Bits

Except for a few random items of information, this month's Newsletter is devoted exclusively to the May 21st meeting of the Western Simulation Council held at the Rand Corporation in Santa Monica, Calif. At this meeting Hans Meissinger (Hughes Aircraft, Culver City, Calif.), Keith Uncapher (Rand Corp.), Walter Kaplan (UCLA, Los Angeles, Calif.), Floyd Steele (Litton Industries, La Jolla, Calif.), and Cornelius Leonides (UCLA) discussed "Trends in Simulation." Their remarks and the discussion were recorded. Tape recording was edited by Ed DeLand (Rand). Ed's notes were edited by your Editor, and his notes by your Secretary. The batted remains follow!

Pieces

WESTERN S/C MEETING OF 21 MAY ON TRENDS IN SIMULATION

About 75 representatives of 32 organizations gathered at the Rand Corporation in Santa Monica, Calif. to participate in a discussion of "Trends in Simulation" at the Western Simulation Council meeting of 21 May. By way of greeting and welcome Ed DeLand explained that Paul Armer, the announced host, could not be there because he was in Russia. As the logic relating these two facts seemed rigorously defensible, and the second one amenable to proof (and as a cursory check seemed to indicate that Paul was indeed not present), it was decided to accept Ed's statement and get on with the meeting.

Irwin Pfeffer (Space Technology Laboratories, Los Angeles 45, Calif.), Chairman of the Western Simulation Council, called on the first speaker, Hans Meissinger.

Meissinger on Trends

"I think we ought to address ourselves to this task by being open-minded. We know that all types of computers are here to stay, and that each one has its particular function. There might be some areas of overlap. However, I would like to point out how the different kinds of computers really complement each other. The one used should be selected to fit the engineering or mathematical needs of the user. Probably most people here are more familiar with analog computers than with digital, because the analog are more often used for simulation. But I will also take into account the areas where simulation ought to be done digitally. One of the primary objects of our panel is to examine the pattern of usage of analog or digital computers.

"Economy is important, and it's a fact of life that the digital computers are expensive; analog computers may be expensive or not, depending on how large a computer you want. In the case of Hughes Aircraft, per-diem expenditure for the machine, not counting overhead, is probably $350 for IBM equipment of the 709 type compared with $50 for the large analog; Mind you, this is one analog computer big enough to handle problems similar to those that the IBM 709 would handle, but certainly not able to do exactly the same kind of computations. Common sense must be used; we could not possibly use a digital computer of the magnitude of the 709 to conduct a trial-and-error experiment as we often like to do in engineering problems.

"It's just not feasible to let a computer of that type stand idle for 15 minutes while you decide on another way of attacking the problem. We can and often do it, however, with analog computers.

"I'd like to point out that the ease of problem interruption on a digital facility, and the relative awkwardness on an analog, is very important. On the other hand, a great deal of program adjustment can be done on the analog computer which cannot be accomplished as well on the digital. I talked to a mathematician the other day who swears by* digital computers. To him the idea of going into a computer lab and twiddling a knob

*Not at!
58 FACTS PROVE THE MC-5800 OBTLETES EVERY OTHER ANALOG COMPUTER MADE solves problems faster, more accurately, and at less cost!

The MC-5800 provides FASTER answers
1. Selection of real-time, expanded-time or high-speed compressed-time without reprogramming.
2. Real-time precision @ speeds to 60 solutions/sec.
3. Dynamic memory with time-base accuracy of ±10 µsec provides automatic parameter searching by iteration—an exclusive capability.
4. It programs 134 amplifiers, 30 electronic multipliers, 18 diode function generators, 2 time-delay generators, 8 relay amplifiers, and 6 servos from one 2128-hole patchboard.
5. Unique automatic problem check checks problem board patching in seconds and can record errors.
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7. Complete control of all amplifiers, multipliers, dividers, and non-linear equipment at patchboard.
8. Quick overload recovery in less than 1 sec.
9. It is the only computer offering card-programmed diode function generators.

