The Michigan Heart: The World's First Successful Open Heart Operation? Part I

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In 1952, a machine built by General Motors in Detroit made medical history. Dr. Forest Dewey Dodrill used it to perform the world's first successful open heart operation. The news media and others referred to this mechanical device as the Michigan Heart, because it was built and used in the state of Michigan and because the project was partially funded by the Michigan Heart Association.

There have been a number of books and many articles written about other open heart surgery pioneers such as Drs. John H. Gibbon, Jr., C. Walton Lillehei, and John W. Kirklin, who all followed Dodrill with reports of their own successful open heart surgeries. Almost nothing, however, has been written about Dodrill since that first case was reported. Now, 50 years later, it is time for that oversight to be corrected.

THE FIRST PATIENT

On July 3, 1952, a 41-year-old male suffering from shortness of breath was about to make medical history. He was the first patient on whom the Michigan Heart, officially known as the Dodrill-GMR (General Motors Research) Mechanical Heart, was successfully used.

The patient was born in Poland and during World War II had enlisted in the Polish army. "But," according to Henry Opitek, "when the doctors examined me, they said my heart was too bad for combat or any other [physically active] duty."[1] He remembered that he had been bothered by chest pains for many years, tired quickly, and was short of breath.

When he was admitted to Harper Hospital for the surgery, he recalled seeing dogs romping on the roof of a nearby building. He wondered why each dog had a shaved chest. He later learned that they had been used in the final test of the mechanical heart machine before his surgery. The operation corrected his mitral heart valve, which had become incompetent as a result of the rheumatic fever he had many years before. While he was told he would be the first patient to use the new mechanical heart, he had no idea that the device would eventually be placed on display in the Smithsonian Institution in Washington, DC.

The physicians donated their services, but Opitek received a hospital bill of $340 (room rate of $14/day). The Michigan Heart Association and his physicians paid a portion of that bill.

Henry had been a bachelor at the time of his operation in 1952. Seven years after the operation, he met and married a widow who was visiting this country from Poland. According to an article in the *Detroit News,* "On the 21st anniversary of his operation, Opitek, now a gray-haired 62½-year-old machinist, sipped a cherry-flavored brandy in a merry toast. He lives in a modest home in Wyandotte [Michigan]. He takes full advantage of every hour. He has very little physical discomfort, and does everything any 62½-year-old would do. He is looking forward to an easy retirement."[1] In a subsequent interview with Opitek 27 years after his surgery, it was reported that he "is now a healthy 68-year-old retiree."[2]

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While the medical ethics of those days kept all patients' names confidential, those same ethical standards also dictated that nothing could be reported or printed about the operation until a full technical report had been published in a medical journal. When the required report finally appeared in the October 18, 1952 *Journal of the American Medical Association,*[3] newspapers all over the world headlined the story. The nickname for the device, 'The Michigan Heart' seems to have originated with a member of the Michigan Heart Association or research team or someone else at Harper Hospital. It appeared in many of the newspaper headlines on October 17 and 18 and was also the title of an October 27, 1952 article in *Time* Magazine. Other newspaper headlines referred to it as 'Robot Heart,' 'Iron Heart,' 'Mechanical Heart,' 'New Gadget,' etc. The use of the mechanical heart at Harper Hospital was designated one of the top ten scientific developments of 1952 by the National Association of Science Writers. One author (CHH) recalls, "It was also voted the top news event of the year by one of the major networks." Although General Motors' involvement in the project was well described in the news, the names of the General Motors' engineers and scientists were kept anonymous. At the request of the Smithsonian Institution, the Michigan Heart was presented to the museum on September 9, 1954 for permanent exhibition.

DODRILL'S HISTORIC OPEN HEART OPERATION

Dr. Forest Dewey Dodrill was the surgeon who performed the historic operation on Henry Opitek for his deformed mitral valve that was predominantly incompetent secondary to fused chordae tendineae. According to a medical report, the patient had "a definite history of 'rheumatism' (rheumatic fever) in earlier life," and during the previous year had noticed increased shortness of breath with exercise and had a loud heart murmur.[3] His chest x-rays showed enlargement of his left ventricle. Henry was admitted to Harper Hospital in Detroit, Michigan for surgery.

