The Distinguished History of Radiology at the University of Michigan

On the Occasion of the Centennial Celebration of the Discovery of X-rays

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To my beloved wife, Rhoda,
and our wonderful children,
Lisa, Pamela, Caryn, Jonathan and David.

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The Distinguished History of Radiology at the University of Michigan

As we celebrate the centennial of Roentgen's discovery of X-rays, it is appropriate to reflect on the events at the University of Michigan that arose from that discovery and on the significant influence the Department of Radiology subsequently had on the emergence of radiology as an important, scientific medical specialty. The University had notable "firsts" in medicine: it was among the first of the state-supported universities to have a medical school (1850), it had the first teaching hospital owned by a university (1869), and it had the first university department of roentgenology (1917). Given these circumstances, teaching and research were early priorities.

The Medical School and Hospital

Although the school's charters of 1817 and 1837 called for the establishment of a medical education curriculum, no action was taken until 1848 when the regents appropriated funds for the construction of a medical department building. The first students were enrolled in the medical school in October 1850 when the building was completed [1]. In those times a hospital experience was not part of the curriculum of American medical schools. In 1856 Michigan medical students were offered three months of clinical instruction at a Detroit hospital. Students were expected to gain practical experience during an apprenticeship with a "respectable physician."

In the ensuing years the faculty recognized that students could profit from systematic teaching in a hospital; however, there were no hospitals in Ann Arbor. This changed in 1869 when the University of Michigan built its own hospital. This was the first hospital in the United States owned and operated by a university [1] (Fig. 1); it was converted from a professor's home at a cost of $582. It had no operating or dressing rooms, and patients were treated at no expense. During the next several years, the hospital's bed capacity was increased from 20 to 60, and it became known as the Campus Pavilion Hospital. At this time there was considerable agitation by some faculty members who wanted to move the clinical years to larger clinical facilities in Detroit. This was strongly opposed by the University president, James B. Angell, who felt that it would lead to intellectual and administrative fragmentation of the university; he feared the loss of the advantages of a close association between the medical school faculty and the rest of the university. As a result, in 1891 this hospital was replaced by the larger Catherine Street Hospital, viewed then as the largest teaching hospital in the nation. This served the medical school well for many years, but in 1915 the faculty and regents recognized the need to expand their clinical facilities further to provide adequate instruction to medical students. The legislature endorsed the concept of a large new replacement hospital, but World War I caused planning to be postponed. It was a controversial project because some felt there would be insufficient patients brought to Ann Arbor to fill its beds.

Fig. 1. The nation's first university hospital [1]. At the right is one of the original campus faculty homes on North University Avenue opposite the present Michigan League building, converted to accommodate twenty hospital patients in 1869. At the left are the two pavilions added in 1876, increasing the capacity to 60 beds.

Fig. 2. University Hospital in 1927, 2 years after it opened. In subsequent years it was known as "Old Main." It was demolished in 1988 after the new hospital opened just north of this location.

When it was finally completed in 1925 at a cost of $4.4 million [2],* the magnificent, new 700-bed University Hospital, was the pride of the state. It was designed by the famous architect Albert Kahn, and its double-Y architectural configuration was an entirely new concept in hospital design [1] (Fig. 2).

The Setting for Radiology

Radiology began at the University on April 26,1896, only five months after the announcement of Roentgen's discovery when Mr. S. M. Keenan of Eloise Hospital, brought a patient to Ann Arbor with a bullet in his foot [3]. Henry S. Garhart, professor of physics, had a long-standing interest in Crookes tubes. Using X-rays produced in the physics laboratory, Carhart and William J. Herdman, professor of diseases of the mind and nervous system and of electrotherapeutics, made an image of the patient's foot showing the bullet. In subsequent years, in conjunction with his course in electrotherapeutics, Herdman often used a static machine in his office to demonstrate the production of X-rays and their medical value to his students. A paper by W. A. Spitzley (Class of '95) on "X-rays and the Development of their Usefulness," given scarcely more than three years after Roentgen read his preliminary report before the Physico-Medical Society of Würzburg, and subsequently published in the Michigan Alumnus, is of particular interest. The author described the significance of Roentgen's discovery as follows [4]:

> *Few scientific discoveries have astonished the world more or have incited scientific workers to greater activity; and fewer still, have received less opposition and have been less stunted in their growth...Immediately scientific men all over the world began investigations; surgeons thought of the great possibilities opened up to them in their work, and the world, generally, found itself in a mood of expectation. No one has been disappointed; Professor Roentgen's intelligent observations, by improvements in methods of application, are of the greatest value to us today; in fact, in certain conditions they make possible the previously impossible...We have surely not yet reached the limit of usefulness of the rays; investigators will go on working, and I doubt not that their field of application will be constantly increased and their value greatly enhanced.*

He cited specific diagnostic applications in conditions of the bones, joints and soft tissues, as well as in the chest and abdomen. He included four illustrations of skiagraphs (roentgenographs) of cases in the surgical clinic of the University Hospital, possibly the first such illustrations published in Michigan (Fig. 3).

*Other sources (annual hospital report, 1925-26; plant department listing, 1958) give slightly lower figures.

Figure II Figure I Figure III Figure IV

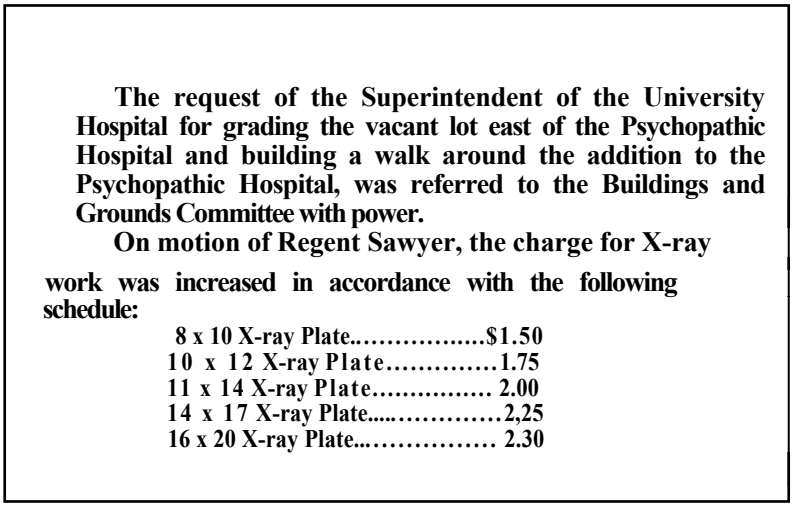
Skiagraphs of cases in the surgical clinic of the University Hospital

Fig. 3. Four "skiagraphs" published at University of Michigan in 1899 [3]. They depict, left to right, a bullet in a hand, a bullet in a collar bone (screw shown was on tabletop outside bosy), a needle in the tarsal region of a foot, and a "diseased knee joint" (femur is uppermost and patella is in upper left).

The first piece of X-ray equipment in the hospital was purchased personally about 1900 by Charles B. G. Nancrede, professor of surgery, and Cyrenus G, Darling, clinical professor of surgery [3|. X-rays were first mentioned in the university calendar in 1901-1902 in a revised description of the electrotherapeutic laboratory. C. Perry Brings, pharmacist at the University Hospital for many years, is credited with having developed the X-ray technique employed during the early years, after having first familiarized himself with the subject in Carhart's laboratory [3|.

The first X-ray equipment purchased with university funds was acquired in 1903 with a $1000 appropriation by the Board of Regents; it was placed in a small X-ray laboratory directed by Herdman in the basement of the Palmer Ward of the Catherine Street Hospital. In 1906 Vernon J. Willey. instructor in electrotherapeutics, was given the title of Director of the Roentgen Laboratory, and Almus A. Hale was appointed his assistant and clinical photographer; the expenditures for fiscal year 1907 were $514.62 [3]. Tackling the perennial problem of jurisdiction over roentgen rays, the regents ruled that Willey alone was to operate the machine [5]. By 1903 Nancrede and his assistant Conrad George used X-rays for treatment as well as diagnosis. Although enthusiastic, Nancrede warned against attempting to make it diagnosis by X-rays alone. At the same time George Dock, professor of internal medicine, introduced students to skiagrams of the chest of patients with tuberculosis and described X-ray treatment of an enlarged spleen in a leukemic patient and an exophthalmic goiter. Thus, the evidence is clear that X-rays were commonly used at the university for diagnosis and treatment in the early 1900s [5]. Willey attained considerable prominence in the field of roentgenology. He was innovative and made numerous technical improvements, describing his methods in detail. He attended medical school while working in roentgenology and, after graduating from Michigan, resigned his position in 1909 to

become head of the Section of Roentgenology at the Mayo Clinic [5].



The request of the Superintendent of the University Hospital for grading the vacant lot east of the Psychopathic Hospital and building a walk around the addition to the Psychopathic Hospital, was referred to the Buildings and Grounds Committee with power.

On motion of Regent Sawyer, the charge for X-ray work was increased in accordance with the following schedule:

8 x 10 X-ray Plate.....$1.50
10 x 12 X-ray Plate.....1.75
11 x 14 X-ray Plate..... 2.00
14 x 17 X-ray Plate.....2,25
16 x 20 X-ray Plate..... 2.30

Fig. 4. Fee schedule for "X-ray work," established by the regents in September 1912 [5].