The MC-5500 performs MORE ACCURATELY
10. Amplifiers provide lowest noise level output—less than one millivolt at unity gain.
11. Greatest distortion-free amplifier output — 50 mls at ±120 V—only 12 mls quiescent drain.
12. Lowest amplifier grid-current < 10^-6 ampere.
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14. Drift < 50 µv in 8 hours in summing mode.
15. Amplifier frequency response—flat to 10,000 cps and only 3 db down at 28 kc.
16. Only diode function generators utilizing resistors, potentiometers, and diodes of equal quality to those in computing networks.
17. Only diode function generators with individual hi-lo gain preset for each segment.
18. Lowest function generator drift < 5 mv/8 hrs.
19. Highest servo multiplier accuracy, ±0.008%.
20. Only fully shielded patch bay and patchboard.
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22. Highest performance electronic multiplier—flat to 10,000 cps and only 5 db down at 20 kc.
23. Only servo multipliers and resolvers with zero backlash gearing—maximum one part in 36,000.
24. DC tachometer feedback on all servos.
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26. Lowest step-function overshoot—less than 1%.

27. EVERY SPECIFICATION IS GUARANTEED TO BE TRUE PERFORMANCE STANDARD— IN SUSTAINED OPERATION.
28. Highest sin-cos resolver accuracy ±0.03% peak-to-peak.
29. Power supplies eliminated from console—lowest, most stable operating temperatures—rise < 5°C.
30. Passive networks stabilized at < 1°C above room ambient—no oven required.
31. Servo-set pots can be set to 2 parts in 10,000.
32. Accuracy of computing networks at least 0.01%.
33. Lowest computer cross-talk—rejection greater than 2,000 to 1.

The MC-5800 can be operated at LESS COST
34. Greatest available problem capacity per dollar—by 20%.
35. Least cost for future expansion.
36. Output tube filaments operate with DC bias for maximum life.
37. Centralized overload indication for quicker trouble-shooting.
38. Only computer with hermetically sealed transformers.
40. Plug-in relays and step switches throughout for lower down time.
41. Plug-in dynamic components ease maintenance.
42. Quickest trouble-shooting by automatic problem check.
43. Costliest and best patching system for lowest programming cost thru maximum reliability of patchcord connections.
44. Choppers de-energized when computer in standby for max. life.
45. Separate power-supply venting minimizes room heat load.
46. Exclusive equipment-door packaging for free access and quick maintenance without shutdown.
47. Insulated patchboard prevents costly shorting accidents.
48. Sealed servo gear boxes for maximum reliability.
49. Fully transistorized ADRC system with plug-in logic modules.
50. Available on lease basis as well as for purchase.

The MC-5800 can SOLVE MORE OF YOUR PROBLEMS
51. Exclusive dynamic memory makes automatic iterative solution of statistical or optimization problems a reality.
52. Dynamic memory + high-speed quick-reset rep-op provide practical approach to solution of simultaneous partial differential equations.
53. Exclusive bi-variable function generators can also be used as amplifiers, multipliers, or generators of single-variable functions.
54. More computer capacity per dollar means more solutions.
55. Solution of problems with up to 15 amplifiers in closed loops.
56. Starting with as few as ten amplifiers, at a cost of little more than the cheapest available computer, you can build to a complete computing center of unsurpassed performance.
57. Add-on capacity up to 134 amplifiers, 30 electronic multipliers, 18 diode function generators, 2 time-delay generators, 8 relays with amplifiers, 4 bi-variable function generators, 6 servos, 8 function switches—all field-expandable without mechanical rework or rewiring.
58. Add-on features include automatic problem check, integrator rate test, high-speed repetitive operation, dynamic memory, expanded time base, compressed-time base, servo-set potentiometers, and ADRC (Automatic Digital Recording and Control) system—all field-expandable without mechanical rework or rewiring.

There are over 100 more facts—let us tell you about them in person, or better still, visit our factory—and see for yourself!
to see what the results look like is abhorrent; he feels that this is the result of lack of forethought and proper planning by the engineer! Well, in some areas it is simply impossible to predict what parameter variations are practical or suitable. So I think there is certainly a place for cut-and-try techniques, and the analog computer is particularly well suited to them.

"Is there going to be an eventual ease of program adjustment on a digital computer to give the engineer the immediate feedback that he needs for optimization of synthesizes while he is standing by? The mathematician I talked to felt that if the engineer gets his results within a day, he should be very happy; I think the engineer wants them within a matter of seconds!

"What kind of man operates an analog computer? In my experience, he will be a systems analyst or an engineer with a broad feel for the physical realities of his problem, not a mathematician to whom the problem is an assemblage of differential equations. And the engineer should be free to interpret his results directly as obtained.