Dodrill used the Michigan Heart to bypass the patient's left ventricle for 50 minutes while he opened the patient's left atrium and worked to repair the mitral valve. The operating room team included Dodrill as the surgeon and three surgeons assisting him, Drs. Edward Hill, Aran Johnson, and Arthur Miller, and a couple of interns who took turns second- or third-assisting during various stages of the procedure. Anesthesia was administered by Dr. Alexander Bryce Stearns, chief of anesthesia at Harper Hospital. Dr. Robert Gerisch, a cardiologist, did the cardiac monitoring. Gertrude Wunsche, R.N., was the instrument nurse; Donna Graham, R.N., Jane Emery, R.N., and Wanda Plunkett, R.N. were responsible for the operating room.[4] Also present were Edward Rippingille and Louis Self, members of the engineering staff at General Motors, and Calvin Hughes, a research biologist at General Motors, who operated the Michigan Heart during the procedure. The operating room nurse in charge, realizing the potential historical significance of the surgery, allowed three medical students, two from Wayne State University and one from the University of Michigan, in the operating room to observe. Although none of the three were allowed close to the operating table, they were each required to be fully gowned and gloved.[5] They were also "sworn to secrecy" about the procedure until the case report appeared in the medical literature.

So what did Dodrill do and how did he do it?

With what we know today, none of us would have chosen a mitral valve repair for mitral regurgitation as our first case. We would not have had any training with this technique and would not have understood the functional anatomy. Perhaps worst of all, the echocardiogram had not yet been invented! On the other hand, Dodrill the pioneer did not understand the importance of these obstacles. Most of his intracardiac surgical experience was with closed mitral commissurotomies. He knew how to dilate the valve with his finger and separate fused chordae tendineae. He probably knew, as we do today, that sometimes as a result of the procedure, not only is the stenosis relieved, but the regurgitation also becomes less (of course, sometimes the regurgitation gets much worse). He probably thought that if he could see the valve, he could fix it.

In the last eight dogs, where he had used left heart bypass, all had survived and he could directly visualize the mitral valve in each.[3] In the canine experiments, one cannulá was placed through the left superior pulmonary vein into the

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left atrium and connected to tubing running to the Michigan Heart. Tubing coming from the Michigan Heart was connected to a cannula placed through the left subclavian artery into the aorta. After the pump was activated, Dodrill placed a clamp across the left atrium in such a way that all of the blood entering the left atrium from the four pulmonary veins was returned to the pump.[6] The left atrium on the other side of the occlusive clamp could then be opened, allowing visualization of the mitral valve.

In the first clinical case report after the pump was turned on, the pump flow was increased to 4.5 liters per minute and the aortic pulse pressure trace became flatline, indicating to Dodrill that he had achieved complete left heart bypass. Dodrill states, "An attempt was made to expose the mitral valve, but because of enlargement of the left ventricle, the atrium was displaced posteriorly and this could not rapidly be done in this patient." We interpret that as meaning he could not place the clamp as he had in the dog experiments across the left atrium, and therefore if he had opened the left atrium under these circumstances, the patient would have suffered a massive air embolus.

Dodrill therefore went to 'Plan B.' He placed a pursestring suture around the left atrial appendage (he probably had the pump flow decreased temporarily to keep the atrium full of blood while inserting his finger). "The finger was kept within the valve and the ventricle for a period of 14 minutes while manipulative procedures were carried out."[3] This is all he tells us about the surgical procedure he performed on the valve, but in two later reports with accompanying diagrams, he states, "The finger was inserted down through the mitral valve into the ventricle and the chordae tendineae were stretched to allow for valve closure."[7,8] In the actual hospital operative report, he says, "And by use of the finger technique, manipulation of the mitral valve and chordae tendineae was accomplished." In that same operative report form, on the line labeled, 'operation performed,' is listed, 'mitral commissurotomy.' In our view, he was separating fused mitral valve leaflets and chordae in a rheumatic valve that had mitral regurgitation as the predominant hemodynamic lesion. He seems to have been lucky with the results he obtained, perhaps very lucky! He also said, "It is probable that such a severe procedure could not be carried out when the left ventricle is maintaining the systemic circulation."

