate "persons seemingly dead" but such use was not widespread. With the introduction of inhalation anaesthesia in the 1840's and the problem of some patients failing to regain consciousness, the need to have a convenient and effective means to stimulate the patient became evident. From the 1850's on, Canadian, as well as European, hospitals were equipped with appropriate electrical devices. 28

Generally speaking, Canadian doctors did not adopt electrical treatments. There were, however, some notable exceptions. It will be
recalled that Rosebrugh had designed an ophthalmoscope-camera combination—twenty years later he still displayed an interest in medical gadgetry. During the 1880's, Rosebrugh styled himself a consultant in electrolytic and electro-therapeutic apparatus, and published several articles, and a book (A Handbook of Medical Electricity, 1885), on the uses of electricity in medicine. Furthermore, Rosebrugh designed at least one piece of electro-medical apparatus: a modified, portable galvanic-faradic battery. 29

Unlike Palmer's battery, Rosebrugh's came housed in a large wooden cabinet; but it possessed two advantages: it was simple to use and cleaner in its operation, and thus ideally suited to physicians who did not wish to become "practical electricians". Briefly, this new battery incorporated a design feature that obviated a problem common to earlier batteries, viz., the dripping and spattering of acid solution. The battery could, moreover, be engaged without the time-consuming task of connecting each of the cells by a series of bolts and screws. Rosebrugh's innovation made this process "automatic": simply opening or closing the cabinet activated the battery.

Other notable practitioners of electro-medicine were Drs. Jennie Trout and Amelia Tefft who operated the Therapeutic and Electrical Institute on Jarvis Street in Toronto. Both Trout and Tefft graduated from the Women's Medical College of Philadelphia in 1875, and from 1877 until 1882 they offered "treatment to ladies by galvanic bath or electricity" at the Institute. Patients would be treated for chlorosis, depression, asthenia, as well as other Victorian gynaecological disorders. 31

Surgery was another area where there were technical innovations. Although many are trivial, some items show originality of thought and ingenuity of design. Mention should be made first of an artificial leg manufactured by a Kemptville resident named Condell. In praising this prosthetic, the editor of an 1856 issue of the Medical Chronicle remarked on its strength, lightness, convenience, good workmanship, and reasonable cost. He drew attention to the fact that Condell was a Canadian, and
deserved every encouragement in his venture of manufacturing these devices for amputees. And, a McGill lecturer, Dr. J. Crawford, devised an aid for those who suffered broken collar bones or fractured arms. His orthopaedic brace was constructed so that the positioning of the arm relative to the shoulder and abdomen allowed greater patient comfort, while it reduced the chances of subsequent deformity.\textsuperscript{32}

Probably the most interesting area of surgical invention in Canada during the nineteenth-century was anaesthetic inhalers. These devices ranged from improvised articles to specialized manufactured items. The first successful inhalation anaesthetic agent, sulphuric ether (diethyl ether) was introduced in 1846; by early 1847, several Canadian physicians had used the agent and extolled its virtues. One such practitioner was E.D. Worthington of Sherbrooke, C.E., who not only performed one of the earliest operations in Canada while his patient was anaesthetized, but who also devised one of the most curious pieces of Canadian medical technology. Some practitioners administered ether by dropping a few drops onto a sponge from which the patient then inhaled, but Worthington built his own inhaler which he described as:

A large ox-bladder, with a stop-cock attached, a mouth-piece, made of thick leather, covered with black silk and well padded around the edges, with a connecting long brass tube that had done service as an umbrella handle in many a shower, formed an apparatus that, though rude looking, and bearing marks of having been got up in haste, presented withal a very business-like and, for the country tolerably professional appearance.\textsuperscript{33}

Having constructed his device, Worthington then devised the following operative plan:

A couple of ounces of ether were poured into the bladder, which was then filled with air from a bellows. Not having time or ingenuity sufficient to construct a double valve, the objection to inhaling carbonic acid gas again into the lungs was done away with, by simply allowing the patient, after a full inspiration from the bag, to expire through the nose, for three or four times, when the nostrils were kept closed, and the breathing confined to the bladder.
Clearly, Worthington’s inhaler was an improvised one, and in all likelihood his publication of its construction details was not done in an effort to persuade other doctors to adopt his design.