"Analog development should go in the direction of still more ease of manipulation—more automation. Not all of the automatic features now available inspire full confidence. I believe there is more to be done along these lines. New procedures ought to be cultivated.

"A fruitful field seems to be perturbation methods which lead to a combination of digital and analog operations, not in a simultaneous but rather a sequential operation. If a full-time solution of high accuracy is available from a digital computer, it would certainly be economical and practical to use an analog computer to study the effect of perturbations around this nominal solution. A typical case was first discussed by Emery St. George (formerly of MIT). The problem involved a ballistic missile and its perturbations due to windage, inaccuracies of the cut-off point etc. A followup of the digital study was conducted on an analog computer to discover trends. A new paper on the subject, presented at the Dallas National Simulation Conference last fall, has been published by Bush and Orlando of Cornell, and I recommend it highly."

Following Han's observations, Irwin Pfeffer introduced the next speaker, Keith Uncapher (Rand Corporation, Santa Monica, Calif.).

Uncapher on Digital Trend

"Within the spectrum of trends in simulation," Keith said, "I should like to cover a fairly narrow band—the direction in which the digital arts are going and why, and the implications for simulation.

"The current emphasis of the digital art is to bring about a new concept in machine design and fabrication which will result in fairly low-cost, very reliable devices with fast circuits and flexibility in design. Engineering techniques will be developed for the fabrication with relative ease of not only general-purpose computers but also special-purpose devices." The possible application of this new generation of computers to simulation is what brought Keith, a strictly digital man, to this meeting.

"The digital field," he said, "has adequate financial support, and has had it for a long time. This has pushed the digital art considerably faster than most people ever thought possible. Today, for example, the circuit designer faces a difficult fact of life: in being asked to design circuits which operate in the millimicrosecond region, he faces a real physical problem trying to assemble components. Since light travels essentially at the rate of one foot per millimicrosecond, the designer knows that if he is going to design a large system he must package the device in one or two cubic feet. This is a problem! He's not about to get around the difficulty with the hardware available at present.

"So, with the requirement for millimicrosecond speed it appears that the only way out is a new concept of design and packaging. A most promising design is the evaporation-deposition of thin films, which may be used for circuits which will operate in the required range. These circuits show promise because physically the components are one or two or three thousandths of an inch thick, and considerably less than a sixty-fourth of an inch long. Therefore, packaging several thousand such passive and active elements per cubic inch—hundreds of millions to the cubic foot—looks promising. Thus the transmission of digital signals in the milli-microsecond region may cease to be a problem.

"There are other payoffs which are extremely interesting; there is the possibility of using digital devices for simulation. This particular kind of fabrication of circuit elements lends itself extremely well to continuous automatic fabrication of incremental building blocks, and even large sections of digital devices, for example an entire adder. Ultimately the art shows promise of allowing the automatic fabrication of an entire machine. This is, of course, years off, but we'll get there!

"This technique also holds promise of allowing production of digital devices to describe the entire control process required to deposit large segments of a future digital computer or, in the limit, the entire digital device. This of course frees the designer of many problems he now faces using available components.

"The side effects of this kind of fabrication are extremely interesting. They promise low-cost elements, reliability beyond that expected now of the more discrete circuit elements, and extremely flexible organization and construction.

"These techniques, coupled with the fact (which most of us realize) that this is the age of discrete mathematical solutions rather than continuous**, would lead one to believe that there might be a more promising tool for simulation in the field of digital art. I believe this is true. And I think another attractive feature is that the research cost will not be borne by people interested in simulation. The real impetus behind construction of machines of this nature will come from the fields of business and scientific where machines now available fit neither the problem nor the cost.

"In the future, from the standpoint of implied reliability and flexibility of design, it looks as though the digital field will offer much to simulation. There is, of course, the problem of getting man into the feedback loop, which is important to many simulators. I believe this will be solved in the digital field, because there is much pressure to develop mechanisms to permit intimate contact between man and his machine. Some of the promising techniques which come to mind are direct voice communication between man and machine. Also there will be quite elegant display devices which will help to close the man-machine loop.

"I would expect more effort in the digital field than in the analog for some time to come, because more dollars are available for research.

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*Oh!
**or Ouch!
“I see a very promising tool for the field of simulation that will come about, not as a result of simulation per se, but because there is a requirement for millisecond machines and a requirement for coupling the scientist to his machine which will have incidental payoff to simulation.”