In 1907 Carl D. Camp was appointed clinical professor of diseases of the nervous system and assumed supervision of the Roentgen Laboratory. James G. Van Zwaluwenburg, instructor in internal medicine, through association with Hale became interested in the clinical use of roentgen rays, particularly for evaluating the heart and stomach. This interest and Nancrede's desire to expand the clinical use of the roentgen apparatus resulted in the transfer of the Roentgen Laboratory in 1910 to the departments of Internal Medicine and Surgery. Van Zwaluwenburg took charge of all X-ray activities and Nancrede represented the laboratory in faculty meetings. Under these arrangements, X-ray examinations became sufficiently numerous for the regents to establish an X-ray fee schedule in 1912 [6] Fig. 4). In 1913, Van Zwaluwenburg took full charge as the first clinical professor of roentgenology. His scientific training, knowledge of internal medicine and inquisitive mind were instrumental in his ability to establish new roentgenologic methods. He readily attained a national reputation as a "Roentgen" diagnostician, teacher and investigator. What has been referred to as the first department of roentgenology in a medical school in the United States [7] was formally designated such by the regents in 1917, and in view of his outstanding accomplishments, Van Zwaluwenburg was designated as professor and chairman [3,5] (Fig. 5).

Fig. 5. James G. Van Zwaluwenburg, chairman of radiology, 1917-1922. A zealous teacher and investigator who was unsparingly devoted to clinical roentgenology and the department

James G. Van Zwaluwenburg (1917-1922)

Van Zwaluwenburg obtained a bachelor of science degree from the University of Michigan in 1898 but could not afford a medical education, so he worked for five years as a chemist and metallurgist before entering medical school. As a medical student, he developed a profound knowledge of anatomy by assisting in the dissecting room. After graduation, he served in internal medicine under George Dock and Walter Hewlett, who were enthusiastic about the value of X-rays in clinical medicine. In 1910, he undertook a study of the heart in 187 patients using orthodiagramography (fluoroscopy) and clarified the measurements to be used in evaluating cardiac and specific chamber enlargement. The pioneers in radiology were largely self-trained and Van Zwaluwenburg's early publications demonstrate his considerable knowledge of roentgenology before assuming the chairmanship.

The need for additional equipment to meet increasing clinical demands was apparent. In 1917 "there was but a single generator, a ten-kilowatt high tension transformer, one radiological table with a tube stand and a Groedel fluoroscope with orthodiagraphic attachment. Gas-filled X-ray tubes were costly and unreliable. The number of examinations conducted each year had risen from less than 600 in 1911 to 4,203 in 1917-1918, by which time the activities of the department had far out-grown the quarters which it occupied in the basement of the old Palmer Ward. Late in 1918 a machine was acquired for the production of medium-voltage X-rays to be used therapeutically" [3].

Before Van Zwaluwenburg's tenure, the X-ray laboratory had been purely a service enterprise and roentgenology was not formally taught. Van Zwaluwenburg immediately instituted weekly lectures on diagnosis and therapy for senior medical students. Early in his tenure he had only technical assistants, but he had one physician instructor in 1919 and two in 1920. He recognized that providing good clinical service was a way of teaching the clinical staff; a surgeon, he said, "could learn continuously by relating roentgenologic findings to his operative findings" [5]. He published a correlation of roentgenographic and surgical findings in 62 operative cases and each month he showed slides of cases to the medical school's Clinical Society [5]. This was an important educational experience for the clinical staff and was probably a significant factor in the remarkable growth of roentgenology.

Van Zwaluwenburg made important contributions regarding technique and interpretation of roentgenographic examinations of the lungs, heart and great vessels, and abdominal organs. His diagnoses before surgery were made blindly because he insisted the clinical diagnosis and laboratory results not be sent to him to avoid bias and a nonobjective interpretation. In evaluating patients for peptic ulcer, he preferred to use the fluoroscope. If he used films he could examine only two or three patients per day and visceral motion required that he make frequent serial exposures, which increased cost and examination time. With a fluoroscope, he could examine

20-25 patients per day. In 1915, he used bismuth sulfate suspended in fermented milk as the contrasting agent, but he switched to barium sulfate in 1917. He thought milk was preferable to a water suspension because it delayed gastric emptying by exciting the pyloric reflex. Van Zwaluwenburg devised a stereographic technique to localize ocular foreign bodies and to evaluate the skull, cervical spine and paranasal sinuses. He also used it in conjunction with pelvic pneumoperitoneum for gynecologic problems and preferred carbon dioxide to oxygen because it produced less patient discomfort. He recognized that most of the lung shadow is due to blood in the lung and was intrigued by the "apical cap" and its possible pathologic significance; in the final year of his life he made lung stereograms of the entire first- and second-year class with the intent of investigating this further, but did not live to do so [5].

Van Zwaluwenburg was affectionately called "Van" by his colleagues and students. He developed pneumonia and died at age 48 on January 5, 1922, leaving his family destitute. The faculty requested that the University continue his salary to his widow for the balance of the school year because "Van Zwaluwenburg," the faculty said, "had worked without regard for money" [5]. Indeed he had boundless energy and was heedless of his personal welfare, devoting himself unsparingly to medicine and the department. In the year of his death, more than 10,000 X-ray examinations were done by the department [3].

Preston M. Hickey (1922-1930)

Fig. 6. Preston M. Hickey, chairman of radiology, 1922-1930. A major influence in American radiology and a pioneer in departmental planning.

Within three weeks of Van Zwaluwenburg's death, the regents appointed Preston M. Hickey as professor of roentgenology at an annual salary of $12,000 (Fig. 6). Hickey had been educated at the University of Michigan but obtained his medical degree from the Detroit College of Medicine and Surgery in 1892. Initially he practiced pathology but later changed to otolaryngology. He obtained one of the first pieces of commercial X-ray apparatus in Michigan about 1900 and set up a private practice at Harper Hospital in Detroit. He was soon recognized as an expert in the new specialty and in 1906, became founding editor of the *American Quarterly of Roentgenology.* It evolved into the monthly *American Journal of Rontgenology,* of which he was editor for 10 years. He was elected president of the American Roentgen Ray Society in 1906. He was one of the first to advocate setting professional standards for roentgenology. During World War I, Hickey provided special service to the Army Medical Corps by participating in the organization of specialty schools for roentgenologists [3, 5].

The regents gave Hickey $10,000 for new equipment in the Catherine Street Hospital and instructed him to plan the radiology department for the new hospital that was to be opened in 1925. The new department, on the fourth floor of the surgical wing, consisted of 12,000 square feet with important functional innovations. The examining rooms were grouped around the film-developing rooms. Hickey specified the characteristics of the light traps for exchanging cassettes, the temperature control of the developing tanks and the arrangements for turning lights off and on in the film-changing room. He provided for recovery of silver from spent developing solutions and had dressing rooms that patients could enter from the waiting area and exit into the examining rooms. The room for barium enemas was planned with a toilet nearby, and a separate room was provided for the Graham test (oral cholecystography) for gallbladder visualization that was in heavy demand. The room containing the vertical fluoroscope with orthodiagraphic attachment was indirectly lighted at floor level so patients could find their way but examiners would not lose their dark adaptation. The fluoroscopy room had a clock that recorded the length of radiation exposure for each patient. A treatment room contained a 250,000-volt tube for deep therapy; its floor was battleship linoleum over a thick layer of barium plaster to avoid stray radiation in the room below. The department also had 100 milligrams of radium bought in 1928 with $35,000 authorized by the regents. Finally, there was a shop for instruments used for measuring radiation. Hickey preferred teaching small groups so there was a classroom for section teaching as well as rooms for film viewing. Films were filed and kept in the department for two to three years and then transferred to vaults for permanent storage [5]. Hickey's plan was an important pioneering achievement because many of its principles were subsequently adopted in planning other departments.

Hickey was an accomplished technician, a superb clinician and an excellent teacher, but unlike Van Zwalu- wenburg, he was not a significant investigator [5]. He radically revised the teaching of roentgenology. He persuaded George A. Lindsay of the Physics Department to add a 12-week sequence on the physics of X-rays to his course in physics for premedical students, and required his residents to take this course. Lindsay periodically measured the output of X-ray tubes in the department. He introduced roentgenology in the first two years of the medical school curriculum not for its own sake but to "stimulate student enthusiasm by injecting something of the practical side of medicine" [5]. Roentgenologists gave lectures to the students on anatomic topics, such as skeletal development, and view boxes were installed in the dissection room so students could see pyelograms and films of injected blood vessels, bronchi and paranasal sinuses. Hickey moved the roentgenology lectures from the senior to the junior year so students might know something about the subject when they were on the wards in their fourth year. He gave no quizzes throughout the year but he provided students with 100 study questions upon which the final examination was based. Senior students rotated through the department in small sections and Hickey offered extremely popular short elective courses for seniors on film reading, X-ray technique and radiotherapy. Senior students on the internal medicine service were expected to be present when gastric or pulmonary patients had fluoroscopy. As in years to come, instruction for medical students

became highly developed.

The radiology residency lasted two years after a rotating internship and the number of residents increased during Hickey's tenure. Formal interdepartmental clinical conferences were established. Hickey had the residents take histories and do physical examinations before fluoroscopy. Residents had to master the techniques of film exposure and development as well as the use of portable apparatus, and they had to know how to measure radiation dosage. He introduced his residents to the economics of roentgenology and gave them training in public speaking. Hickey taught residents how to write reports, for he found that in general, "reports submitted by a roentgenologist were inferior to those of a pathologist and were haphazard and without respect for scientific accuracy" [8]. Clinical photography, originally fostered by Van Zwaluwenburg and then by Hickey, was part of the department of roentgenology.

