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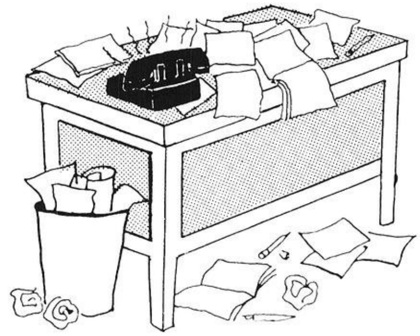
VOLUME 81, NO. 2 NOVEMBER, 1976

wisconsin engineer

The not so famous college career of a famous American, Charles Lindbergh

Long distance point to point bulk power transmission perfected with DC line current

Experimental surgical techniques being tested on a computer baby



FROM THE DESK OF THE EDITOR

Other than the presidential race, perhaps the biggest disappointment of this election year was the defeat of the transportation referendum. It was defeated by almost a two to one margin.

The referendum simply states, "Shall article VIII, section 7 (2) (a) and section 10, of the constitution be ammended to broaden the existing authority under which state funds may be appropriated for highways, for airports and for port facilities to apply, generally, to the development, improvement and construction of transportation facilities?" It allocated no money, instead it would have allowed the legislature to do so within the constitution of the state.

Need for the ammendment arises from discontinuing rail and bus service to small towns. Within the last five years, 56 Wisconsin communities have lost rail service and an uncounted number of jobs due to factories forced to close down. Without state and matching federal funds, 682 miles of track are threatened with abandonment.

The referendum was designed to help smaller cities keep existing bus and rail service. So why did it lose by such large margins in rural areas. We can only hope this was due to misinformation on the part of the voters. The largest misconception was that the ammendment was designed to let state money be used to bail out Milwaukee's bus system. Although the media in the state advised to the contrary, the stigma remained.

We feel that saving the rail service to small towns with state money is necessary to protect industry in rural Wisconsin. If the fear of bailing out city bus systems persists the ammendment should be rewritten to include only the state's railroads. Let the voters decide seperately on the issue of busses and railroads instead of lumping them together and watching the referendum fail time and time again.

Until a revised referendum can be put up to state voters, we urge that the state legislature do everything possible under the existing state constitution to financially help railroads keep service to small towns. We feel that the revenue from industriesthat may otherwise be forced to leave the state due to inadequate freight service will make up for money spent on subsidizing rail service.

—The Editor

The opinions expressed herewithin are intended to be representative of the editorial staff of the **Wisconsin Engineer** not necessarily of the College of Engineering or the University of Wisconsin system. We welcome your comments, pro or con.

wisconsin engineer

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Editor
Lauren Schlict

Business Manager
Dik Eierman

Business Staff
Bill Fuhrmann
Delores Malloy

Writing Staff
Brian Higgins
Scott Garrison
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Irene Piatek
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Terri Kosobucea

Layout
Brad Brown
Roxy Engelstad
Laura Kohn

Circulation
Brad Bondus
Randy Cigel

Photography
Pete McIver

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Chairman: D. C. WILLIAMS, Ohio State University, Columbus, Ohio 43210
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Charles Lindbergh, Engineering Student

by Brian Higgins

Does school get you down? Do you think you can't possibly stand another semester of calculus, physics or engineering classes? Well you're not alone. One of the University of Wisconsin's most famous engineering students, Charles Lindbergh, dropped out after only three semesters in mechanical engineering.

In September of 1920, Lindbergh rode his motorcycle down to Madison from his hometown of Little Falls, Minnesota, and arrived late for registration. His keen interest in machinery led him to study mechanical engineering. Wisconsin was the logical choice since it had the best engineering school in the area.

Lindbergh lived on the top floor of an apartment at 35 North Mills Street with his mother, who taught at Emerson Junior High School.

Two of Lindbergh's closest friends, Delos Dudley and Richard Plummer shared not only his interest in engineering but also his first love, motorcycles. He spent much of his time in Dudley's basement workshop. While the weather was good, they spent much of their free time roaming the countryside.

Lindbergh soon became an expert at riding his cycle down Bascom Hill and jumping Park Street. When winter came they built ice boats to race on Lake Mendota. One boat was powered by a motor driven propeller designed by the three engineering freshmen.

Apart from his motorcycle, Lindbergh found little else of interest in college. He did join ROTC rifle team and soon became the best shot. On many ocassions he scored fifty consecutive bullseyes, winning the competition. Being an extremely shy and quiet student, his extracurricular activities were extremely limited. One of the few class activities Lindbergh did take part in was the "bag rush." In this traditional competition, between engineering freshmen and sophomores, fifteen hugh sacks stuffed with straw were lined up on the field that is now the Memorial Union. The object of the contest was to get as many sacks as possible back to your siee of the field. Winning was made easier by throwing as many members of the other class into the lake and battling in the mud with the remaining few. Records show the freshmen were more victorious the year Lindbergh helped out.