The next speaker was Walter Karplus (UCLA, Los Angeles, Calif.), whom Irwin introduced immediately after Keith’s talk.

**Karplus on Trends in Education and Field Problems**

“I’d like to comment on two items on the general subject of trends,” Walt began. “One of these is in engineering education. The other pertains to my own specialty, that of simulating field problems.”

“As most of you know, the subject of computation, as now handled in most departments of engineering, is a highly specialized one; we have one sequence of courses in analog computing, another in digital. In the analog area, we usually have an introductory and then an advanced course on computer operation; finally a course restricted entirely to applications. Similarly, in the digital area we have courses on the computer, techniques, and applications. The reason for the dichotomy is twofold; on the faculty of a typical college there are usually specialists in analog techniques and specialists in digital techniques, all of whom began some years ago to carve out empires in their particular areas, and there is pressure from industry to provide specialists in each area. I suggest that perhaps the time has come to unify the presentation of computer material in the college curriculum.

“We might begin by having a senior course: an introduction to analog and digital techniques. This should be followed by a graduate course touching such subjects as simulation using both analog and digital techniques. We might have another course in a subject like data processing or the handling of metering data, again using both types of equipment. This might be followed up by extending computer techniques into other fields.

“If such a program is adopted, I believe it will be felt in industry as it will tend to break down the sharp division between the analog and digital groups now existing in many companies. Thus we would have a group of engineers adequately qualified to evaluate any given problem to determine just how it should be handled. This approach would also help in combined simulation, in that a person with a background in both areas could determine at what point one should switch from digital to analog and vice versa.”

“As to the simulation of field problems, some months ago I addressed this group and discussed the Liebmann method of treating field problems—a method which is, to some extent, a blend of analog and digital techniques.* It employs a completely digitized finite difference approach to field problems. Both the space and time variables are approximated by finite difference expressions and the solution is obtained stepwise in time. On the other hand, the device is analog in that the data in the computer are continuous DC voltages measured at network nodes.

“Since that talk we’ve worked hard at UCLA (and there has been parallel effort in England) to generalize this technique, originally designed just for heat transfer problems, to handle problems of waves and beams. We have succeeded in designing a general-purpose computer for field problems—that is, one using plug-in connectors. A computer of this type is particularly useful for problems in which the field parameters vary with time or in which they are non-linear.

“Handling of time-varying or non-linear field problems has always been a tough one, on either analog or digital equipment. On analog the resistors or capacitors, or both, must be adjusted as the solution progresses. On a digital computer the program becomes even more complex. With machines of the type now being developed at UCLA and in England, such adjustments can be made more readily, although they still add to solution time.”

Irwin next introduced Floyd Steele (Litton Industries, La Jolla, Calif.).

**Steele on Trends in DDA’s**

“I’ll confine my remarks to trends in digital differential analyzers as they might be applied to simulation,” Floyd said.

“The actual state of the art today permits the development of a digital differential analyzer of desk-top size, having some 200 integrators. Such a device produced in economical quanti-

ties can be sold at a cost below $10,000, which permits its use at individual desks rather than in computing centers.

“The consideration of 200 to 1,000 integrators instead of, say, 20 or 30, begins to show a completely different speed balance between DDA’s and other types of integrators. I think one of the things that people sometimes fail to notice is that the DDA is inherently a parallel machine in its mode of operation, whereas the general-purpose digital computer is basically serial. Such an observation at present leads to confusion, because the words parallel and serial are being pre-empted by custom to describe memories rather than processes. The parallel nature of the DDA computational process, as contrasted to that of the GP, is evident, however, by considering that in one minor machine cycle the DDA advances the entire computation by one increment, whereas the GP advances by only one step in the large number of steps necessary to make a similar advance. The DDA is thus an inherently faster process, within its proper field of application. Because the general-purpose computer utilizes a serial process, parallel memories have been resorted to at great cost to make up for the speed deficiency. Because the DDA is computationally a parallel machine and has an excess of speed, it can utilize a serial memory to achieve great economy in cost. This low cost, as compared to the GP, is achieved while maintaining equality in speed. If 200 to 1,000 integrators are used instead of 20, the time to advance the computation by one increment still remains unchanged. Thus the relative speed has advanced 10 to 50 times, since the GP normally requires a time in proportion to problem size to advance by an increment. At this point the DDA generally will be found faster than the high-speed GP’s.