When the new hospital opened, a commercial photographer was placed in charge of the new photography studio, but the technical work was distributed among assistant radiology residents, a feature of the training program instituted by Hickey [3].

Under Hickey's forceful guidance the department expanded rapidly. The professional staff was enlarged and Ernst A. Pohle was recruited and placed in charge of radiation therapy in 1925. Hickey had a major influence on American roentgenology. His courses for medical students and technicians served as models for other institutions; physicians holding fellowships from various national foundations were attracted to the department [3]. Hickey was referred to by students and colleagues as "Pop" Hickey, which reflected the character of his professional relationships. On the wall of his office was a bronze bas-relief plaque of himself presented as a testimonial to his eminence in American medicine by his associates in the name of the American Roentgen Ray Society. A few years before Hickey's death on October 30, 1930, a Philadelphia roentgenologist writing about Hickey's school summed up Hickey's impact as follows: "I doubt whether there is another medical school in the country where roentgenology receives anything like the same recognition as at his school" [9].

Fred Jenner Hodges II (1931-1965)

Fig. 7. Fred Jenner Hodges II, chairman of radiology, 1931-1965. An inspiring leader, educator, and innovator who

Carlton B. Peirce, assistant professor, who had begun his training under Hickey in 1926, was appointed acting chairman immediately after Hickey's death. A search committee chaired by Udo J. Wile, after a six-week review of the credentials of many senior academic roentgenologists in the country, recommended Fred J. Hodges II as Hickey's successor on January 9, 1931 (Fig. 7). Hodges telegraphed his acceptance six days later and his appointment began April 1.

Hodges lived through an era that witnessed the early development of the science of radiology. During his boyhood, he and his older brother Paul were influenced by a physician uncle who had acquired some early radiographic equipment. Hodges received his bachelor of science degree from the University of Wisconsin and his medical degree from Washington University. He had an internship in internal medicine and pathology at Barnes Hospital and subsequently returned to Madison where he held university appointments in physiology and roentgenology and was the roentgenologist at Wisconsin Memorial Hospital and then at St. Mary's Hospital.

Hodges was a visionary with an inspirational character and a genius for technical innovation. Upon his arrival, Hodges wished to make some changes in the department. He outlined his vision for the department to the executive committee, proposing a sweeping reorganization and expansion of the physical plant. He said the department should render clinical services as complete, excellent and modern as those rendered by any department in the school. The department should be second to none in undergraduate and postgraduate teaching, and it should make creditable contributions to knowledge, he noted. In great detail he outlined the shortcomings of the existing department and noted the staff was not accorded proper status as consultants. He requested the professional staff be increased from two to four positions. He noted that men in training were allowed to use patients to gain technical experience, whereas employment of a few more technicians would better serve the patients' welfare [5]. Despite the Depression, his plans were approved, and the department moved into new quarters. Dental roentgenology was transferred to oral surgery, a fluoroscope was installed in the new tuberculosis unit of the hospital and uroradiologic services were provided in the department of urology's outpatient quarters. The radiation therapy equipment that had been transferred from the old hospital 10 years earlier was replaced with modern shock-proof 200-kilovolt instruments, and a unit for treating superficial skin lesions was provided. Physical therapy, photography and medical illustration were split off from the department and accommodated elsewhere. These early remodeling projects made it possible for the department to function more efficiently and provided greater learning opportunities for graduate and undergraduate students. A student laboratory for demonstrating X-ray physics was established, and a room was

dedicated as a departmental library; designated as the Hickey Memorial Library, it was maintained largely by Hickey's bequest of $1,000 [3]. In the next 30 years, the department gradually expanded from 9904 to 23,538 net square feet, including a dedicated radiation therapy facility developed in 1954. The number of patients seen increased to nearly 90,000 per year [7].

Hodges was responsible for maintaining medical records of all cancer patients. Using an early punch card system, he collected a variety of data and wrote annual reports on the institution's experience with cancer [5]. The current University of Michigan Tumor Registry was probably established as an outgrowth of this activity. In collaboration with Isadore Lampe he also developed an indexing and cross-filing system for radiodiagnostic data, making it possible to retrieve cases relative to a specific diagnosis, evaluate diagnostic accuracy and access material for continuous upgrading of the departmental teaching file [10]. It is likely this early system had an influence on the American College of Radiology's diagnostic coding system. In 1935, Hodges advocated preadmission chest survey for all patients. Through his tireless efforts and with support from the Kellogg Foundation, routine preadmission chest photofluorography was put into effect in 1941.

In 1935, Hodges collaborated in the construction of a cyclotron for the physics department to be used for nuclear physics research. He recognized early that neutrons might be superior to X-rays for treating cancer and wanted to use the cyclotron for this purpose. He was familiar with E. Lawrence's neutron therapy project at Berkeley. After sending Lampe, who he referred to as "unquestionably the most outstanding young man who has come under my observation" [5] to the physics department for graduate training, he arranged for Lampe to spend time in Berkeley in 1936. Lampe's subsequent doctoral degree, dealing with biological differences in the effects of X-ray and neutron therapy, was founded on this experience. In 1946, Hodges participated in creating the Michigan Memorial-Phoenix Project, which involved using a nuclear reactor for research projects, including medical uses of radioactive iodine and the production of radioactive isotopes [11].

Hodges, influenced by his brother Paul, who was chairman of radiology at the University of Chicago, was interested in equipment innovation. Funding for equipment was scarce and he recognized he could modify and upgrade existing radiologic equipment more cheaply than by relying on industry. Furthermore, he wanted to fashion equipment based on his own, or faculty members', concepts. Consequently, in 1946 he established a departmental machine shop and laboratory (2556 square feet), staffed by a full-time machinist, Quentin Westrick. In 1960 an electrical engineer, Lawrence R. Griewski, joined the department faculty and was subsequently placed in charge of this facility. Film identification devices, similar to the ones used at the University of Chicago, were fabricated using dental X-ray tubes; they were placed in each of the diagnostic rooms and recorded the patient's registration number and examination date on each film before it was transported to the darkroom. Among the more important items developed

in this laboratory was a roll-film apparatus for rapid serial filming (Fig. 8). The need to use large films for adult studies and the desire to obtain filming speeds of four to six exposures per second for proper evaluation of congenital heart disease prompted the development of this apparatus. In 1949 William H. Thompson and Melvin M. Figley collaborated with Hodges on building this apparatus, which was immediately put to clinical use [12]. Several years later Figley added a device that permitted synchronous electrocardiography. This permitted the analysis of images relative to cardiac dynamics and was the first such unit in the United States — possibly the world. Hodges' department was often selected as a clinical site for new or prototype equipment. In 1957, it was one of the first to receive an early version of Kodak's roller-transport film processors (Model M), which required a processing time of only six minutes. This was a radical improvement over its predecessor, the Pako unit, which required each film to be manually placed on special hangers and a much longer processing time. Hodges had known Russell H. Morgan, of Johns Hopkins University, when the latter was on the faculty of the University of Chicago. In I960, with Morgan's advice, Hodges directed the building in the machine shop of the first image intensifier/television monitoring system in Michigan. Within two years, virtually all of the department's fluoroscopy units were replaced with such systems.

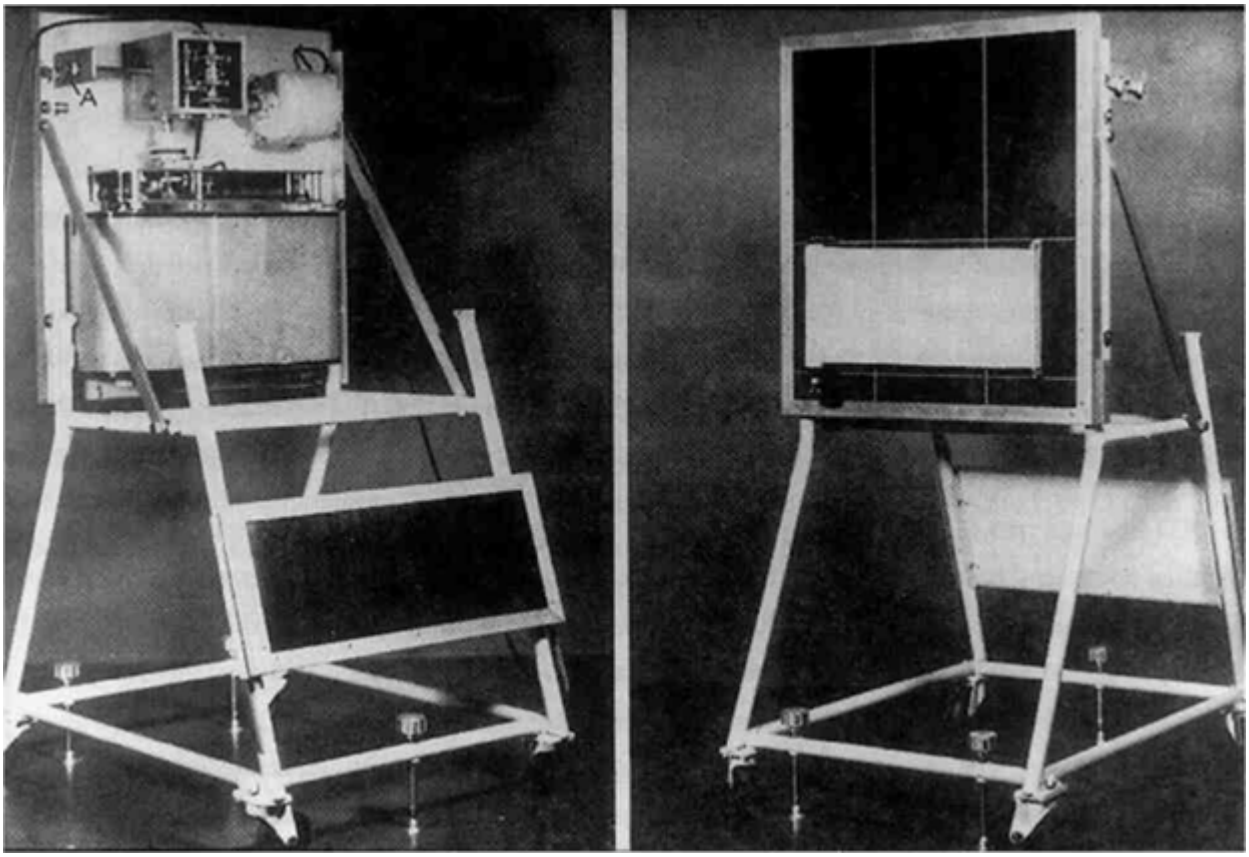


Fig. 8. (Left) Roll-film apparatus for rapid serial filming, viewed from behind. Note exposure speed-selector knobs (A). (Right) Apparatus ready for vertical filming, viewed from the front. The device could be adjusted for horizontal filming.