Although he was on the winning side in the "bag rush", Lindbergh seemed to be fighting a losing battle in the classrooms. He barely struggled through his first year, failing an English course and even having problems passing physical education. His engineering courses interested him but the tedious assignments did not. Dudley was later to comment, "..I never worked with a smarter man, yet he continually got failing marks...Lindbergh did more in the courses which interested him...but refused to hand in written reports of his work, saying: "Why write it up? I can't teach the instructors anything." (1)

The campus of Charles Lindbergh

Charles Lindbergh as he appeared as a Mechanical Engineering freshman at the University of Wisconsin in 1921.

An honorary engineering degree was presented to Lindbergh a year after his famous Paris flight.

His wife was also a flyer. They flew many missions together.

was quite different from what it is today. Bascom Hill contained the entire campus except for the college of Agriculture. Engineers attended classes in the old engineering building (now education) and Science Hall. Directly across "the hill" sat the law building. This added excitement to the engineering student's life since the rivalry between the 'plumbers' and 'shysters' was at its peak.

While a student, Lindbergh wrote one essay entitled "A Day in the University Life of an Engineer". It gives a good picture of Lindbergh's life.

"...At exactly 7:15 the alarm rings in the room of a freshman engineer. It continues to ring. When the noise becomes unbearable, he crawls from bed, muffles the offending machine in the quilt, and becomes sufficiently awake to commence dressing. By quarter to eight he rushes to the lunch counter, and by 8:02 bursts into the room of his 8 o'clock, just in time to answer roll call. Fifteen minutes later he becomes conscious that a lecture is being given in the same room... At 11 he starts for his room with a firm resolve to study math. On the way he meets a Madison milkman who is just beginning his morning round. The Cardinal is on the porch. He looks it over while his roommate tells about last night's party. Then it is time to eat. He glances hastily at his math, decides that he will do it in class, slams his book shut and is off to make up for a light breakfast. In the math class he works one of the examples and copies four; then happily devotes his attention to the feasibility of sniping a hat through the window with a piece of chalk...a chemistry quiz is scheduled for the next day. Therefore from 3:30 to 10, with the exception of a few minutes for supper, he attempts to make up for six weeks' neglected study. At 10 o'clock, with formulas and elements playing tag through his brain, he sets the alarm, places it out of reach, and goes to bed, hoping that 'Louie' will leave a few answerable questions on the exam paper."(2)

Lindbergh continued to muddle through in his sophomore year. His mother had to often visit his professors to plead with them to be

Lindbergh is shown here with his plane, the Spirit of St. Louis, before starting on his transatlantic flight.

easy on her son. It was to little avail, as Lindbergh's interest in school waned. The prospect of working as an engineer in an office or factory became less and less appealing to him. He tried to decide what he wanted to do the rest of his life. Aeronautics interested him but Wisconsin offered little in this area. His love of machines had him considering becoming a mechanic. He even entertained some crazy idea of learning to fly.

Over the Christmas break of his Freshman year, a group of Norwegian engineering students constructed a ski-jump from Muir Knoll onto Lake Mendota. Lindbergh had always loved being a daredevil on his motorcycle and thought the ski-jump was a real challenge. During the winter of his sophomore year he planned to ride his motorcycle down the jump and fly out onto the lake, land upright and race across the ice. He needed only to devise a way of getting his motorcycle to the top of the 35 foot platform. Fortunately, he never got around to attempting this stunt, his attention was diverted to another idea- flying school.

Without his knowledge, Dudley had written to several flight schools and presented the information to him. Since his grades showed no signs of improving, Lindbergh picked out the flight school that interested him most. In the spring of 1922, he was off to Lincoln, Nebraska and flight training.

The rest is history. On May 21, 1927, Charles Lindbergh become the hero of a whole generation by being the first to fly nonstop from New York to Paris. One year later, he received an honorary engineering degree from the University of Wisconsin.

So if your classes aren't working out too well, why not fly from New York to Paris? You too might receive an honorary engineering degree.