Only one year after the introduction of ether to Canada, it was largely replaced by another anaesthetic agent, chloroform. Chloroform was usually administered by the "ready method"; that is, a napkin or handkerchief was placed over the patient’s mouth and nose onto which the attending physician dripped chloroform until anaesthesia was achieved. But there were exceptions to this technique. For example, Dr. James Douglas of the Quebec Marine and Emigrant Hospital in Quebec City administered chloroform by pouring the anaesthetic agent onto some lint that was housed in a "funnel-shaped piece of lead, open at both ends". And a Dr. Steane of Lachine devised a similar inhaler made of morocco leather.

Such inhalers were highly personal creations of the doctors; there is no indication that these devices were to be manufactured and marketed to the medical profession at large. However, an anaesthetic device actually designed and built for production is an ether inhaler announced in 1887 in the Canada Lancet. It was manufactured by the Toronto firm of Stevens & Co., and comprised a japanned metal funnel facepiece and a removable cap at the end of the funnel which allowed the admission of air. The interior of the device was filled with horizontal strips of cotton bandage onto which the ether was dropped. According to the Canada Lancet article, this instrument had been used in the Toronto General Hospital for "some years"; its attributes were its low cost, portability, convenience and the fact that it would "effect considerable saving in the administration of ether".

The significance of the Stevens’ inhaler is two-fold. First, it is one of the few pieces of medical apparatus that was actually manufactured in Canada. Secondly, from a clinical point of view, the inhaler used ether rather than chloroform, the agent which had been the anaesthetic
of choice in Canada since 1848. Thus, this piece of equipment represents the change in anaesthetic methodology taking place in Canada during the 1880's: the re-emergence of ether as a popular anaesthetic agent. A major reason for the switch from chloroform to ether was that chloroform was blamed for several deaths. 37

The final class of medical equipment to be discussed relates to the respiratory system and its ailments. In an age of phthisis and consumption, coupled with the prevalent belief that impure and unwholesome air was an agent of disease, it is not surprising that several Canadian devices related to the lungs and breathing were invented. A ventilator, designed by Dr. Henry Howard, Physician-in-Charge of the St. John's Lunatic Asylum, was patented in both Canada and England. Howard actively sought recognition with a pamphlet outlining its operation. By all accounts the ventilator could be employed in both institutions and at home, for it was designed:

... to be placed in the upper part of windows and is so arranged as to admit air upwards and inwards vertically. Its advantages are the perfect distribution of pure air through all the rooms of a building, freedom from draught, and the absorption in the passage upwards of all impure gases, aqueous [sic] vapours, latent in the atmosphere; the former by a box of charcoal and the latter by a sponge conveniently arranged.

Howard's piece was well received at the time: a McGill professor of meteorology admired its mechanism on "scientific grounds", while an Inspector of Prisons gave it his "unqualified commendation." 38

While Howard's ventilator might well benefit several people in a room, the invention of the Toronto physician James Bovell was designed to address the respiratory needs of the individual. In effect, Bovell's "apparatus for the exhibition of vapour" was a portable humidifier:

As far as my own experience goes, I am impressed with the belief, that in this country much mischief results from neglecting the hygrometric condition of sick rooms; and in cases of pulmonary
disease, both acute and chronic, often leads to protracted if not uncertain convalescence. 39

Bovell acknowledged that inhalers were available but he found fault with them; they obliged the patient:

... to sit in a constrained position, or else to place his head over a vessel, generally covering the mouth with a bag or large tube for inhaling the vapour: in one case excluding too much air; in the other causing too much exertion.

Furthermore, with children it was "exceedingly difficult to induce them to submit to the restraint necessary to hold an inhaler over the mouth".