Hodges' articles on brain tumor localization and intracranial angiography, written in collaboration with Vincent C. Johnson and neurosurgeon Carl F. List, respectively, were major early contributions in neuroradiology. However, his prime interest was in gastrointestinal radiology. Although he encouraged his faculty to pursue research and served as a facilitator on their behalf, he was probably more interested in patient care and education of medical students and house officers. In 1932, to allow more time for these endeavors, he discontinued the training program for radiologic technologists. In 1939 he and Willis S. Peck published a radiology syllabus for junior students. In that year the radiology curriculum for medical students consisted of 32 lecture hours for juniors in the first semester plus 32 additional hours throughout the year. In subsequent years, the lecture format was abandoned in favor of informal small group seminars (20-25 students) in the junior year such that 40 hours of instruction were provided in a 12-week period. A study room where a special teaching file was maintained for medical students allowed students to be involved in their education. His book, *Radiology for Medical Students,* written with I. Lampe and J. Holt and published in 1947, was probably the first such book to be used widely in other schools. Hodges, initially with I. Kaplan, edited the *Yearbook of Radiology* which first appeared in 1948; in subsequent years he shared this role with Isadore Lampe, John F. Holt, Robert S. Maclntyre and Walter M. Whitehouse.

In 1933 Hodges expanded the radiology residency to three years, taking four residents each year. He required an internship year and discontinued rotating residents for one month to Detroit Receiving Hospital. Interdepartmental clinical conferences were expanded. Hodges held didactic meetings on Monday evenings for residents and faculty in which one resident presented interesting cases and another gave a lecture on a subject of his/her choice, the so-called "Monday-nighter"; occasionally, faculty gave these lectures. The Veterans Administration Medical Center, which opened in 1953, became an important training facility for residents and students; Hodges appointed Robert A. Rapp Director of Radiology there, a position he held for 26 years.

In 1953, the name of the department was changed from "Roentgenology" to "Radiology". However, nuclear medicine evolved under the leadership of William H. Beierwaltes in the Department of Internal Medicine, where it remains. Beierwaltes, an internist who was educated at the University of Michigan, began working with radioisotopes in thyroid disease in 1946 and was placed in charge of the clinical radioisotope unit in 1952, the year radiology residents began rotating through the nuclear medicine service. Beierwaltes was one of the nation's pioneers in nuclear medicine, and his research, for which he was known internationally, contributed to making nuclear medicine a scientific discipline. He was one of the earliest to recognize, upon collaboration with basic scientists, that biochemical precursors might be labeled with radioactive isotopes to achieve selective localization in neoplasms. His textbook, *The Clinical Use of Radioisotopes,* published in 1957 in collaboration with Phillip G. Johnson and Arthur J. Solari, was the first of its kind, from which many trainees learned the fundamentals of nuclear medicine. He attracted numerous outstanding graduate students, and Edward A. Carr Jr., Thomas P. Haynie III, and James G. Sisson were among his early faculty members.

In 1939, Lampe succeeded Willis S. Peck as Director of Radiotherapy, a position he held for 35 years. Lampe developed many principles on which the science of radiation therapy is based and made numerous contributions to cancer treatment. He pointed out, contrary to conventional thinking, that adequate radiotherapy could be successful in carcinomas of the oral cavity and hypopharynx despite bone involvement. He was the first to show, in 1952, that external pelvic irradiation was far superior to intra-cavitary radium therapy as a preoperative treatment for endometrial carcinoma. The only physicist in the department at this time was Charles Simons, Ph.D., who worked primarily in radiotherapy. Before 1969, all residents spent one year studying radiation therapy as part of their training. Lampe, as a teacher, had a profound impact on many who were inspired to pursue academic careers in radiation oncology, including Malcolm A. Bagshaw, Howard B. Latourette, Robert G. Parker and Phillip Rubin. Others who joined the faculty to work with him were Juan V. Fayos and Seymour H. Levitt [13]. In 1995 Levitt was awarded the Gold Medal of the American College of Radiology.

Hodges had a special ability to select, inspire and nurture residents and faculty. His leadership abilities, enthusiasm for academic endeavors and talent for teaching, coupled with outstanding qualities in the faculty he assembled, were major factors in the success of his department. As a result, a stream of academic leaders emerged from the Department of Radiology during his tenure. Holt was a pioneer in pediatric radiology. His papers on neurofibromatosis, sarcoidosis, vitamin D-resistant rickets, tuberous sclerosis and bone dysplasias, to name just a few, were works of major significance. He was an astute pediatric diagnostician who had a significant influence on the trainees, many of whom were inspired to pursue pediatric radiology. Figley, while a faculty member at the University of Michigan (1950-1958), was pioneer in angiocardiography. He was interested in cardiac physiology and the quantitative analysis of cardiac function and, in this regard, was "ahead of his time." His papers on coarctation of the aorta, patent ductus arteriosus, constrictive pericarditis, splenoportography and congenital cardiac diseases were seminal contributions. He introduced translumbar aortography at the university, and his description of the arteries of the abdomen, pelvis and thigh in normal patients and in occlusive disease was widely used. Figley was the first Markle Scholar at the university and the first radiologist to be so honored. Other residents who trained under Hodges and became renowned leaders include Theodore E. Keats, Alexander R. Margulis, Edward B. Singleton, Mutsumasa Takahashi and Walter M. Whitehouse. Others who distinguished themselves academically include Murray G. Baron, Leonard O. Langer Jr., Robert S. Maclntyre, Jack M. Tishler, Rosalind H. Troupin and Robert H. Wilkinson. Hodges was particularly proud of his two sons who trained in his department; Fred J. Hodges III distinguished himself in neuroradiology at Johns Hopkins and Washington universities, and Robert E. Hodges entered private practice at the Presbyterian Hospital in Dallas. Hodges was sensitive to portraying radiology as an important academic discipline and participated in creating the Association of University Radiologists in 1953; Holt and Figley were elected presidents of this society in 1956 and 1961, respectively.

Hodges was referred to by his residents and faculty as "the Chief," an expression of admiration and loyalty. This profound loyalty may explain why his department was so stable and "inbred"; William Martel was the first faculty member to be recruited (1957) who had not trained under Hodges. Shortly thereafter, Joseph J. Bookstein and Anthony F. Lalli were recruited from Stanford University and the University of Chicago, respectively. Delbert E. Bobbitt, having been a resident in the department, succeeded Figley as head of angiocardiography (1958-1961). When he resigned to enter private practice in Ann Arbor, Bookstein took his place and proved to be a dedicated and effective academician who had a great impact on angiocardiography. He introduced the Seldinger technique, and developed and refined arterio-graphic methods to evaluate renovascular hypertension. Lalli introduced new uroradiologic techniques and his textbook, *The Tailored Urogram,* was quite popular. He was probably the first to suggest that adverse contrast reactions might be related to patient anxiety. He also introduced transthoracic needle aspiration of pulmonary nodules after a visit with Bjora Nordenstrom in Stockholm. B. Jay Hill and Arthur C. Kittleson remained on the faculty for several years after completing their residencies. Hill was appointed director of radiology at the university's Student Health Service, and Kittleson focused on orthopedic radiology and mammography. In 1961 two residents, Theodore Ditchek and Robert J. Blahut, and Kittleson described for the first time that nodal filling defects on lymphography seen in normal subjects were not necessarily due to metastatic neoplasm.

Hodges was an eloquent spokesman for radiology [14], although he was not active in national organizations. He developed close professional friendships with several Swedish radiologists and spent part of his leave of absence at the Karolinska Institute in 1954; he arranged for similar educational experiences for various faculty members during the years. His friendship with Byrl R. Kirklin and Harry Weber of the Mayo Clinic led to annual exchange visits of residents and faculty between the two departments. Hodges kept in touch with his former trainees and had a wall map in his office that marked with pins where they settled. In 1956, the Fred Jenner Hodges Society was formed by his former residents in his honor, and in 1986, eight years after his death, the Fred Jenner Hodges Professorship was established.

Fig. 9. Walter M. Whitehouse, chairman of radiology, 1965-1979. A revered leader who fostered subspecialization, fellowship training, and academic excellence.