(1) The Wisconsin State Journal, May 22, 1927, p.4

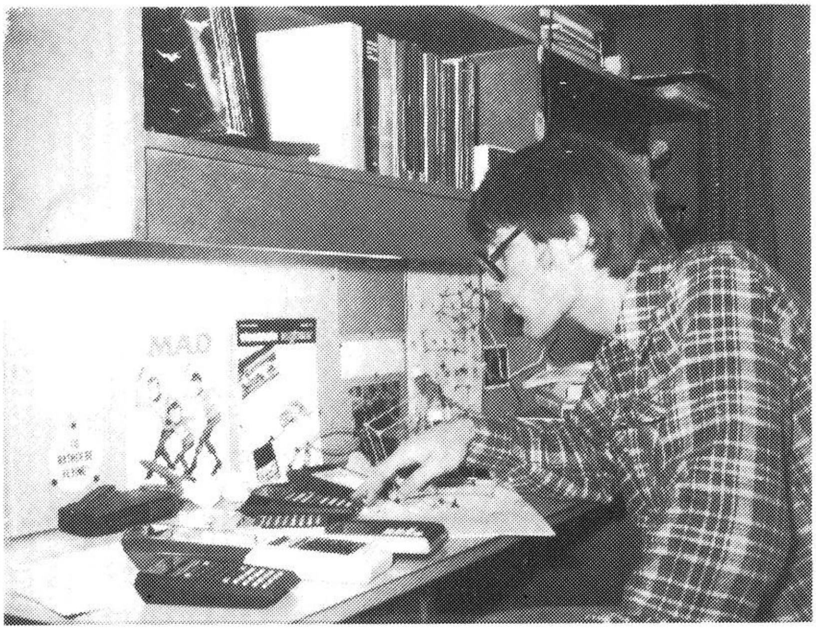
(2) The Wisconsin State Journal, June 1, 1927, p.8

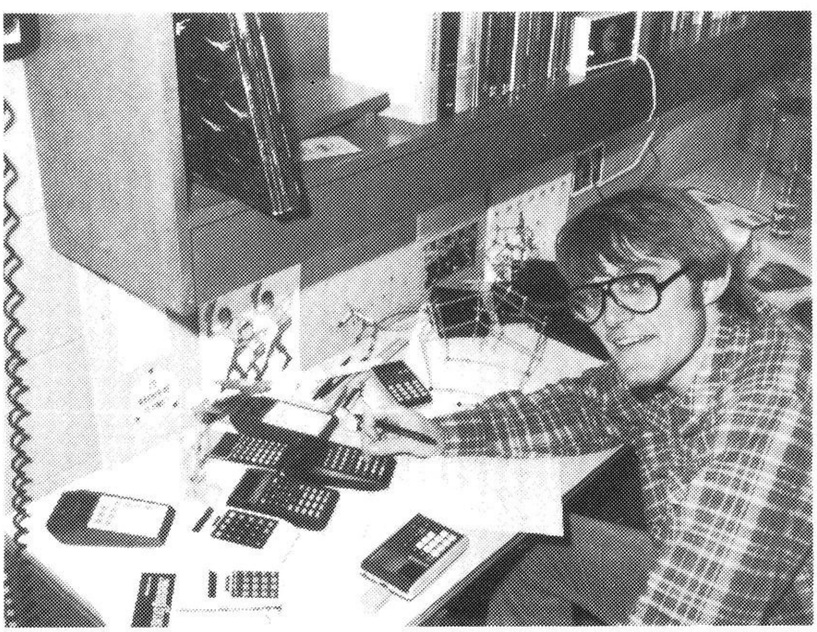
. . . Brian Higgins is a junior in Mechanical Engineering from Brookfield, Wis.

Lindbergh as he appeared shortly before his death in 1974.

MEET

Dexter Eigenbessel, Engineer





This is Dexter Eigenbessel, engineer.

He is employed as a ball bearing designer for a Midwestern company that assembles off-shore oil drilling rigs. He lives in a modest 3-story apartment with his wife, Blanche, and three children (they're expecting a second). His favorite leisure time activities are watching Star Trek and working out solutions for complex nonlinear differential equations.

Several other members of his family are also engineers. His father, for instance, headed the famed Tacoma Narrows Bridge Project.

Okay, Dexter isn't real, but engineers do have jobs, lifestyles, and interests that are a bit different than most peoples'.

We at The Wisconsin Engineer know this. We have articles on recent engineering developements, reports about some outstanding research projects, and even some occasional humor. And we do our best to make it most interesting and appealing to today's engineers.

Because we think engineers are special people.

He Reads the Wisconsin Engineer

The Magazine For, About and By Engineers

Computer Modeling:

The Baby Is a Computer

by Irene Piatek

In many of the sciences, such as physics and chemistry, models are made to represent complex concepts and ideas. The same is true in Biomedical Engineering. First of all, a model is something that simplies conceptual problems, either by words, diagrams, equations, or computers. It is an ideal system, but faithful to verifiable, real behavior; it is internally consistent and operates according to valid mathematical or physical laws. The system being studied, are sometimes revealed when its behavior differs from the ideal system.