To obviate these problems, Bovell designed a simple, convenient apparatus, one that could be constructed by the "most ordinary workman". The resulting piece made by a Mr. Pyper of Yonge Street resembled a modern fondue cooker with an inclined tube emanating from the boiler and ending in a fan-jet tip:

... the tube is so arranged as to admit being placed at various inclinations, and may thus be easily accommodated to the position of the patient while in bed, or as he sits up, who, without the least effort, and remaining perfectly at ease, breathes the moist air surrounding him. The apparatus is placed on a table, for instance, by the bedside; the medicated or simple liquid is put into the boiler, and a small lamp set under; in a very short time a cloud of vapour issues from the fan of the tube, and is directed to the face of the patient.

The extent to which Bovell’s vapour apparatus was appreciated by Canadian invalids is unknown.

Unlike Bovell, who did not patent his inhaler, Mathieu Souvielle of Montreal, having devised an apparatus for "facilitating the use of medicated inhalation," was granted a patent for five years beginning in 1882. Details of Souvielle’s "spirometer" are scant. 40 The term "spirometer" is a misnomer because Souvielle’s apparatus had nothing to do with respiratory measurement.
There existed another class of respiratory apparatus which could be used, not therapeutically, but as an aid in diagnosing or assessing respiratory ailments. Two such pieces of equipment have been identified as originating from Canada. The first was the product of William E. Bowman, a Montreal physician and designer of a "cheap spirometer". Bowman's spirometer was a true respiratory measuring device able to determine lung capacity. The main advantages of Bowman's spirometer were its simplicity, low cost and ease of operation; indeed the mechanism comprised two tin cylindrical vessels, each capped at one end (one 20" by 6", the other 18" by 5"); and two to three feet of flexible tubing connected to a mouthpiece. Bowman's instructions for assembly of this equipment were as follows: the tubing was attached to the capped end of the smaller cylinder, which was then inserted into the larger cylinder which had previously been all but filled with water. Thus when a patient exhaled into the mouthpiece, he could cause the smaller cylinder to rise to a level roughly proportional to the volume of his lungs. A scale translated linear measurements into cubic capacity.

Bowman noted that he had had an English glass manufacturing company prepare a "beautiful" glass spirometer based on the plan just outlined, and although this model was more attractive than the tin vessel version, both achieved the same goal "in ascertaining the presence and progress of phthisis".

The final piece of indigenous medical technology to be discussed is in many respects the most interesting piece because of its originality, potential clinical significance and the fact that it was brought to the attention of an international audience. The apparatus, known as a pneometer, was invented in 1861 by a young McGill medical graduate, G.S. De Bonald. Unlike other Canadian physician-inventors, De Bonald sought recognition for his piece outside of the domestic medical community by exhibiting his pneometer at the Great Exhibition of London of 1862.
A London correspondent for the *British American Journal* reported that it was:

> carefully and minutely examined by the Jury of the Class to which it belongs, and whilst they acknowledged the ingenuity of the inventor, they could not see its general practicability, and hence no medal was awarded.\(^{42}\)

In another report, the *BAJ* correspondent informed his Canadian readers that De Bonald's pneometer:

> ... lies in a horizontal case, and looks like some philosophical instrument. It was well worthy of a medal for the ingenuity displayed in its construction, but I must acknowledge that its application to practice could never be so handy as some of the instruments in use, for estimating the vital capacity of the chest.\(^{43}\)

Fortunately, an analysis of the theory behind, and construction of, this instrument is available in De Bonald's McGill M.D. thesis: "On the Philosophy of Respiration and the Pneometer".\(^{44}\) The work is a combination of medicine and morals in which physiology and theology are intertwined. At the heart of the discussion was De Bonald's belief that as "Respiration is the origin of life and health, so it is also of disease and death". Hence, De Bonald continued, nearly all "the changes produced by a peculiar pathological condition of the body react on the respiration, and alter it more or less". Clearly then, if a physician could assess the respiratory performance of his patient, a great insight into the latter's state of health or disease could be gained. Other methods of evaluating lung capacity were criticized:

> the means hitherto adopted or employed for the purpose have afforded but uncertain results. To breathe into a hydraulic apparatus for the purpose of displacing a certain quantity of fluid [as in Bowman's spirometer], or to blow into a bladder whose capacity is afterwards to be estimated, were the means adopted to establish or prove the power of the lungs.