It may have been that Dodrill played down the mitral stenosis element in that first case report, which likely would have opened him to severe criticism from his thoracic surgery colleagues at that time for performing a mitral commissurotomy on bypass. The bypass technique was experimental, more complicated, and they would have considered the bypass support unnecessary. Interestingly, one of the authors (LWS) recently co-authored a lead article in *The New England Journal of Medicine* on a series of patients having open mitral valve commissurotomy.[9] During the 1954 annual meeting of the American Association for Thoracic Surgery, Dodrill gave a much more detailed explanation on his surgical technique for treating mitral valve insufficiency, but did not mention whether the Michigan Heart was used.[10]

In later clinical cases of left heart bypass, where he exposed the mitral valve for direct vision surgery, he cannulated each of the four pulmonary veins separately and then the veins were temporarily occluded between the left atrium and each cannulae. The left atrium[7,8] was then opened, clearly a very tedious cannulation procedure.

Postoperative follow-up

The patient remained in the hospital about 5 weeks after the surgery for observation. However, according to Dodrill's report, the patient felt he could have been discharged at the end of the second week.[3] In reviewing the actual hospital record, it appeared that the patient had no complications and likely would have been sent home on about the fourth postoperative day in today's era of HMOs and DRGs. In the published case report, Dodrill concluded, "The benefits to the patient have not been fully evaluated. The clinical examination, however, indicates there is a definite improvement. To our knowledge, this is the first instance of survival of a patient when a mechanical heart mechanism was used to take over the complete body function of maintaining the blood supply of the body while the heart was open and operated on." In a subsequent report, Dodrill stated that "This patient has great relief of his symptoms." "Preoperative capillary wedge pressure at cardiac catheterization was 18 mmHg." "Eight months after operation, cardiac catheterization was repeated and the pulmonary capillary wedge had fallen to 7-8 mmHg, or essentially to normal."[7] In another report 14 months later, Dodrill stated that the patient was vastly improved and the loud heart murmur the patient had before the heart surgery had almost completely disappeared.[8]

Dodrill and three other physician members of his team, Drs. Hill, Johnson, and Gerisch, received the Hektoen Bronze Medal for Original Investigation from the American Medical Association at its annual meeting in New York in June of 1953.

EVOLUTION OF THE MICHIGAN HEART

Starting as early as the 1930s, a number of groups around the world were working in research laboratories to develop heart-lung machines.[11] In the late 1940s, surgeons, including Dodrill, were performing shunt operations in children born with certain types of heart birth defects. The operations were "palliative." None of them corrected the problem because, according to Dodrill, in nine of ten children, the problem was within the heart.[12] Realistically, at that point in time there was no way of directly viewing defects inside the heart. But research had already begun on finding solutions to the situation. For Dodrill and his colleagues, that led to 30 months of research and experiments that culminated in building the Dodrill-GMR Mechanical Heart.

In late 1949, Dodrill approached Dr. Warren B. Cooksey, who was a cardiologist at Harper Hospital and president of the newly established Michigan Heart Association. Dodrill discussed the possibility of building a mechanical heart pump to be used for open heart operations. The Michigan Heart Association had just been founded under the auspices of the American Heart Association and one of the goals they were charged with was supporting innovative heart research. Charles E. Wilson was then President of General Motors and board chairman of the Michigan Heart Association. He was extremely interested in heart diseases, their causes, and cures.[13] He was contacted by Cooksey on Dodrill's behalf. Dodrill met with Wilson and showed him many sketches and ideas for building such a pump. Wilson, in turn, called Charles L. McCuen, Vice President of General Motors, who at that time headed the research staff.[13] They agreed that Dodrill's idea was worth an engineering try. The General Motors research laboratory was given the task of developing a mechanical heart pump for Dodrill. This project would be done courtesy of General Motors, as a public service. Incidentally, the very capable Wilson left General Motors in January 1953 to become the U.S. Secretary of Defense under President Dwight Eisenhower.