In Biomedical Engineering, modeling can be defined as the simulation of a physiological function by means of a computer or mathematical equation. The purpose of this process is to duplicate the conditions under study, and to try experiments that would otherwise be harmful or damaging to the human body. There are three basic applications:

1) research - most common,
2) teaching - on the increase, with special equipment and special packaged programs,
3) clinical and laboratory - limited, use of simple, empirical models.

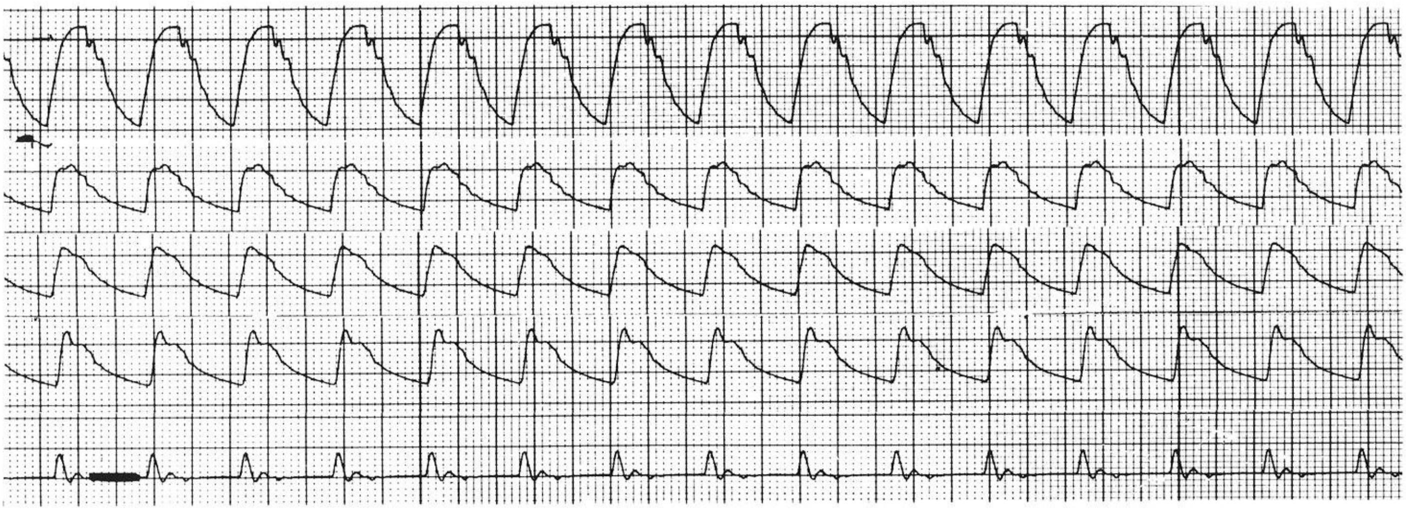
In Biomedical Engineering today, research is the largest area of pursuit, invloving computer modeling of biological systems and development of research instruments. In the future, as models become better and modeling of physiological systems becomes more and more exact, the field of clinical and laboratory engineering should grow larger.

Basically, there are two types of models, the physically based model and the black box model. The physically based model uses equations and terms individually related to the parts of the system being modled, while the black box type uses input and output signals of a system or subsystem to express its action as a transfer function. The physically based type is preferable, but it usually gives more complex models. The mathematical techniques most often employed in studing physiological systems include:

1) ordinary differential and difference-differential equations
2) digital simulation languages
3) probability and statistics
4) system theory
5) graphical methods

The basic tools used in computer modeling are the analog, digital and hybrid computers. The analog computer is the most economical way to solve many of the differential equations, which are the first approximations to dynamic biological systems. Another feature it has, is that the input, intermediate, and output voltages are analogs and measures of quantities in the biological problem. An oscilloscope can give a display of how the individual quantities being represented are varying with time. A digital computer, in contrast, is usually expensive and slow in solving differential equations. One advantage of the digital computer combines the best of both. It uses the continuous generation of functions of the analog component and the precision and data storage of the digital component. There is one major problem that must be overcome before the hybrid is of any use. This problem lies in the difference in computing speeds of the two component computers. Since the analog continuously generates the function, the digital must sample this function and then solve the appropriate equations. Oftentimes, because the digital performs its operations in sequence, the equations cannot be solved in real time. In other words, if something is not done to overcome this problem, the digital computer would fall farther and farther behind the data comimg in from the analog computer. However, the hybrid computer also has one major advantage over either of the two components. It can divide the problem into two parts, each computer doing the part to which it is best suited. Using the computer, it is possible to simulate and study complex and detailed systems.

