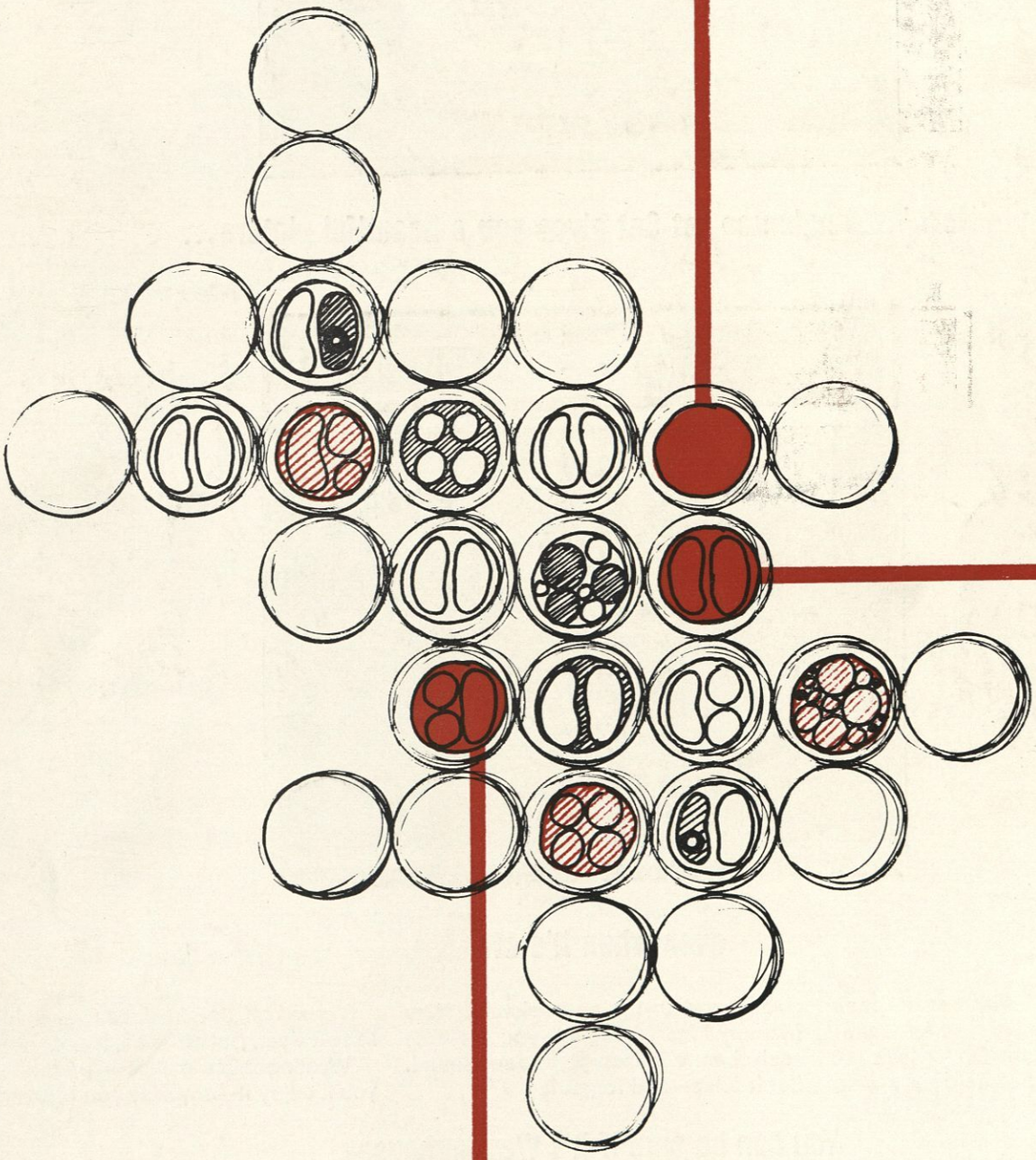
The COLORADO Engineer



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The COLORADO Engineer

VOLUME SIXTY-TWO NUMBER THREE

MARCH, 1966

TABLE OF CONTENTS

ABOUT THE COVER: The cover, by Jerry Carroll, illustrates the use of the laser on cells. See "The Laser in Embryology" by Jim Hamilton, beginning on page 10.