The air expired, in a natural or forced expiratory effort, differs so essentially from that which has been inspired, both in volume,
density and properties, that it is impossible to ascertain the volume of air inspired, by the mere appreciation of the quantity expired... 

For De Bonald, the "surest means" to determine lung capacity was the measurement of inspired air by carefully recording the three-dimensional movement of the chest upon the patient's intake of breath; this task was the function of the pneometer:

This dilatation of the lungs shows itself in three different directions: 1. in an antero-posterior one; 2. in a lateral one, and 3. in a vertical one. To determine with precision these three measurements, with the modifications which certain pathological conditions of the lungs may make them undergo, and especially pulmonary consumption... such the object which we think we have obtained in the invention of the Pneometer.

Using the pneometer, the patient lay on his back with a velvet-lined, metal collar around his neck; attached to this collar was a horizontal tube, which extended parallel to the patient's chest. This tube, known as the "Regulator" could move in three dimensions corresponding to those of chest expansion. It connected to another transverse tube which incorporated a spirit level. This tube also had three motions:

1. One which permits it to slide along the whole length of the Regulator, permitting it to be fixed at any point of this latter. 2. A movement round the axis of the Regulator, which enables it to enregister the most trifling differences in the antero-posterior expansion of either lung; and 3. A movement on its own pivot, capable of enregistering the difference in the relative vertical expansion of either side of the chest.

Suspended from the transverse spirit level was a series of movable discs which could be raised or lowered as a function of chest movement; this movement was recorded on gauges graduated in divisions of an inch.

To comprehend fully the action of the pneometer, in addition to its mechanism, one must also understand the computational theory behind it. The foundation of De Bonald's thought vis-à-vis his physiological mathematics were the following "laws" which were based on his own observations as
well as published medical sources; these were:

1. That the quantity of air respired governs the quantity of blood; 2. That the quantity of blood governs the weight, size and height of the body; 3. That every cubic inch of air respired represents very nearly a pound of blood; 4. That every pound of blood in the body, is equivalent to eight or ten pounds of weight of the body; and 5. That twenty-four pounds in weight of the body are about equivalent to an English foot in the height of the body.

The following example is cited by De Bonald: Say a patient had thoracic dimensions as follows: lateral = 3-1/2"; antero-posterior = 2-1/2"; and vertical = 2-1/4"; then the capacity of the chest would be 19-3/4 cubic inches. Applying his "laws", De Bonald then transmogrified this last figure to project that a man who inspired 19 cubic inches of air should have 19 pounds of blood and hence, weigh 152 pounds with a height of 5 feet 10 inches.