Here at the University of Wisconsin - Madison, under the direction of Prof. V.C. Rideout, three graduate students; Ira Rampil, John



Electrocardiograph printouts can help researchers determine the health of the baby and determine to what extent the treatment is working.

Slate, and Ashok Gupta, are using the digital and hybrid computers, in Rm. 1011 of the Engineering Research Building, to study the circulatory system of a one year old infant and one with a birth defect known as Transposition of the Great Arteries. This is being done in conjunction with Dr. E.H. Blackstone in the Department of Surgery at the University of Alabama School and Medical Center. In this condition, the blood returns to the heart in the normal manner, but the blood does not get sent to the lungs to be oxygenated and then sent back through the heart and then to the body. Instead, there is one system in which the blood is pumped only through the lungs, and another in which the blood is pumped only through the body. (The pulmonary artery and the aorta are transposed; switched. See picture of heart) Usually accompanying this defect is a hole in the septum (the space between the two upper chambers of the heart) and if one is not there at birth, one will be placed there, so there is some exchange of blood between the two systems, so that the baby will live.

At about one year of age, the defect can be corrected by placing a y-shaped Dacron baffle between the two upper chambers of the heart. The procedure is known as the Mustard operation.

The procedure for studying and modeling a physiological system is as follows: 1) take the mechanical equivalent of the system (circulatory system - tubes and pump) 2) convert it to the electrical analog (schematic) 3) write the state equations of the system (solved with Euler Integration). The analog component of the hybrid computer generates the wave functions of pressure and flow, while the digital component solves the fourteen differential equations simultaneously.

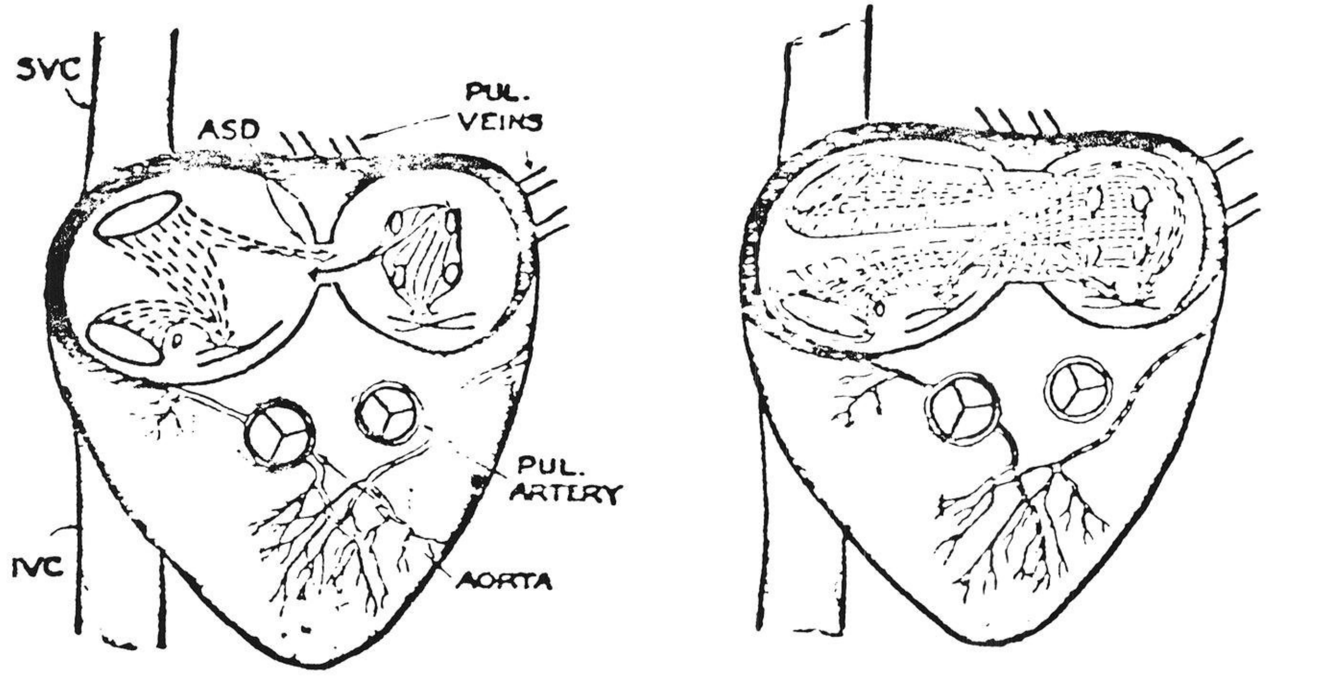
Prof. Rideout and Ira Rampil have solved the problems of time difference in the hybrid computer in a unique way. The digital computer samples the analog output every 1/25 of a second and does its computing. Since it takes longer than real time to do the computations, whenever the digital computer gets behind, the analog generation is temporarily halted and resumes when the digital is ready to accept more data (known as a time optimal system).