Walter M. Whitehouse (1965-1979)

Walter M. Whitehouse (Fig. 9) succeeded Hodges as chairman and was viewed as a kind and gentle leader, well-liked by the faculty and loyal to the institution. He obtained his education at the University of Michigan and, after his training at the university hospital, joined the faculty in 1952. He had expertise in pulmonary radiology but was also active in gastrointestinal and obstetric radiology. He clarified the proper use of biliary contrast agents, advocated chest film surveys and recognized the radiation hazards of obstetric radiography. He was elected president of the Society of Chairmen of

Academic Radiology Departments in 1975 and was a founding member of the Society of Gastrointestinal Radiologists, of which he was elected president in 1977.

Whitehouse appointed Martel as director of diagnostic radiology and had Fayos succeed Lampe as director of radiotherapy. Harry W. Fischer was recruited from the University of Iowa to head the radiology department at Wayne County General Hospital when it affiliated with the University of Michigan in 1966, and Holt was named director of pediatric radiology when the C. S. Mott Children's Hospital opened in 1969. Although the department was not formally organized into diagnostic subspecialty divisions, Whitehouse fostered subspecialization by recruiting academically gifted individuals and encouraging them to concentrate their efforts in subspecialty areas. Bookstein, already known for his leadership in angiocardiography, drew national attention to the program and the addition of Stewart R. Renter and Helen C. Redman, who were based at the Wayne County General Hospital, greatly enriched it. Significant contributions were made in pharmacoangiography, embolization techniques for gastrointestinal bleeding, magnification angiography and the angiographic diagnosis of pancreatic carcinoma. The fellowship became extremely popular and many outstanding trainees were attracted, some of whom remained as faculty members. Trygve O. Gabrielsen, who was a resident under Hodges, headed neuroradiology for more than 20 years and developed this subspecialty and its fellowship program. In 1965 Hodges arranged for Gabrielsen to train with Torgny Greitz at the Karolinska Hospital and in 1968 Whitehouse made it possible for him to have additional training with Per Amundsen in Oslo. Thereafter, cerebral angiography was performed by catheterization; the University of Michigan was one of the first institutions in the country to adopt this technology. As a result the department was given jurisdiction for virtually all invasive neuroradiologic procedures and a formal fellowship program was established, eventually with NIH funding. In 1971, Reuter succeeded Fischer and three years later moved to the U-M Hospitals to succeed Bookstein whereupon Ray Brinker was appointed director of radiology at the Wayne County General Hospital. Andrew K. Poznanski, recruited from Henry Ford Hospital, joined Holt as co-director of pediatric radiology; he made significant contributions on skeletal dysplasias and introduced novel pediatric radiologic techniques. The department was given jurisdiction for sonography in 1972, and under the leadership of Terry M. Silver, this technology and the scope of its clinical applications grew dramatically. In 1977, Silver organized a very successful postgraduate course in ultrasonography which was given annually thereafter and brought national attention to the department's sonography program; this was a factor in the subsequent recruitment of outstanding fellows and faculty. John Thornbury, placed in charge of uroradiology following Lalli's departure, collaborated with Dennis Fryback on using decision theory to improve patient management. Barbara Threatt, who had trained as a resident while Kittleson was on the faculty, was given responsibility for breast imaging. Others who joined the faculty for varying periods include Lawrence R. Bigongiari, Bruce D. Doust, Vivienne Doust, Fred E. Patterson, Yoeh M. Ting and Alan H. Wolson. When Whitehouse succeeded Hodges as the editor of the *Yearbook of Radiology* in 1971, he appointed several faculty members as associate editors, each having responsibility for different

subspecialties of radiology. This emphasized the subspecialty focus in the department, and the book continued to give national visibility to the department throughout the Whitehouse era.

Research advances in nuclear medicine were enhanced by several basic scientists, including Donald M. Wieland (chemistry) and W. Leslie Rogers (physics). Raymond E. Counsell (pharmacology) was instrumental in developing derivatives of cholesterol to image steroid-producing neoplasms. James H. Thrall developed radionuclide ventriculography and diuresis renography, and John W. Keyes Jr., was responsible for fabricating the first single photon emission computed tomography (SPEGT) unit in Michigan. Milton D. Gross, currently the national director of the Veterans Administration Nuclear Medicine Services, was placed in charge of nuclear medicine at the Veterans Administration Medical Center.

The fellowship training program, begun in the late 60s, was initially restricted to angiocardiography and neuroradiology. Shortly thereafter fellowships were offered in virtually all subspecialties. Many fellows, some of whom also trained as residents, were inspired to pursue academic careers. In addition to those already mentioned, these individuals include Kyung J. Cho, Vincent P. Chuang, W. Dennis Foley, Maureen E. Forrest, Stephen S. Gebarski, Harvey M. Goldstein, James E. Knake, Lawrence R. Kuhns, Richard E. Latchaw, Thomas L. McCormick, Harvey L. Neiman, Ronald G. Quisling, Joachim F. Seeger, James J. Shields and Jeffrey D. Wicks. Seeger remained on the faculty for 10 years and Cho headed vascular/interventional radiology for 20 years. An important development which supported the fellowship program was the establishment of an animal imaging laboratory for basic research in 1967.

The adoption of a medical service plan for all clinical departments in 1974 had a major impact on radiology. For the first time, faculty radiologists were required to supervise and take direct responsibility for all radiologic procedures and film interpretations with residents and fellows taking supportive roles. Initially this reduced available time for teaching and research, but the department, now responsible for its own professional fee billings, enjoyed incremental income and a measure of financial independence. The incremental revenue was used largely to support teaching and research and made it possible to recruit additional faculty.

In 1968 the medical school changed its curriculum radically and, to expand opportunities for elective courses, reduced formal course teaching for all departments with the deletion of the junior course in radiology. Clinical teaching was to be accomplished as interdepartmental efforts in the freshman and sophomore years, and Whitehouse directed Martel to coordinate the department's effort. Initially the department's assigned teaching time was negligible, but in a few years it gradually became significant, providing approximately 25 lecture hours in the freshman and sophomore years. In addition, arrangements were made for senior radiology residents to teach radiologic anatomy to small student groups in the anatomy laboratory. When the medical school denied the department's request to create a required course in radiology for medical students in 1972, a semistructured elective course, "The Role of Radiology in Clinical Medicine," was developed and became one

of the most popular of the elective offerings, chosen by 70 percent to 80 percent of senior students.

The residency expanded from six to 12 residents per year and teaching activities increased to include more weekly clinical interdisciplinary conferences and daily informal diagnostic conferences for residents and fellows. An experiment of daily rounds with individual Internal Medicine Services proved successful and was continued for many years. Residents who trained in the Whitehouse years, other than those already noted, and who pursued academic careers at other institutions include Janet K. Baum, Paul E. Berger, Nancy L. Brown, Arthur A. DeSmet, Kenneth E. Fellows Jr., Guerdon D. Greenway Jr., Tim B. Hunter, Robert A. Kaufman, Michael J. Landay, Donald E. Newman, Hideo Onitsuka, Robert S. Seigel, Herbert J. Smith, William H. Straub and Michael F. Smolin.

With the expanding clinical load and growing sophistication in the new imaging techniques, the inadequacy of the physical facilities and obsolescence of the radiologic equipment became significant problems. The first computed tomography (CT) scanner was an EMI head unit, installed in 1975. It was not until 1980 that a body CT unit was finally placed at the university. Fortunately, a body CT unit had been installed at the Veterans Administration Hospital in 1977, giving the faculty and residents an opportunity to gain experience with this new modality. Despite these drawbacks and owing to the resourcefulness of Whitehouse and Griewski, who had been placed in charge of equipment maintenance, the department's imaging equipment was kept functional. Innovative methods were used to optimize the facilities and to prolong the life of the equipment. Whitehouse resigned the chairmanship in 1979, and the following year his colleagues and former trainees, recognizing their debt to him, established the Walter M. Whitehouse Lectureship.

Fig. 10. Douglass F. Adams, chairman of radiology, 1979-1981. An accomplished academician and pioneer in cardiovascular radiology.

After a prolonged search Douglass F. Adams was named chairman effective July 1979 (Fig. 10). Adams received his medical education at Bowman Gray School of Medicine and took his residency at Stanford University. He was recruited from Harvard Medical School and the Peter Bent Brigham Hospital. Adams was known for work in cardiovascular radiology and computed body tomography. During his tenure he organized the department into formal divisions, initiated the concept of a basic science division, established a contract for professional services at the Veterans Administration Medical Center for the first time and introduced the practice of providing dedicated research time for the faculty. For a variety of reasons, including the school's failure to meet the commitments made to him, Adams resigned in 1981. At this time a controversy arose regarding jurisdiction for magnetic resonance (MR) imaging. One view held that it belonged with nuclear medicine and therefore in the department of internal medicine. (In that period, this technology was referred to as "nuclear magnetic resonance.") Senior members of the department protested vigorously and eventually the Department of Radiology was given jurisdiction for MR imaging. Martel was appointed acting chairman in July 1981.

Fig. 11. William Martel, chairman of radiology, 1982-1992. "A dynamic teacher and outstanding clinician and investigator who rebuilt, modernized and revitalized the Department (Dunnick NR, personal communication.