“When non-linear equations requiring 200 to 1,000 integrators are involved, it becomes difficult to appraise analog speeds. The growth of error will often render analog solutions meaningless. Results can be obtained only in conjunction with a digital computer, for example by running a wide range of digital solutions, then matching them by making analog adjustments. The end result can thus serve as an enormously expensive interpolate. It is doubtful whether this represents an economic application.

“Present-day DDA approaches have not successfully exploited the low-price market for which the serial memory embodiment is suited. Sev-
eral developments using parallel memories have been undertaken. This represents a case of mechanizing a parallel process in a parallel memory.

“Each integrator is made up entirely of sets of flip-flops, or alternately uses individual re-circulating memories. This leads to a fast computer for which, unfortunately, there is little economic use, especially since the hardware count increases enormously. A problem of intermediate size might require on the order of 100,000 semi-conductors for its solution. Parallel-memory differential analyzers are generally to be shunned as a development because the apparent applications, if carefully considered, can nearly always be reorganized to do without the parallel memory machine. In fact, I know of no valid applications, and would appreciate hearing of any.

“There is another class of machines that is wide between the incremental and the numerical—those that use an increment in the independent variable that is represented by a number of several bits rather than a single bit. One can carry this to the complete numerical increment, and have a peculiar kind of cross between the general-purpose and the differential analyzer processes. Again, it turns out that this speedup does not appear warranted in most applications. The cost and complexity seem to increase more rapidly than the utility.

“In many cases where the higher speeds appear to be needed, resolution has been confused with accuracy—a misunderstanding which has plagued the DDA both when applied to some simulation applications and when pronounced unsuitable for others. A great loss of speed is often occasioned by scaling the DDA to high accuracy in order to get 'smooth' results when low accuracy is acceptable. Smoothing can usually be done externally. As an example, pilot trainers do not need accuracies above about one part in 16 in most loops. At this accuracy a serial memory DDA has an excess of speed. Unfortunately, this application has often been investigated at accuracies of one part in several thousand, an artificial circumstance which excludes the low-priced DDA application.”

**Leonides on Training Devices**

_Pfeffer:_ Our last speaker is Cornelius Leonides of UCLA.

_Leonides:_ “I want to talk rather broadly about trends in simulation usage and present my own opinions on training devices in system and component design, on system evaluation, and anthropomorphic systems.

“There are several types of training devices—combat information center devices, flight trainers, and others. Initially, analog computers (AC rather than DC) were used for flight trainers. With an analog computer you are more or less committed to the simulation of a particular type of system—e.g., an F9F and no other. This leads naturally to the consideration of digital computers for training devices because all you have to do to the computer to change the plane being simulated is to slip in another program. By contrast, the analog calls for a change in the computer. So in the area of training devices my feeling is that probably digital computers have the edge.

“In the area of system design the first problem is component design. The component can be designed in other than real time either on the digital or the analog computer, and the hardware can be checked out dynamically before inclusion in the system in a real-time closed-loop system simulation.

“In system evaluation, we have the same sequence of possible combinations. I don’t think that in the areas of component and system design and system evaluation either analog or digital computers can be signed out as having the edge.

“An example of the power of analog computers may be found in their use for system synthesis.

“Recently I’ve been looking at adaptive systems, very non-linear devices. We have spent some months trying to evolve theories for the conception of adaptive systems and for ways of showing that one adaptive system is better than another. We have on campus a Bendix G-15 and an IBM 709, and we have been conducting our studies in the main with these. In the past few weeks we have had available an analog computer, and by playing with knobs and trying different setups we have developed whole new thought areas. I would say we have accelerated our program of research by several months at least. If we had gone on for several years without using an analog device these months would have been wasted, there’s no question about it. You
just can't plan everything. When you're studying systems like these you simply can't have everything well thought out in advance because there are lots of things you discover when you go off on tangents. And you want to go off on tangents! Of course I feel strongly, but until something is done with digital devices to make them comparable to analog ones, I think that analog devices hold a strong edge when it comes to studying problems in areas like the one I have referred to. This, after all, is the direction in which we're moving in control system synthesis. We've beaten linear system synthesis pretty much to death. Now we are forced to move into areas involving analysis and synthesis of non-linear systems.