The way in which the system has been modeled is as follows: the normal circulation was first determined and studied, then the abnormal system, and finally the corrective procedure. The wave forms that were produced have been studied, and the model is constantly being improved as more data is obtained.

Presently, John Slate is studying the hypothermic reactions of the baby, during and after the operation. The operation itself involves lowering the baby's body temperature to 35°F, so that the body requires less oxygen while the heart is stopped. This cooling down stops the heart and allows the 45 - minute operation to proceed. John is studying the metabolic needs during the process, the shivering phenomena afterwards, and the type of incubator that is best for these children after the procedure has been completed. This work is being done primarily with a digital computer.

Ashok Gupta is studying the operation itself, and the effects of the body on the baffle. After a period of time, fatty deposits and other non-useful blood solids buildup on the soft baffle and slowly cause it to stiffen. The efficiency, as time passes, is also an area of concern. He is also trying to answer the question of how old the child will be, before the old baffle will have to be replaced with a new one. This has to be done, because as the child grows, the heart does also, but the baffle does not. This part of the study is nearing completion.

Ira Rampil is studying the model itself (and improving it): what the pressure waves look like compared to the actual ones seen in a real baby. As it is now, the model compares very well with the real function. The waveforms the computer is putting out are in agreement with what is taking place in the body. There is an advantage with the model, however. By adjusting heart rate, or 'cutting' a major artery, or 'adding' or 'removing' too much blood, the 'baby' can be made to 'die' on the computer, whereas in real life, this would be



(a) (b)

With the computer, researchers can give the baby congenital heart defects such as these missing valve and heart wall defects shown above.

very much frowned upon.

Other work that is waiting to be done is that of adding other parameters to the already existing model. These could possibly include: studying the effect that breathing has on the pressure and flow of blood; how CO2 content or pH factor affect the pressures and flows; and what effect the kidney function has. All these would improve and make the model more accurate.

One possibility, for the future in Biomedical Engineering, would be to take all of the studies done on the various systems of the human body and to put it all together and have a 'human being' on the computer. This has unlimited possibilities for experimentation and study. In the near future, it has been suggested that, here at Madison, 100,000 microprocessors be connected in parallel, to produce a computer that would have all the advantages of both the analog and digital computers and none of the drawbacks. The current estimate of the cost of such a computer is about equivalent to that of a good digital computer today.

Computer modeling has a wide range of possible applications today, in almost any field imaginable. Some of these include:

1) Neural Modeling
2) Muscle Modeling
3) Prosthetic and Life Assist Device Modeling
4) Mass Transport
5) Thermoregulatory Systems
6) Cell Dynamics
7) Epidemic Modeling
8) Ecological Modeling
9) Hospital Organization, Management, and Health Services Modeling
10) Physiological Control Systems
11) Body Motion Simulation
12) Pressure-Flow or Momentum Transport
13) Chemical Reaction Modeling
14) Population Dynamics
15) Genetics and Chromosome Mapping
16) Medical Diagnosis Modeling
17) Medical Education System Modeling

In the future, these will be the fields that will be of most interest and growth.

...Irene Piatek is a sophomore electrical engineering student from Menomonee Falls, Wis. She is interested in circuit design and biomedical engineering.

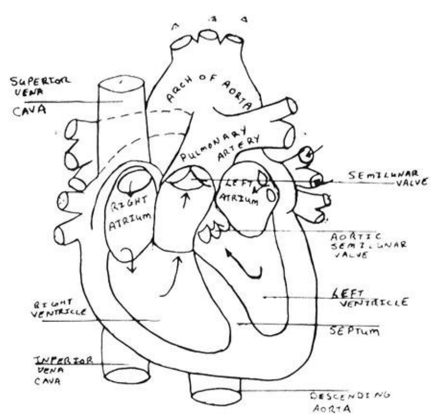


Diagram shows the makeup of a healthy heart.

D.C. Power Transmission

by Mike Stemper

DC Transmission Comes Back

In its infancy, electrical research was all DC (direct current). The first electric power system, built on Pearl St. in New York by Thomas Edison in 1882, was a DC system.