William Martel (1982-1992)

William Martel (Fig. 11), appointed chairman in October 1982, received his bachelor's and medical degrees from New York University. After a radiology residency at Mount Sinai Hospital, New York, he joined the Michigan faculty in 1957. He had broad clinical and research interests and became known for his contributions in gastrointestinal and musculoskeletal radiology. He was the first to advocate tubeless hypotonic duodenography and was a pioneer in the radiology of joint diseases. Many of his papers form an important basis for current concepts in the differential diagnosis of arthropathies. He was the first and only member of a clinical department of the medical school to receive the university's Amoco Award for outstanding teaching and he participated annually in instructional course programs of national radiologic societies for more than 20 years. In 1985 he was named the first Fred Jenner Hodges Professor. He was a founding member of the International Skeletal Society and was awarded the Gold Medal of the Society in 1993, and the Schinz Medal of the Swiss Society for Medical Radiology in 1994.

When Martel assumed the acting chairmanship in July 1981, the department was markedly understaffed, equipment and space were inadequate, research activity was minimal, and morale was low. The report of the departmental external review committee noted the situation was serious enough to "place in jeopardy the tertiary care mission of the entire Medical Center." Responding to this crisis was a major challenge. Many faculty members and administrative staff were recruited in the first year, and with the recruitment of James L. Aldridge Jr., as administrative director, the department's administrative structure was reorganized. Formal subspecialty divisions with emphasis on organ or body system orientation were established. Donna C. Eder, who had been Martel's secretary since 1969, joined the administrative staff and was given major responsibilities for human resources and faculty affairs. Terry M. Silver, recognized for his outstanding contributions in uroradiology as well as ultrasonography, was appointed associate chairman. Many relatively young faculty members were recruited in this early period including Alex M. Aisen, Ethan M. Braunstein, Michael DiPietro, James H. Ellis, Isaac R. Francis, Barry H. Gross, Stephen W. Trenkner, Kay H. Vydareny, and Susan White. Several were immediately given positions of significant responsibility. Gross was appointed director of the residency training program, and Caroline E. Blane, recruited by Adams in 1980, was placed in charge of medical student education. In 1989, Vydareny, having joined the faculty five years earlier, succeeded Blane in this role. She became active in the affairs of the Association of University Radiologists, becoming president in 1992, and in the American Roentgen Ray Society, serving as president-elect in 1995. In 1981, with the addition of Paul L. Carson, Ph.D., initially recruited by Adams, a basic science division was created which eventually

included medical physics, bioengineering, biochemistry, medicinal chemistry, biostatistics, and magnetic resonance spectroscopy. In 1987, Carson became president and chairman of the board of the American Association of Physicists in Medicine. Gary M. Glazer, recruited by Adams in 1981, was initially placed in charge on computed body tomography. In 1983 when the status of computed tomography as a division was terminated, Glazer was appointed director of magnetic resonance imaging and Aisen was given associate director status. Ingvar T. Andersson of the University of Malmö, Sweden, was recruited as visiting professor to expand and improve the breast imaging division. Terry M. Brady, after completing his residency and joining the faculty in the division of vascular/interventional radiology, where he developed an interdisciplinary approach with urology, established the first program in percutaneous renal stone extraction in Michigan.

Martel anticipated that even if the institution were to receive approval to build a new hospital, it would not be available for several years. With that in mind Martel, with the assistance of Aldridge and James A. Mulvaney, medical physicist, directed short-term renovations and acquisition of incremental clinical space and equipment, including sonographic and CT facilities, deemed essential to meet clinical obligations and to recruit faculty. In 1983 the manual system of reporting examinations was replaced with an early version of a digital dictation system (RTAS) and a computerized radiology information system (MARS II) that enabled electronic editing of reports; the latter was subsequently replaced with a more comprehensive radiology information and management system (Images 3000). To provide a more complete pediatric diagnostic service, sonographic and CT capabilities were added to the department at Mott Hospital. In 1975 the jurisdiction for cardiac imaging, both pediatric and adult, had been transferred to the department of internal medicine (cardiology). With the recruitment of Ramiro J. Hernandez as director of pediatric radiology in 1983, ties with pediatric cardiology were strengthened and the department once again played an integral role in pediatric cardiac imaging. Shortly thereafter, the floor space for the department of Mott Hospital doubled, and the physical facilities were rearranged for greater efficiency. Martel, with the assistance of Carson, Glazer, Aisen, and Gabrielsen, established the first clinical MRI facility in Michigan with a 0.35T Diasonics magnet. It was installed in November 1983 in the Kresge Research Building with a plan to move it to the new hospital when that became available. It was one of the earliest superconducting systems in a clinical facility in the nation and was approved for clinical use

Fig. 12. The new University Hospital and Taubman Ambulatory Care Centre opened February 14, 1986.

by the FDA shortly after it was installed, giving the Medical Center an immediate experience with clinical MRI. Patient care and teaching activities improved dramatically at the Veterans Administration Medical Center under Ellis, who was appointed chief of the radiology service in 1984. Obsolete equipment was replaced, and an MRI system, shared with the university department, was acquired in 1987 and placed in the Kresge Research Building.

Upon assuming the chairmanship, Martel, working closely with his division directors and staff, notably Aldridge, Griewski and Mulvaney, directed a radical revision of previously developed plans for the department in the new hospital. Space was reorganized as subspecialty cores, such that examining rooms, film handling and interpretation activities were near each other for each subspecialty. For the first time, a daylight film-processing system was established for the entire department. The resulting efficiencies in space use and resource conservation were remarkable. Plans were developed for an MRI facility in the basement of the new hospital, one floor below the main department. This was developed as a subspecialty core, allowing for two MRI systems with potential space for two additional systems. The input from Thomas L. Chenevert, medical physicist, and Glazer and Aisen was invaluable in the planning process. Debra Bangerter played an important role in this project as assistant to Mulvaney and Griewski. She subsequently functioned very effectively as administrator for facilities and capital programs and continues in that role. The limited space for a radiology facility in the A. Alfred Taubman Health Care

Center (which was constructed with the new hospital) was a disappointment, and, as predicted, this proved to be a major problem. The new hospital and outpatient center were opened in February 1986 (Fig. 12). The clinical space for radiology doubled (70,300 net square feet) with state-of-the-art imaging equipment and, as in the Hickey era, the department was once again viewed as among the most modern in the nation.

Martel requested that radiation oncology be established as a separate department. He emphasized that this was essential if radiation oncology was to develop as a vigorous academic unit with modern patient care and research facilities. Allen S. Lichter, appointed chairman of the new Department of Radiation Oncology in 1984, was educated at the University of Michigan and completed a residency in radiation oncology at the University of California, San Francisco. He was recruited from the National Cancer Institute and was a pioneer in using computerized techniques for three-dimensional treatment planning. This technology permits using tissue doses far beyond what was previously felt possible. As a result of Lichter's efforts and the accomplishments of his faculty, his department is today viewed as one of the country's outstanding radiation oncology centers. In 1993 Lichter was named the first Isadore Lampe Professor.

David E. Kuhl, an internationally recognized pioneer in emission CT and neurochemical brain imaging, was recruited from UCLA in 1986 as Beierwaltes' replacement. Given the historical evolution of nuclear medicine in the Department of Internal Medicine, the leadership of the institution decided at this time to continue this arrangement. Kuhl's division has become a world center for basic science and clinical research, involving in vivo imaging of the biochemistry and function of the brain, cancer and heart using state-of-the-art developments in positron emission tomography (PET) and (SPECT). The nuclear medicine faculty grew to its present size of 10 physicians and 12 chemists or physicists, all involved in radioactive tracer research; this is now supported largely by external funding that totals more than $7.5 million annually.

During the period 1982-1989, research space increased from 400 to 7,500 net square feet. In 1983 wet laboratory space was acquired in the new Medical Science Research Building for investigating and developing new contrast agents, and in 1985, the animal imaging laboratory was relocated and expanded with replacement of obsolete imaging equipment. In the same year a 2T chemical shift imaging unit for animal research (20-cm bore) was acquired, and an image processing laboratory was established under the direction of biomedical engineer, Charles R. Meyer, Ph.D. In 1991 a 7T MRI/S system (11-cm bore) was acquired in incremental space. The number of publications in peer-reviewed journals rose from 44 in 1982 to an average of 95 during the next five years. During a 10-year period the department's external funding support for research doubled, much of it from industry, reaching an annual level of $800,000. Although notable, this was less than expected in view of the department's great academic potential and impressive research facilities. However, there were numerous honors and significant accomplishments by

the faculty. Within a four-year period, three junior faculty members, Dorit D. Adler, David M. Williams, and Leslie E. Quint, received Clinical Oncology Career Development Awards from the American Cancer Society and funding for clinical oncology fellows was provided for approximately 10 years. Quint received two awards from the Society of Body Computed Tomography for her work on the use of carbon-13 magnetic resonance spectroscopy (MRS) in prostatic carcinoma and the use of PET/CT scans for staging the mediastinum in non-small cell lung cancer. Dorit D. Adler was appointed to the President's Cancer Panel Special Commission on Breast Cancer. In 1989 Glazer was appointed chairman of the radiology department at Stanford University and Gross assumed the chairmanship of radiology at Henry Ford Hospital; Gross was persuaded to return to the department in 1992.