The General Motors Research team started by reviewing almost everything that had been written anywhere on the subject.[14] Wilson assigned Edward V. Rippingille, Sr., to be consulting engineer for the project in late 1949. "Rip," as he was known, a graduate of the London School of Technology, was a no-nonsense Englishman. His official title was assistant general manager of research at General Motors Research Laboratories, a position he had held since 1937. He had many engineering innovations and inventions to his credit. Until 1947, his immediate boss at General Motors had been the inventive genius, Charles F. Kettering, whose list of inventions include the automobile self-starter, ethyl gasoline, the 2-cycle diesel engine for trains, high compression automobile engines, freon refrigerant, and several types of accounting machines. Kettering was also co-sponsor of New York's Sloan-Kettering Institute for Cancer Research founded in1948. After Kettering stepped down at age 71 as vice president and general manager of General Motors Research Corporation in 1947, he continued to keep an office in the research building and remained good friends with Rippingille. Kettering, who had been vice president in charge of research at General Motors for 30 years, would stop by from time to time to check on the progress of the heart pump project and he and Rippingille would then have lunch together, which indicates that Kettering likely, directly or indirectly, had some influence on the Michigan Heart project. As General Motors' senior person on the project, Rippingille took charge and traveled extensively, examining various pumps that had been made for such use but had failed for one reason or another.[1] Rippingille summarized the problem, "We have pumped oil, gasoline, water, and other fluids one way or another in our business. It seems only logical we should try to pump blood."[14] During a period of approximately 30 months, six to ten different types of pumps were built and tested by GM engineers. Howard Kehrl was initially made project engineer for the heart project and guided the project until being transferred to Cadillac-Cleveland.[14] Louis Self was another engineer assigned to the project. There were eight or nine people from the research laboratories who principally worked on the project and probably another eight to ten who also contributed.

Dodrill's heart pump looked somewhat like an old Cadillac V-12 engine. What looked like six cylinders on each side of the engine were actually six separate pumping chambers. Interestingly, Dr. John W. Kirklin from the Mayo Clinic was also exploring different designs for a heart-lung machine in the early 1950s. As part of his research, he visited Dodrill's laboratory on November 13, 1952 with Dr. David Donald, a research veterinarian, and Richard Jones, head of the Mayo Clinic's Engineering Section. They also visited Dr. John Gibbon's laboratory in Philadelphia. Kirklin later commented that Dodrill's pump, built by engineers at General Motors, looked much like a car engine, whereas Gibbon's machine, built by engineers at IBM, resembled a large computer.[15]

By January 1951, research had progressed to the point that animal studies were needed. Dodrill got permission from the Harper Hospital administration to use the research laboratories on top of the Buhl Building, which was one of the buildings within the hospital complex.[16] The Michigan Heart Association supplied $18,500 in grants from 1949 to 1952 for Dodrill's research. That money was obtained from contributors to Michigan's United Foundation 'Torch Drive' and the 'Red Feather' campaign. According to Dodrill, " . . . nearly 84 dogs were lost in testing the pumps as part of the search for a technique that would save humans from heretofore inoperable heart conditions. Dogs doomed to gas chambers were taken from the pound and used for this project."[1] Dodrill took 2 days a week out of his busy schedule as a surgeon to work in the animal research laboratory (Fig. 1).

Eventually, Dodrill and his colleagues reached the point where eight consecutive dogs that were tested survived.[3] These, in fact, were the dogs seen through the window by Henry Opitek, who would be Dodrill's first patient to use the machine. Hughes recalls with a chuckle that the first surviving dog of that group was a German shepherd, which Rippingille subsequently adopted and kept at his country estate. "The dog greeted you in the driveway when you arrived and in Rippingille's opinion, the dog could do no wrong."

Calvin H. Hughes was hired by General Motors specifically for this research effort in early 1952. He had been working in a Department of Physiology research laboratory dealing with platelets and blood coagulation at Wayne State University School of Medicine. He was given the title of research biologist and made overall coordinator for the project. He participated in pump, oxygenator, and cannula design, and ran the pump and pump oxygenator for all of the animal experiments after joining the group. He dealt extensively with blood coagulation and anticoagulation issues as they related to the project. He also operated the Dodrill-GMR machine during all of the clinical cases from July 3, 1952 through September 1956. Hughes worked in the Buhl Research Laboratory at Harper Hospital, in the Harper OR, and conducted his own in vivo experiments with oxygenators and other equipment in his laboratory at the General Motors Research Center. As the project progressed, the physiologic aspects became seemingly more important than engineering and Hughes gradually replaced Rippingille as General Motors's leader of the project. Also as the years progressed 'Rip', as he was known to the group, retired from General Motors, but remained intimately involved with the Michigan Heart development. Hughes was on the General Motors payroll during the entire period until he left to attend medical school in September 1956 at the University of Michigan. While a medical student, he worked part time as a consultant for Dr. Herbert Sloan, Jr., and his newly formed open heart program at the University of Michigan. Dr. Hughes is currently a retired psychiatrist.