The invention of the transformer allowed AC voltages to be changed simply and efficiently. Combined with the polyphase induction motor, which runs on AC, the transformer brought about the use of AC for power distribution systems. AC systems were used almost exclusively by the end of the century.

In the last twenty years, many DC transmission systems have been built in various locations around the world, and more are under way: why has made this comeback after fifty years of dormancy?

To find out, let's compare various features of AC and DC systems.

The most important comparison to make in any engineering decision is economic. A DC system requires extremely expensive equipment at each end of the line to convert to and from AC. Although an AC system does not need this equipment, AC transmission line and towers are more expensive than DC. DC is two conductor, rather than three. This means a large cost reduction in copper, tower, and right-of-way. For a short line, the total cost for an AC system is less than that of an equivalent DC system, but, when the line is long enough, the AC system becomes more expensive.

Technical considerations are also important. AC systems can use transformers to change voltages between generation, transmission, distribution, and use. There is no DC equivalent of the transformer, limiting a DC system to one voltage. This means that DC systems are point-to-point with no use of the electricity between the points.

Another drawback of DC systems is that there is no high voltage DC switch. AC switching, on the other hand, is a highly developed art.

A DC system added as part of an AC system will improve overall system stability, while a long AC link will decrease stability.

These different characteristics of AC and DC systems show that the best use of DC is in a long-distance, point-to-point bulk power transmission system. There are several systems of this sort in operation in the United States.

The first one to be built was the Northwest-Southwest Intertie, which is a link from The Dalles, Oregon, to Los Angeles. This link takes hydroelectric power generated on the Columbia River by the Bonneville Power Authority (BPA) and transmits it eight hundred miles to Los Angeles. A second DC link has been built from The Dalles to Boulder City, Nevada.

There is also a link from Central Canada to Minnesota, supplying Northern States Power. NSP is constructing another line to run from Minot, N.D. to Minneapolis. Coal that is mined in Minot will generate the power that will be transmitted to Minneapolis. In addition to these DC installations in the U.S., there are about a dozen other DC links around the world, with more planned.

The heart of a DC system is the bridge converter. The circuit diagram of a converter is shown in Figure 1. It is basically the same as a rectifier used for DC power supplies, except it is designed for three-phase power input. The equivalent circuit for the converter as seen from its DC terminals is shown in Figure 2. It consists of a variable voltage in series with a resistance.

A constant current control is usually added to the converter. It keeps the direct current, I_d, within a few percent of a set current over a large range of positive and negative V_d. This means that the power delivered is proportional to V_d.

The most common type of DC power transmission network is seen in Figure 3. This is called a bipolar network, because one line has a positive polarity, and one line is negative. Typical values would be V_d=400KV, I_d=1 KA. Each half of the network operates independently from the other half with a ground return. This way, if one line goes out of service, the other one can continue to transmit power.

Under normal operation, each half operates with the same I_d. This causes the ground return current to net out to zero, which is a desirable

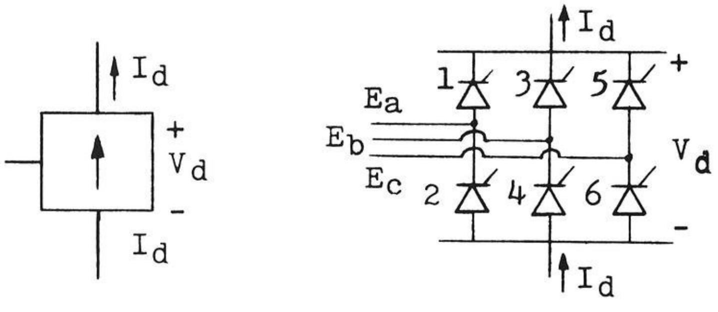


Fig. 1. Bridge converter

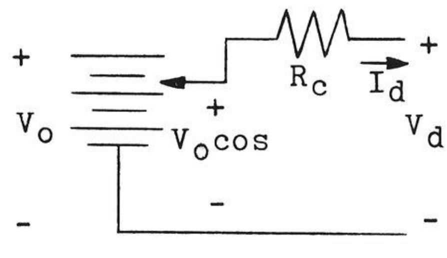


Fig. 2. Equal circuit

feature of any power system.

Since the current is almost constant, the power transmitted is proportional to the voltage, VD. With VD positive, power is transmitted from left to right in Figure 3. With VD negative, power flow is reversed.

The University of Wisconsin is a leader in the DC field. There are two courses in DC at an undergraduate level, ECE 539 and ECE 540. 539 is a lecture course on converter theory and 540 is the accompanying laboratory course.