Between 1982 and 1989 the faculty increased from 38 to 54 full-time equivalents, of which there were 46 physicians and eight basic scientists. Faculty members were given dedicated time, scheduled in advance, for research and other nonclinical activities. A practice of modified subspecialization was developed, allowing faculty members to work in two divisions, with one a "major" and the other a "minor" activity; this provided faculty enrichment and administrative flexibility while preserving the academic benefits of subspecialization. The total number of house officers was 36 in 1982, but when radiation oncology became a separate department, only 28 positions were allowed. The number of fellows gradually rose from four in 1982 to 16 in 1989. The postgraduate teaching program now included more interdepartmental conferences, an expanded noon conference schedule for residents and fellows and weekly divisional subspecialty teaching conferences. The number of radiologic examinations increased by 33 percent, totaling 270,000 in 1989, and the quality of patient care activities improved dramatically. A comprehensive program to raise faculty and staff morale was established and a successful "guest relations" program was developed under the effective leadership of Carol E. Wesolowski and Cathy L.Frank [15].

It is difficult to do justice to the advances in the department's clinical programs and academic accomplishments during this period. The following descriptions are an attempt to characterize the most important of these developments in each of the divisions.

An accomplished angiographer and interventional radiologist, Cho was an excellent mentor and role model. His division, vascular/interventional radiology, consisting of James C. Andrews, M. Victoria Marx and David M. Williams, was outstanding. Methods of tumor embolization and percutaneous angioplasty and venous sampling procedures for the detection and localization of hormone producing neoplasms were refined. Venous access procedures for prolonged intravenous therapies and percutaneous treatment procedures for ischemic complications of aortic dissection were pioneered. In addition, the scope of interventional procedures was expanded and techniques were developed for a variety of conditions, particularly gastrointestinal, hepatic and biliary abnormalities.

Glazer, an excellent clinician, mentor and researcher, exerted a major influence in the department, particularly in body computed tomography; Gross, Francis, Ellis and L. Quint played important roles in advancing this technology. Francis, who had trained in the department as a fellow, was an outstanding diagnostician and teacher. The CT criteria for staging primary and recurrent cancer of the esophagus were established. The department was selected as one of five centers to participate in the first Radiologic Diagnostic Oncology Group (RDOG) project, funded by the National Cancer Institute and the American College of Radiology, to study the role of various imaging modalities in patients with prostate and lung cancer; it was also one of a few centers involved in two subsequent trials for staging pancreatic, colorectal, ovarian and pediatric neoplasms.

Glazer and Aisen developed and refined MR imaging techniques early in the evolution of this technology when relatively little was known about its applications and usefulness; their work, done in collaboration with faculty in the basic science division, particularly Carson and Chenevert, contributed greatly to the department's growing national reputation. Important research accomplishments included the development of MR criteria to distinguish adrenal adenoma from metastatic carcinoma and hepatic metastasis from hemangioma. Attention was drawn early to the role of MR imaging in evaluating musculoskeletal neoplasms and degenerative and traumatic lesions of articular cartilage and diagnosing systemic lupus erythematosus and Wilson's Disease in the brain.

In 1989 Brunberg succeeded Gabrielsen as director of neuroradiology and was named co-director of magnetic resonance imaging. Board-certified in neurology and pediatric neurology and having completed a neuroradiology fellowship with emphasis on MR imaging, he greatly enhanced the division. A painstaking and diligent researcher, he contributed significantly in pediatric neuroradiology, established a program in interventional neuroradiology under John P. Deveikis and expanded the fellowship. He and Chenevert established the clinical significance of MR water diffusion measurements for characterizing central nervous system lesions. In collaboration with nuclear medicine, PET scanning techniques were modified to allow for quantifying cerebral blood flow during interventional procedures. Gabrielsen continued as a senior mentor, particularly in his area of expertise, cerebral angiography, and Stephen S. Gebarski took a key role in radiology of the head and neck. O. Petter Eldevik, Douglas T. Quint and Richard A. Levy were valued members of the division.

Hernandez, a superb diagnostician with broad interests and expertise, particularly in pediatric computed tomography, continued the rich tradition in pediatric radiology. Under his influence CT became an important pediatric imaging modality. The role of MR imaging in congenital cardiac diseases and dermatomyositis was described. Blane, White and DiPietro expanded the use of pediatric sonography and DiPietro pioneered its use in diagnosing the tethered cord syndrome. Estelle R. Bank, Alan E. Schlesinger and J. Michael Zerin were important faculty additions in pediatric radiology. In addition,

Schlesinger succeeded Vydareny as director of medical student education.

Gross, an excellent teacher and superb clinical radiologist, was in charge of chest radiology prior to 1989. During this period the role of CT and related criteria for staging lung cancer were defined. In 1991, Cascade was recruited from Sinai Hospital, Detroit where he was department chairman. He was appointed director of chest radiology and placed in charge of the department's quality assurance program. Following his appointment as chief of the division, multidisciplinary programs with pulmonary medicine and thoracic surgery were enhanced. High resolution computed tomography (HRCT) was refined and used to assess patients with idiopathic pulmonary fibrosis and lung transplant candidates. Other individuals whose major activity was in this division include Ella A. Kazerooni, Perry G. Pernicano, Khalil K. Shirazi and David L. Spizarny.

Prior to 1987, gastroenterology and uroradiology were headed by Trenkner and Marco A. Amendola, respectively; Trenkner was an excellent teacher and Amendola was a highly regarded clinical radiologist Subsequently, an abdominal division was created with Ellis as director. In 1989, Melvin T. Korobkin, who already had an international reputation for his expertise in uroradiology and abdominal CT, joined Ellis as co-director. Faculty in this division, other than those already mentioned, include Charles S. Marn, Tom Miller Jr., and Joel F. Platt. Research on the CT findings in abdominal trauma focused on the detection and significance of pneumoperitoneum, the value of delayed and enhanced images of the pelvis to detect bladder and urethral disruptions and the detection of duodenal injuries. Complications of adrenal mass biopsies were described and a prospective evaluation of CT attenuation values and chemical shift MR sequences to differentiate benign adrenal adenomas from other adrenal masses was begun. Using duplex Doppler sonography, new applications were developed for differentiating obstructive from nonobstructive urinary tract dilatation and types of medical renal disease and for identifying early hepato-renal dysfunction.

Owing to the leadership of D. Adler and Mark A. Helvie who succeeded Andersson as directors of breast imaging, this division became one of the nation's distinguished centers. Important faculty additions include Debra M. Ikeda, Naomi M. Kane, Chintana P. Paramagul, Murray Rebner and Todd E. Wilson. The clinical program expanded with the establishment of an off-site breast imaging unit in addition to the one in the Taubman facility and mamographic techniques were further refined. Fine-needle aspiration of the breast was introduced and its efficacy in managing palpable and non-palpable lesions was established. In collaboration with Heang-Ping Chan of the basic science division, digital processing of mammograms were investigated to determine its role in diagnosis, especially with regard to enhancing the detection of microcalcifications.

Silver, as director of ultrasonography for 10 years, deserves credit not only for advancing this technology but for establishing the division as a highly regarded, nationally recognized center. Jonathon M. Rubin,

who joined him as co-director in 1987, enriched the group with his strong background in medical physics. The division became known for advancing neonatal cranial and intraoperative sonography. Knake, of the neuroradiology division, pioneered the latter which significantly altered neurosurgical practice. The division was among the first to employ color Doppler techniques to image blood flow in tumors, particularly in the breast. Concepts of flow quantification were developed, which soon led to power Doppler sonography, a technique which significantly increases sensitivity to low-flow states. One of the first papers on elastography, a technique which uses tissue motion to measure tissue stiffness, was published. Richard A. Bowerman gained a reputation for his expertise in obstetrical sonography. Other radiologists who had major roles in the division include Ronald S. Adler, Robert L. Bree, and Ronald O. Bude.

Initially, Braunstein, a fine teacher who was popular with the clinicians, headed musculoskeletal radiology. In 1989 R. Adler was appointed to this position. His advanced training in physics enhanced the division's basic research activities and his special interest in ultrasonography led to the expansion and refinement of sonographic applications for musculoskeletal lesions. Working closely with Rubin and Carson, he established the clinical use of power Doppler for assessing soft tissue inflammation. In addition he developed the technique of using angle-dependent acoustic backscatter for measuring articular cartilage surface fibrillation, an early finding in osteoarthritis. Other faculty in this division include Robert M. Cantor, Kathran M. Chan, Craig Lundquist, and David R. Pennes.

Several radiologists served primarily at the Veterans Administration Medical Center during this era. These included Pauline W. Chee, Kathleen M. Gebarski, Deborah S. Granke, Mary M. Hamer, Angelena M. Ho, Albert H. Peterson, Bruce D. Richmond, Karen J. Stuck, Kay H. Vydareny and Gail M. White. Under the leadership of Robert L. Bree who was named director of radiology services there in 1987, ultrasonography became a more widely used modality, particularly with regard to prostatic lesions and Doppler sonography, and academic activities grew significantly.

The establishment of a basic science division was a major factor in enhancing the overall research capability of the department. Close collaboration between radiologists, many of whom already had significant interest and expertise in the basic sciences, and faculty in this division was stressed. Carson, nationally recognized for his work in ultrasonography, attracted capable faculty and post graduate fellows. Significant research was done using speed of sound and attenuation images in breast and testicular cancer and techniques were developed for creating microbubbles in blood vessels and the urinary bladder to enhance sonographic diagnosis. Methods were developed for registration and fusion of multimodality data sets (CT, MRI, PET) to improve diagnostic accuracy in tumors. Collaborating with faculty in radiation oncology, a technique for automatic definition of the liver was established for use in radiation treatment planning. Catheter-based intravascular sonographic imaging techniques and quantitative methods to

assess fetal maturity were developed. Quantitative diffusion and perfusion MR imaging was applied to neurological diseases, 31P spectroscopy was developed to evaluate muscle physiology, and magnetization transfer imaging was used to clarify factors that determine MR contrast. In addition a promising CT hepatocyte-specific contrast agent was developed. In addition to those already mentioned, the following faculty members played important roles in this division: Peyton H. Bland, J. Brian Fowlkes, Mitchell M. Goodsitt, Marc A. Longino, Loren T. Niklason, Brian D. Ross, Scott D. Swanson and Jamey P. Weichert.