A few days before Dodrill was scheduled to perform a heart operation using the Michigan Heart on a young child, Hughes realized that none of the highly polished 'S' shaped stainless steel valved cannulae they had for cannulating the subclavian artery seemed to be the appropriate size for this patient. Early that morning, Hughes drove over to his laboratory at the General Motors Research Center where he discovered a labor strike in progress. Among those hourly workers who were walking the picket line were four or five highly skilled machinists who worked for Frederick Ross, foreman of the General Motors Research instrument shop. Hughes spotted them and explained to one of the machinists what he needed for the pending surgery on the little girl. This man talked it over with his colleagues, who said they would have to discuss it with the union

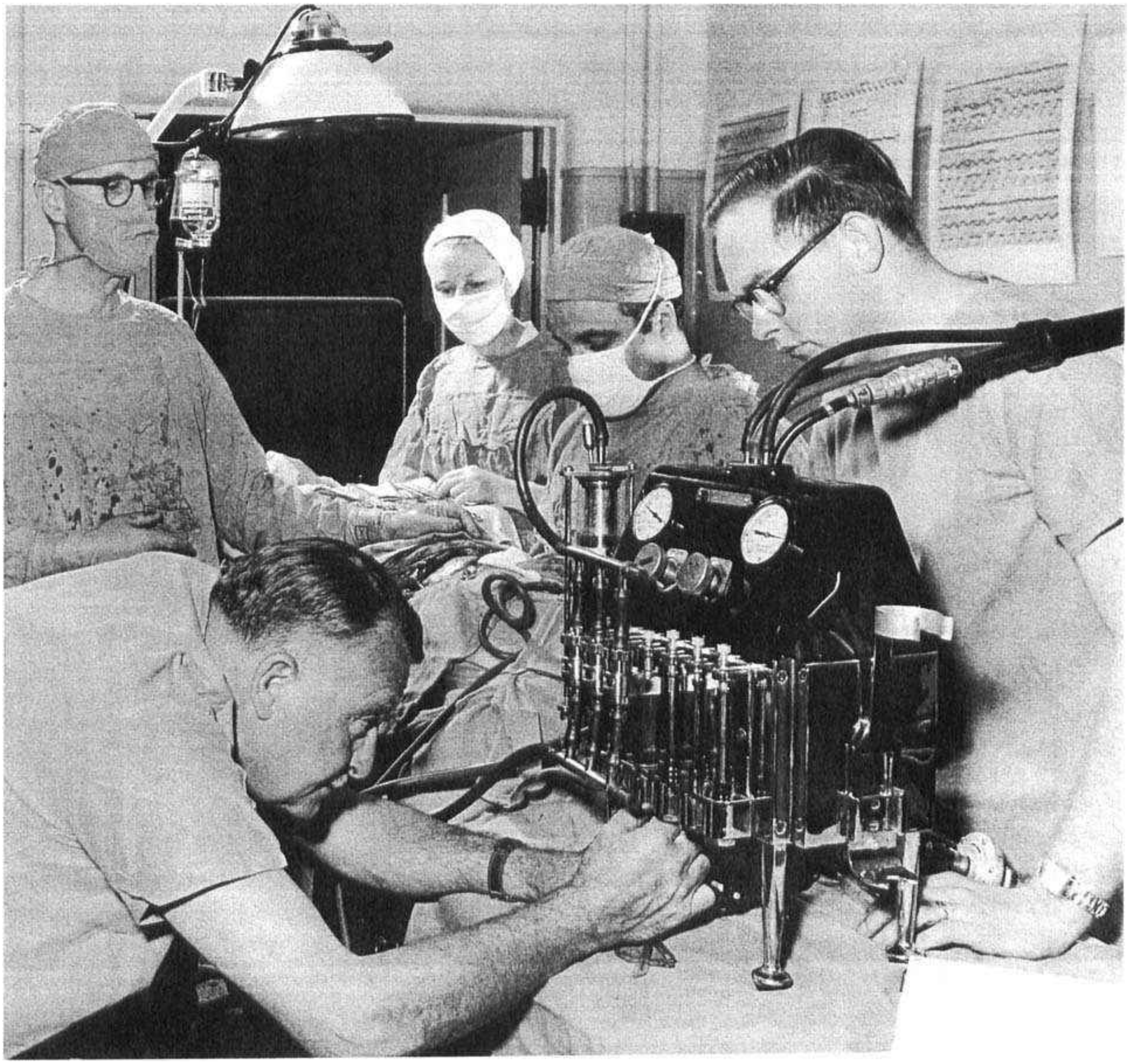

Figure 1. *Photograph taken in 1952 in the Harper Hospital complex, Buhl Building animal research laboratory during testing of the Dodrill-GMR mechanical heart. The mechanical heart is in the foreground. To the left and foreground is Rippingille. From left to right in the background are Dr. Dodrill, Gertrude Wunsche (Dodrill's scrub nurse), Dr. Aran Johnson (resident surgeon who assisted Dodrill, both in the laboratory and on his first open heart surgery cases), and Dr. Hughes. (Photo courtesy of Calvin Hughes.)*

person in charge of the picket line, who in turn gave his permission for them to return to the shop inside the picket line and make the needed cannula. They all got into Hughes' car, crossed the picket line, and headed for the shop. Around 4:00 PM, when they had completed the job, Hughes dropped them off and they rejoined the picket line. The operation, as Hughes recalls, was successful.

What follows is a description of how the mechanical heart functions. This information was supplied to the Smithsonian Institution by the Detroit research team (Fig. 2).

The Dodrill-GMR Mechanical Heart has two sides, one substituting for the right side of the human heart and the other for the left. During surgery, either one or both sides of the mechani-