"Another area that I wish to mention is the use of simulators in anthropomorphic systems—systems having human characteristics. In some weapon systems we want to replace the human operator—and we want to make decisions rapidly. The more routine decisions, which take place at a very rapid pace, call for the replacement of human operators. Probably here the edge is held by digital devices. Suppose we have a number of observations on an array of objects and they can be correlated. If the information is gathered in a systematic manner and can be represented by an array of symbols we can take the human operator out of the system and insert a device or devices which can make the necessary decisions much more rapidly and reliably.

"I also wish to mention these new devices called perceptrons, which are used for system evaluation where the system we're trying to evaluate is the human himself. From experiments on such machines we might, in the future, glean information which will put us in a stronger position when it comes to treating people with mental ills."

* * *

Irwin Pfieffer opened the question period with one directed to Hans Meissing: "I think you indicated that you expect an increase in post-flight evaluation using simulation. How do we prepare for this? Should we strive for a general program, either analog or digital, capable of simulating any system down to the last detail? Or should we try to tailor each post flight evaluation towards a particular case, thereby risking delay because we have to do the programming after the fact?"

"My own opinion is that we should shy away from the excessive complexity of large problem mechanization," Hans answered. "I don't think an analog computer setup involving more than a couple of hundred amplifiers is warranted, no matter how complex a task you want to simulate. I feel that some of the techniques which have been discussed recently for trying in perhaps a thousand or more amplifiers are not going to prove practical. I'm sure more complex jobs can be handled on the digital rather than on the analog computer. I would rather risk the delay of tailored programming than the delay involved in not getting a giant computer to work."

"In San Francisco," Irwin pointed out, "A paper was presented by Hintze in which he described a simulator to be used not only for post-flight evaluation, but also for in-flight control."

Dr. L. D. Kovach (Douglas Aircraft, El Segundo, Calif.) remarked, "I think the real trend is towards more faithful simulation, and this does not lead to simple systems, discrete systems, few amplifiers, nor small installations. If we're going to have more faithful simulation we're going to have to face the large installations. I'm thinking of the important non-linear effects that are all around us, and the continuity which is also in nature."

Karplus: "I would like to make a point. Getting the problem on the computer tends to become the end of the thinking phase of a project. I think this is a dangerous trend for scientific development. The increasing reliance on simulators brings with it a corresponding sacrifice of analytic ability."

Leondes: "I'd like to ask Dr. Kovach a question. Can you give us some examples in which the simulation was not faithful enough?"

Kovach: "Yes, I think I can. Several failures in missiles have been analyzed recently, and the failures have stemmed from inaccurate analysis of non-linear effects."

"Was it because the computers were not faithful enough, or because the mathematical model was not faithful enough?"

"I think both. I think the reason that our mathematical model was not faithful enough is that we've been limited in the actual equipment. We do not have 300 multipliers and a thousand amplifiers!"

Ed DeLand (Rand Corporation, Santa Monica, Calif.): "I'd like to ask Mr. Uncapher if it will be possible five years from now to tell a computer to design another special-purpose computer and then in a half hour walk away with a completely designed new machine ready to go?"

Keith: "By far the most difficult aspect of this problem is the design. That is why it was stated that a present-day computer can aid in the design, and this is about all I see for quite a while."

Ed: "I should like to simply give the digital computer a set of differential equations and have it construct from these equations a special-purpose computer which I can then install in my plant to control a process."

George Bekey (Space Technology Laboratories, Los Angeles 45, Calif.) said: "It seems to me that there are two good reasons for using an analog computer. One is to solve the problem which at present cannot be handled as efficiently, as well, or as inexpensively on a digital computer. This is gradually becoming less important as digital machines advance. More important, the analog computer is an insight accelerator. My personal feeling is that at STL this is really the only valid reason for analog studies. We certainly do not use the analog computer to get numerical results. This raises the question of why you would want to do a thousand-amplifier study as Dr. Kovach mentioned. If you do this you will completely negate the insight function. My feeling is that the surest way to wipe out the analog computing art altogether is to generate thousand-amplifier installations. To use an analog computer to gain insight into the operation of a physical system, we should limit ourselves to smaller problems."

"Another comment: Keith Uncapher said that we are tending in the direction of discrete mathematics. What has happened since our undergraduate days? It wasn't so long ago that the world was linear, free of disturbing influences, and continuous. Now it is not only non-linear and noisy; it's no longer continuous. It is discrete. Of course, there is some justification for this—as we look more closely at the structure of matter we see crystals which are discrete entities, as are the molecules. But when did this happen?"