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EDITORIAL:

THE VALUE OF ENGINEERING

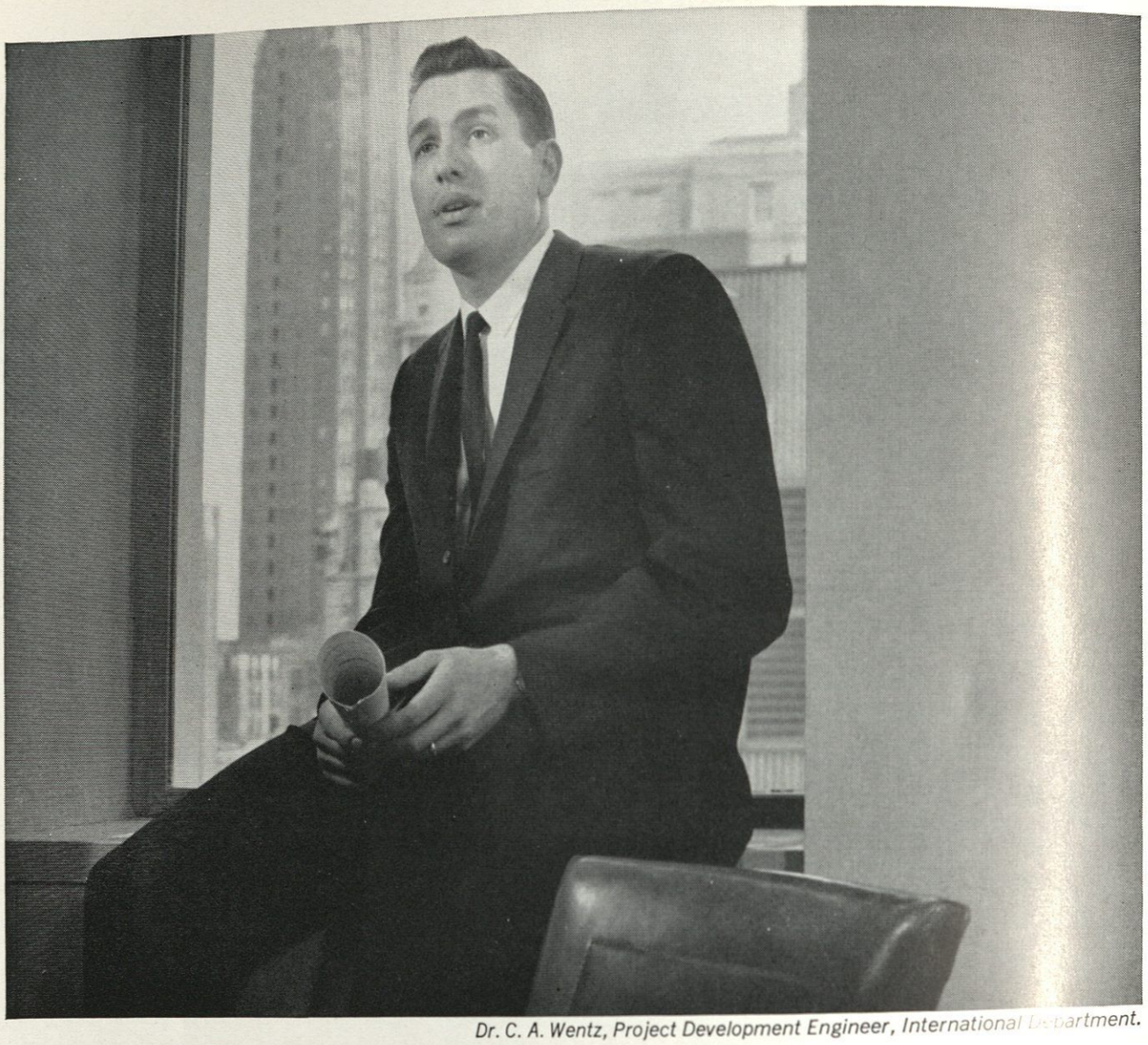
Very recently there has been a great deal of controversy over the emphasis on the sciences and engineering here at CU. The sudden interest in the problem was, of course, caused when engineering began to move into the new Engineering Center and turned over its old facilities to the College of Arts & Sciences. Let's face it—nobody deserves Hunter.