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Figure 2. *The Michigan Heart was presented to the Smithsonian Institution September 9, 1954 in Washington, D.C. Left to right: Dr. Frank Van Schoick, President, Michigan Heart Association; George Cartmill, Director of Harper Hospital; Dr. F.D. Dodrill; E.V. Rippingille; Dr. Leonard Carmichael, Secretary of the Smithsonian Institution; C.L. McCuen, Vice President in charge of Research, General Motors, and Calvin H. Hughes. (Photo courtesy of Calvin Hughes.)*

cal device may be connected with the patient's circulatory system.

As the mechanical device is turned on, the human heart continues its beat and pumps itself dry. Normal circulation is taken over by the mechanical heart. When a patient's heart is dry of blood, the surgeon may make his incision and repair such defects as malfunctioning (heart) valves.

Prior to the use of this mechanical counterpart, a surgeon performed such operations by entering the heart with a small knife on the end of his finger to repair heart damage—without being able to see what he was doing.

Each side of the mechanical heart accommodates six pumping units. The number used depends on the volume to be pumped. Individual units consist of two valves, one inlet and one outlet, and a finger cot inside a glass cylinder.

Positive and negative air pressures are alternately applied to the inside of the finger cot causing it to expand and collapse. When a cot collapses, blood from a patient's system enters through the inlet valve and fills the glass cylinder.

When the cot expands, blood flows through the outlet valve into the patient's system. The medical-engineering team found this type of pump action may be made to approximate the human heart's action.

The device itself is portable—approximately 10 inches long, 12 inches wide, and 14 inches high.

The Michigan Heart also required a separate source of pressure-vacuum supplied by two commercially available pumps. They were placed side-by-side and put on a cart with wheels and connected by tubing to the Michigan Heart.

WHATEVER HAPPENED TO THE MICHIGAN HEART?