Unfortunately, for all De Bonald's effort and research the worth and reliability of his pneumometer can obviously be challenged on several grounds. First, an error in measuring a patient's chest dimensions might be multiplied by the necessary successive calculations. Secondly, De Bonald's "laws" are obviously overgeneralized. Finally, the processing of raw data is a potential source of error. In his example, De Bonald used the conversion factor of 8 lbs. body weight equivalent to 1 lb. of blood weight, thus arriving at a figure of 152 lbs. for the projected body weight. However, De Bonald suggested a range from 8 to 10 lbs. of body weight as being equivalent to 1 lb. of blood weight; thus in the example cited, the body could have varied by up to 40 lbs! Furthermore, in the calculation of projected body weight from the calculated weight, De Bonald stated a figure of 5 feet 10 inches, but using the McGill medical student's conversion factor (that is, 24 lbs. body weight per "English foot"), a height of 6 feet 4 inches should have been computed (152 lbs. ÷ 24 lbs/ft). Indeed, if one were to calculate the height from the upper limit of De Bonald's scale for body weight, one would
arrive at a projected height for the patient of almost 8 feet (190 - 24)! One is forced to agree with the judges of the London Exhibition who considered the instrument to be ingenious, but somewhat impracticable. It would, however, be an historical error to dismiss this instrument wholly for the pneometer was in the mainstream of nineteenth-century medicine. To diagnose lung ailments and measure lung capacity by mechanical means was a pursuit undertaken by many nineteenth-century doctors, the most notable being the English physician, John Hutchinson, who invented the "spirometer"; indeed there are many resonances between De Bonald's approach and the work of Hutchinson. Like Hutchinson, De Bonald was trying to devise a technique that would allow a "quantitative examination of the lung" through the recording of the patient's vital statistics (height, weight, vital capacity, and so on) with the ultimate goal being a "numerical portrait of the patient".45

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Most of the indigenous devices described were either modified versions of existing medical apparatus (trusses, vaporizers, and so on) or ad hoc appliances got up in haste to facilitate a specific clinical need (for example, Worthington's anaesthetic inhaler). Occasionally, however, apparatus appeared in Canada of such ingenuity and apparent novelty that they must be considered to be original inventions; examples of this class would include Palmer's voltaic battery, Rosebrugh's photographic-ophthalmoscope, and De Bonald's pneometer. Both professionals and laymen contributed to the medical technology of Canada: twelve physicians, one dentist, one lawyer, four scientists, three mechanics, and seven gentlemen put forward designs for medical devices. Of these categories, physicians were the most active single group, producing thirteen separate pieces of equipment. Although physicians were the most productive, only three patented their devices, while the general laymen and mechanics patented ten of the eleven devices. The physician perhaps saw it as his professional and moral duty to produce better
equipment; other non-professional groups saw invention as a path to financial gain.

Of the twenty-nine devices examined, only one was commercially produced (the Stevens' ether inhaler); the other devices were made by local artisans or by the inventors themselves. Thus, there is no evidence to suggest that any medical or scientific instrument industry existed in nineteenth-century Canada. Charles Potter, the Toronto optician who possibly built his own microscopes, as well as making selected electrical and optical devices for Dr. A.M. Rosebrugh, is a special case. By the nineteenth-century, both Europe and America had well-established medical and scientific instrument industries; thus any new Canadian venture into this field would face stiff competition from mature manufacturing ventures. In sum, economic importance of indigenous medical technology during the period studied amounted to naught.46

NOTES


Next to the microscope, the second most popular subject for the technical narrativist is the relationship between medicine and electricity. David C. Schecter's study in seven parts, with a running title of "Background of Clinical Cardiac Electrostimulation", appeared in the New York State Journal of Medicine (1971-72), Vol. 71, 2575-81; 2794-2805; Vol. 72, 270-84; 395-404; 605-19; 953-61; 1166-91.


12. Joseph Watson, Patent No. 308, ibid. Curiously, in May of 1877, a Pennsylvania resident, Charles T. Moore, patented an "Improvement in Invalid Bedsteads" (U.S. Patent No. 191,068). This bed also had a crankable roller mechanism that allowed the bed to be arranged in different positions (see Item 66, Catalogue E, *Tesseract* (New York: Fall 1983).


27. "Notes of Cases in Which Mr. Palmer's Voltaic Pocket Battery was Used at St. Patrick's Hospital, Under the Charge of Dr. Hingston, on 9th May, 1861," RAJ 2 (1861): 200-201.


42. "London Correspondence No. IX," British American Journal 3 (1862): 263-66; see p.266.


46. Certainly if one follows the example of J.J. Brown, this conclusion is justified. In answer to the question "What is an important invention?" Brown writes that it is one which makes millions of dollars annually and creates many new jobs. (Ideas in Exile: A History of Canadian Invention (Toronto: McClelland and Stewart, 1967), p.5).