I very strongly believe that the arts and the humanities are at least as important to society as the technical subjects that we in engineering and the physical sciences have chosen to study. However, the lion's share of public support—both in money and in interest—has been given to our portion of the academic world. Contentions that this is either right or wrong prove nothing. It is better that one should try to understand why the imbalance exists.

The successful product of a technical education is a person who can provide answers to some of the physical problems that face his world. On the other hand, the student of the arts must cope with questions that are much more nebulous—that may, in fact, not have answers. This is the simple cause of the problem. Who among us would buy something which is ill-described and which may not even exist? Support given to science and engineering is easily accounted for—a problem is solved; an answer is obtained. Appreciation of the arts, of necessity, requires value judgements, rather than simply appreciation of technical accuracy. This value is difficult to quantify, and is thus often overlooked by society.

The answer to this disporportionate situation is not for the proponents of the arts and the humanities to demand a fair share of that support which is presently being given the sciences. Rather, those of us who feel that the arts can make worthwhile contributions to society must attempt the admittedly difficult task of convincing our society that it should provide such support.

—Fred E. Love



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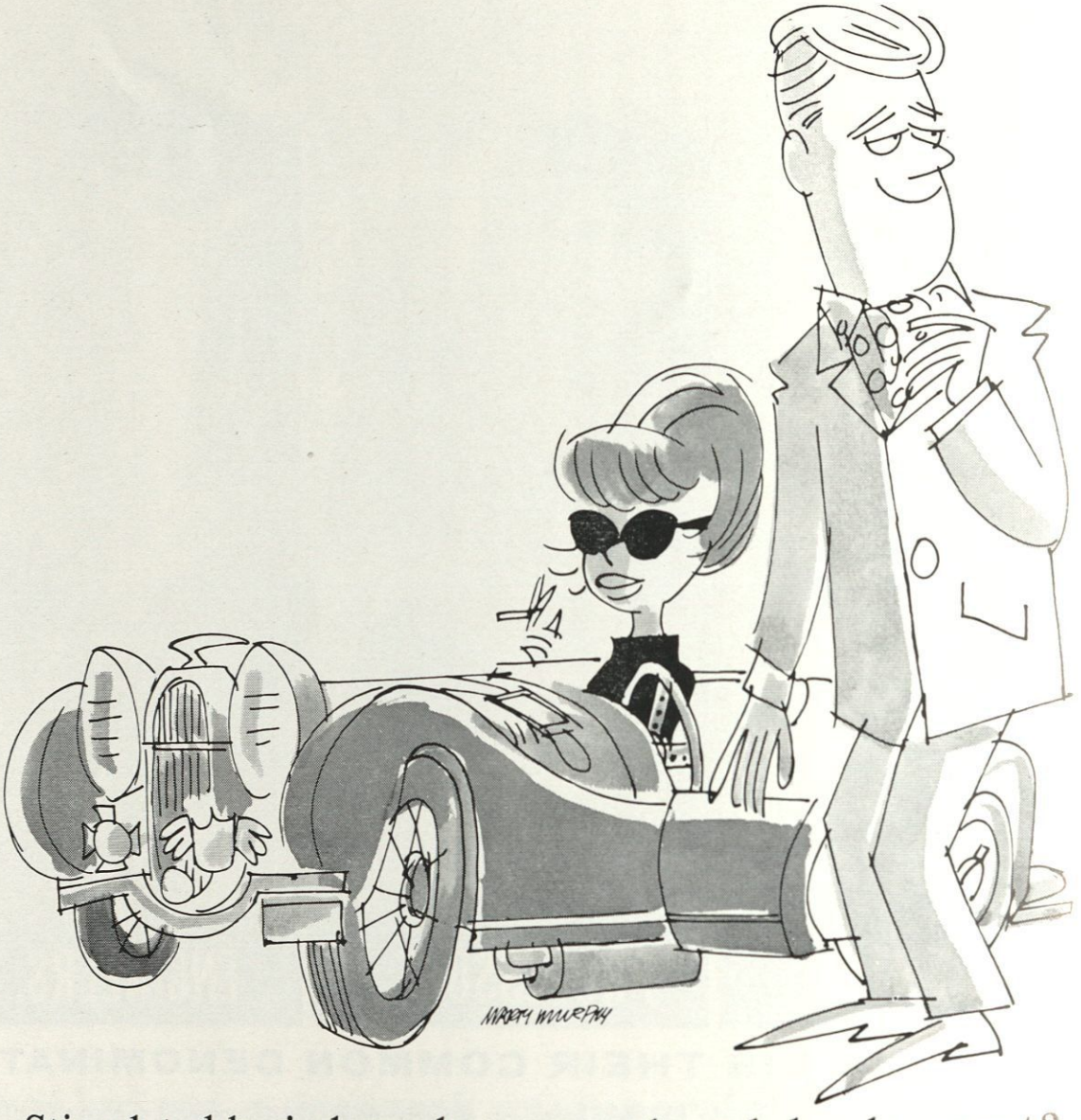