The General Motors engineering team built four Dodrill-GMR mechanical heart pumps for Dodrill between about late 1951 and 1956. The first two were model #47-3-1 and the other two #47-6-1. Use of the later Model #47-6-1 began in early

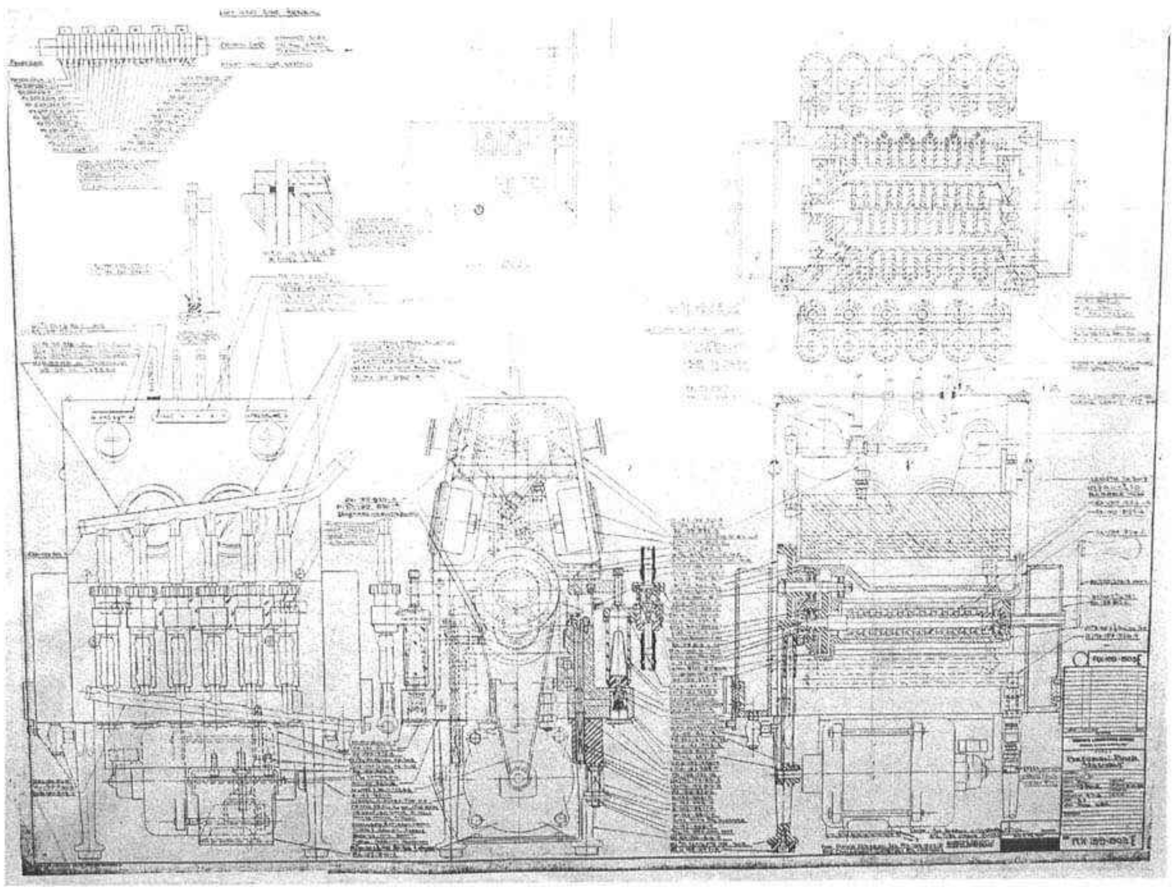

Figure 3. *Blueprints for the Dodrill-GMR (General Motors Research) mechanical heart, Model 47-6-1. These drawings were completed September 10, 1954.*

1956 (Fig. 3). Although they all looked similar, refinements were made in the internal workings as the project progressed. Also the mechanical oxygenator design changed over time. Dodrill was the only surgeon to use the Michigan Heart up until the time Hughes left the project in September 1956. After that we do not know whether other surgeons at Harper also used the Michigan Heart. General Motors' involvement in the project was phased out at about the time Hughes left, although they did offer to make subsequent repairs on the Michigan Heart. The last of the Michigan Hearts used clinically was retired at Harper Hospital in 1957 or 1958 when it was replaced by the latest version of a Gibbon-Mayo type heart-lung machine. Besides the machine on display at the Smithsonian Institution in Washington, D.C., another has been on display at the General Motors World Heaquarters, Detroit, Michigan and a third is on display in the lobby at Harper University Hospital.

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