Many who trained as residents or fellows or both pursued academic careers at other institutions. The outstanding faculty role models and the rich academic atmosphere in the department were important factors in their experience. These individuals include Joseph A. Borrello, Kenneth A. Buckwalter, Klaus P. Fechner, Rebecca L. Hulett, Ian A. Sproat, Joseph A. Introcaso, Laurie A. Loevner, Joel R. Meyer, Gwen K. Nazarian and Peter J. Yang. Many others, some of whom trained in the department, were recruited to the faculty and remained for varying periods. These include Farooq P. Agha, Joseph T. Latack, Barry I. .Samuels, Steven E. Sheffner, Wayne P. Wolfson, and Edward J. Woolsey.

Martel resigned the chairmanship in 1992 to return to clinical practice and academic activities. The department, already known for its outstanding clinical and teaching programs, was recognized now also as a major research facility. Its international reputation was enhanced; many distinguished radiologists from European and Asian countries came as visiting faculty, and many junior radiologists came as fellows for subspecialty training. Martel's colleagues and former trainees paid tribute to his contributions to radiology and to the department in the June 1992 issue of the department newsletter, "The Roentgen Review" [16].

Fig. 13. N. Reed Dunnick, chairman of radiology, 1992-present. An established, capable, and highly esteemed academic leader who continues the rich tradition in radiology.

N. Reed Dunnick (1992-Present)

N. Reed Dunnick {Fig. 13). appointed chairman in April 1992, was recruited from Duke University. He took his medical education at Cornell University, and following two years of training in internal medicine at the University of Rochester, he completed his residency in radiology at Stanford University in 1976. Before joining the faculty at Duke, where he was appointed director of diagnostic radiology in 1987, he was a staff radiologist at the National Institutes of Health for four years. He is known for his research on the CT and interventional aspects of uroradiology and served as president of the Societies of Uroradiology and Computed Body Tomography.

Since Dunnick's arrival, objective methods for monitoring department activities have been put in place. Richard H. Cohan was recruited to head the residency training program. Blane succeeded Schlesinger as director of medical student education. Evaluations with constructive criticisms of faculty teaching have improved faculty teaching skills. This method, with its monitoring system, will soon he reported in *Academic Radiology*.

Ellis was given the role of director of clinical services. The number of clinical conferences has increased and services are now able to provide same-day examinations for most patients. Revisions in many of the film processing and reporting procedures has reduced the time to generate the radiology report by 50 percent. In view of expected decentralization of professional services in the Medical Center, the department has been in the process of developing an electronic image management system so that subspecialty expertise can be provided regardless of the image location. The electronic radiographic image is anticipated to eventually replace conventional film, and electronic communication methods, including image transmission, will play an important role in future teaching and research missions.

Bree was brought from the Veterans Administration Hospital to the University Hospital to become the department's research director. Many more physicians are now involved in funded research and there are four research assistants to assist with this work. Marn replaced Bree as chief of radiology services at the Veterans Administration Medical Center and has been successful in acquiring badly needed equipment including a digital angiography suite and a continuous acquisition CT scanner. A computer link with the U-M Hospitals has been established which provides e-mail communication as well as remote report-approval capability. A contract for neuroradiology and vascular/interventional radiology services has better defined these departmental obligations.

Carson has continued to lead the division of basic radiological sciences. External funding has increased dramatically. For each of the last two years the Department of Radiology has had the highest percent increase in externally funded research of any department in the Medical School. As a result, three new faculty have been hired into this division.

Larry R. Kuhns was enticed to return to the University and the C.S. Mott Children's Hospital. Martin R. Prince, recruited for his expertise in magnetic resonance and vascular radiology, became co-director of MR and has firmly established MR angiography as a commonly used diagnostic technique. Junior faculty members who were recruited by Dunnick include Kei Doi, Kimberly A. Garver, Lynn K. Joynt, Sahira N. Kazanjian, Joel S. Newman, Stephanie K. Patterson, Marilyn A. Roubidoux, Peter J. Strouse and Daniel S. Uri. Crabbe, Cohan and Newman received the department's "outstanding teacher of the year" awards in successive years (‘93-'95).

The faculty continue to distinguish themselves nationally in the quality and number of scientific contri-

butions, awards and honors. In succeeding years, 1990, 1991 and 1993, Holt received the gold medals of the Society of Pediatric Radiology, the Association of University Radiologists and the American Roentgen Ray Society. In 1993, culminating many years of research, Weichert and Longino received a major award from the Society of Body Computed Tomography and Magnetic Resonance for their work, "Targeted Polyiodinated Triglycerides for Hepatic CT." Having received national recognition for his expertise in quality improvement in radiology, Cascade was appointed chairman of the American College of Radiology Task Force on Appropriateness Criteria in 1993. In 1995 Kazerooni was selected as one of five young radiology investigators in the nation to receive a GE-AUR Radiology Research Academic Fellowship Award, Silver received the Harry Z. Mellins, MD Master Teacher Award in Radiology from the alumni association of his alma mater, the State University of New York Health Science Center at Brooklyn, and R. Adler received the James A. Shannon award from the NIH for his work with angle-dependent acoustic backscatter.

Teaching and research at the University have been largely supported by patient care revenues, as in most academic institutions. The radical changes in our nation's health care delivery system will continue to have a major impact on academic programs, and the department will continue to be challenged to "do more with less." Nevertheless, the stewardship of the department has passed to a capable academic leader. He and his talented and dedicated faculty face a difficult new era. However, the progress of the last three years indicates that the rich tradition of radiology at the university will continue despite this challenge.

Overview

Dedicated to teaching, technical innovation, and the highest standards of practice and research from the beginning, the University of Michigan's leaders provided models of excellence and inspired countless radiologists and scientists. The department has grown continuously to world-class stature and, starting in the 1950s, spawned a steady stream of academicians. Its influence is reflected by the fact that 460 residents and 182 fellows were trained, to say nothing of the many who served on its faculty before moving to other institutions. Of these residents, fellows and faculty, 20 are current or past chairmen o; academic radiology departments, and 77 are members of the Association of University Radiologists. However, the ultimate legacy of the Department of Radiology lies in the rich values instilled in its trainees who went elsewhere and entered community practice, assumed leadership roles in our professional societies, and distinguished themselves in teaching and research.

Author's Note

This history of radiology was organized according to chairmen's tenures as a matter of convenience. Chairpersons play pivotal roles in recruiting and retaining faculty, nurturing their academic development, setting priorities and goals for the department, and negotiating for space, equipment and financial support. Obviously, the success of the department does not depend on the chairperson alone. The faculty, particularly division directors and directors of special programs, establish through their dedication, talent and energies the effectiveness of the clinical, research and teaching programs. It is these programs which ultimately determine the overall success of the department and create the positive environment that is key to recruiting outstanding residents, fellows and faculty. All members of the department's various "job families" contribute to this success in various degrees. An important role of the chairperson is to motivate and inspire the faculty and staff and direct attention to the department's mission, role and responsibilities [15].

The evolution of radiology as a medical discipline during the past century has been phenomenal and I am obviously proud of the many outstanding contributions made by our department. My passion for radiology and its growing importance in the practice of medicine is shared by many of my colleagues. Whereas pathology was once viewed as the backbone of medicine, modern medicine now has two backbones, one of which is radiology. This has been particularly true since the emergence of computed tomography, ultrasonography, single photon emission tomography, positron emission tomography, magnetic resonance imaging and the many percutaneous interventional techniques guided by imaging modalities. The attractiveness of radiology is reflected by the increased number of candidates for residency and their outstanding qualifications.

Throughout my tenure as chairman, I vigorously resisted repeated efforts of chairmen of clinical departments to obtain jurisdiction for various imaging modalities. Such moves would not have been in the best interests of patient care, and would have greatly weakened the clinical, teaching and research missions of the department. A robust academic radiology department invariably strengthens the clinical and academic programs of other departments. It was particularly disappointing that, despite an intense effort in 1986, I was unable to persuade the medical school's executive committee to join nuclear medicine to radiology. Both departments would have benefited from such a union.

With regard to teaching, many medical schools underuse radiology in their formal curriculum. Physicians need to know how to employ radiology in their practices and choosing the most appropriate radiologic examination for a particular problem is often complex. In addition, radiology can provide a dynamic in vivo demonstration of pathologic processes and is admirably suited for teaching at both undergraduate and postgraduate levels. The responsibility for preparing medical students for clinical practice should rest with the faculty and we should periodically re-evaluate our curriculum in light of the changing patterns of medical practice.

The creation of a basic science division with emphasis on close collaboration between radiologists and

basic scientists was a needed and important development, particularly with the emergence of the newer imaging modalities. However, it is critical that we engage in meaningful patient outcomes research related to our many costly and complex radiologic examinations and procedures. We need to develop a better understanding of their efficacy, accuracy and cost vs benefit considerations. Such research is needed for the proper practice of radiology. Unfortunately, it will be challenging to sustain our research programs in the face of shrinking departmental revenues in the years ahead.

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