Keith: "I guess it has always been. I can't think of anything more discrete than the charge on an electron. It is a matter of recognizing the dis-
How analog techniques assure accuracy in vibration test systems

MB Electronics, manufacturer of complete complex motion testing systems, uses modern analog computer techniques to reproduce actual vibrational environments met in the operation of aircraft and missiles.

The MB Model T88 Complex Motion Console, which puts all the system controls within easy reach of a single operator, utilizes 10 Peak & Notch Equalizers — each containing 8 K2-W analog DC amplifiers by Philbrick. The equalizers are the key to test system accuracy. They adjust to the exact inverse electrical equivalence of the mechanical system resonance, and automatically provide the mass offset required for any table loading condition by assuring a flat frequency response identical to that of the input voltage.

This is a special application, true. But it may provide the spark of an idea as to how you can use analog techniques — and efficient Philbrick plug-ins — to your advantage. Write for freely given opinions on your particular problem.

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CIRCLE 78 ON READER-SERVICE CARD

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creteness, and we are getting more perceptive.”

Bekey: “The analog then is really the gross look computer.”

Harold Ehlers (Autonetics, Downey, Calif.) said he’d like to give a summary of experiences at Autonetics on the DDA versus the analog computer: “When we set up programs on our DDA (the MADDIDA) typical of those which we solve in the area of flight control, we found that because the DDA used integrators for scaling, integration, multiplication and generation of functions, the 50-integrator MADDIDA had insufficient capacity. It was equivalent to a 20-integrator analog computer. Even with expert programmers we were not able to approach the speed of the analog. A typical trajectory problem requiring one minute on the analog took 60 minutes on the DDA. Of course, the MADDIDA is an old machine, but later checks in the industry, with particular problems, disclosed that for comparable accuracy the time involved for the DDA was substantially greater than for the analog. In addition, the parameters on the analog were more amenable to adjustment.”

Abbott Levine (NOL, Corona, Calif.): “There seems to be an impression that there is a basic speed limitation on the DDA. Of course this isn’t true. If you double the drum rate—i.e., the clock rate, you double the speed of the computation on the DDA, so one could easily design a DDA to be thousand or a million times the speed of the current DDA.”

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Information
(Without Theory)

Your Editor was invited by Daystrom Systems to participate in a panel discussion of the systems approach to process control as opposed to control by the application of standard control components. This session took place on July 20th in Ensenada, Mexico, and kicked off an intensive two-week training program for new marketing personnel.

Chal Jones, a charter member of the original Western Simulation Council and now General Manager of Daystrom Systems Division, and Thomas Hudson, Systems Coordinator, and this writer contributed to the defense of the systems concept. In the component applications camp were Manny Otis, Chief, Systems Engineering and Systems Coordinators Jim Burr and Martin Lyford. The discussion was moderated by John Palmer, Marketing Manager.

After it was agreed—more or less—that a systems engineer is one who considers the dynamics of an entire process, including all of the cross-coupling and feedback effects while an applications engineer considers the application of standard controllers to control individual units of the process, the discussion really got spirited.

So much has been written in support of the systems approach of late that I will not repeat the well-known and sometimes valid arguments in its behalf. I will however express some surprise (and—as one who in the past sold and installed, and later designed “standard controllers”—a little nostalgia) at the case for the opposition.

The systems approach requires very specialized talent, which will probably be expensive, and possibly special-purpose equipment which may have limited application if the process changes. And in many cases proprietary information may be compromised. Unless the process is complex, non-linear, or strongly influenced by cross-coupling and feedback loops it might be more economically “regulated” by standard components which can be installed by plant personnel and readjusted or used elsewhere if the process changes.

But if the process is sticky, the specifications on the product critical, or the cost of processing high with respect to the raw material, better put a systems engineer on the job.

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He Went—Back!

Our friend of long standing, Ted Kusto, to Computer Systems, Inc. (formerly Mid-Century Instrumatic) as Director of Research to head up the company’s development program for analog computers and simulators.

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Computer Events

Central Simulation Council
Date: October 1959
Place: McDonnell Aircraft Co., St. Louis, Missouri
Subject: “Computer Environment”

Eastern Simulation Council
Date: October 19, 1959
Topic: Unusual Applications of Analog Computers

*Still Chief Systems Eng., Manny?