Both of these courses are taught by Professor D.K. Reitan, who designed and built the AC DC Network Simulator. This simulator models the Northwest-Southwest Intertie, and has successfully predicted system problems. Dr. E. W. Kimbark, head of the BPA, took the DC courses here at the University, as did the engineers constructing a 1700 Km DC link in Zaire, which will be the world's largest when complete.

...Mike Stemper is a May graduate of UW and is presently employed by Northern States Power in Minneapolis.

HVDC systems under construction

System and Scheduled Commissioning Date	Capacity, MW	DC Voltage, kV	Length of Route, km	Valve Type	Six-Pulse Bridge Rating kV	Six-Pulse Bridge Rating kA
Nelson River Bipole I, Canada, 1975/76	1620	±450	890 (overhead)	Mercury arc	150	1.8
Vancouver Stages IV and V, Canada, 1976/78	552 (1976) 792 (1978) (winter)	+260 −140 +260 −280	41 (overhead) 32 (cable	Thyristor, air-cooled and insulated	140	1.72 (winter)
Tri-States, U.S., 1976	100	50	0	Thyristor, air-cooled and insulated	25	2.0
Cabora-Bassa, Mozambique–South Africa, 1977/79	1440 (1977) 1920 (1979)	+266 −533 ±533	1410 (overhead)	Thyristor, oil-cooled and insulated	133	1.8
Square Butte, U.S., 1977	500	±250	745 (overhead)	Thyristor, air-cooled and insulated	125	1.0
Skagerrak, Norway–Denmark, 1976/77	500	±250	100 (overhead) 130 (cable)	Thyristor, air-cooled and insulated	125	1.0
EPRI Compact Substation, U.S., 1978	100	100 (400 kV to ground)	0.6 (cable)	Thyristor, freon-cooled and SF_6 insulated	50	1.0
CU,* U.S., 1978	1000	±400	656 (overhead)	Thyristor, air-cooled and insulated	200	1.25
Inga–Shaba, Zaire Stage I, 1976	560	±500	1700 (overhead)	Thyristor, air-cooled and insulated	250	0.56
Nelson River Bipole 2, Canada, 1978/81	900 (1978) 1800 (1981)	±250 ±500	920 (overhead)	Thyristor, water-cooled and air-insulated	125	1.8

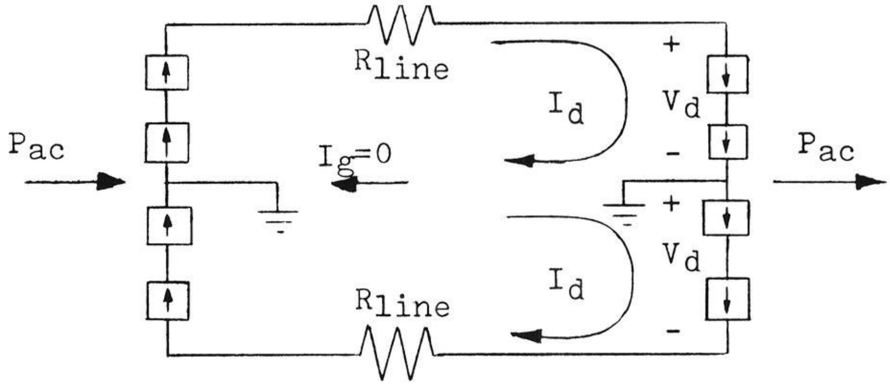


Fig. 3. AC-DC link

Dear Miss Schlict :

You and your staff are to be commended for the special Engineer's Day issue of the **Wisconsin Engineer**. Given an almost impossible deadline, you produced an attractive and highly useful magazine which is treasured by me and by many friends and alumni of the college.

Especially do I want to thank you and all who had a part in getting out this issue for the article on the dedication of our new library, and for the honor you have accorded me by once again placing me on your cover. I greatly value the many years of support that I enjoyed from the **Wisconsin Engineer** while serving as Dean and the continuing warm relationship that we enjoy.

Best wishes for a most successful year.

Sincerely,
Kurt F. Wendt

Dear Dik:

I wish to express thanks on behalf of the faculty of the College of Engineering and myself for the outstanding achievement the **Wisconsin Engineer** staff accomplished in preparing the special issue of the **Wisconsin Engineer** about the dedication of the Kurt F. Wendt Library and the program for Engineers Day. This truly was a unique issue and one which should become an historical issue of the magazine.

Sincerely,
W. Robert Marshall
Dean

We're looking for engineers who never gave electricity a second thought.

Most people think that at General Electric, our first, second, third, fourth and fifth thought is electricity.

Nothing could be further from the truth.

We did start out as an electrical-equipment company. And while products that generate, distribute and run on electricity are still very important to us, we've grown into all kinds of interesting business areas.

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