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DEAN'S COLUMN:

PLANS FOR E-DAYS—'66

DEAN MAX S. PETERS

The dates of May 5 and 6, 1966, mark two major events for our University and for our College of Engineering. The dedication of the new Engineering Center on May 6 will represent the beginning of a new era of engineering development at our University, and the date of May 5 is our day to recognize a truly great teacher on our faculty.

Charles A. Hutchinson, during a teaching career of nearly 50 years, has come to exemplify outstanding teaching at our University. The rapport he has developed with his students and the inspiration he has been to them through his teaching is attested to by the constant reference made by his former students to the great influence Hutch has had on their lives. There are few people in the history of education in the United States who have attained a stature of a great teacher equivalent to that accorded to Professor Hutchinson, and it will be a great honor for us to recognize his contributions on Charles A. Hutchinson Day — May 5, 1966.

As we complete our move into the new Engineering Center, there are many small problems which obviously will come up and which we will need to solve. We hope to have these straightened out as soon as possible with a minimum of inconvenience to those involved.

Our students are going to have an unusual opportunity to demonstrate to the public what goes on in Engineering during the Open House on May 6 and 7. I hope that each of our student groups will make every effort to develop and present effective displays for the Open House. With the large number of people we expect to have touring the building, this will be a fine opportunity for us to show the public what we can do as engineers.

We are counting on all of our students to help with our plans for the Dedication and our E-Days. I have been delighted with the response of the students to-date in assisting with the planning, and I am looking forward to seeing all of our students participating in our Dedication activities.

Max S. Peters
Dean

— *FOR THE COMPLETE E-DAYS SCHEDULE SEE PAGE 47.*

The Laser In Embryology

JIM HAMILTON

In the few years since the inrtoduction of the laser in 1960, this versatile tool has been applied in an almost uncountable number of fields, ranging from destructive weapons to three dimensional photography to James Bond movies. It has been said that the laser is the solution to a multitude of problems as yet unposed, waiting only for the spark of imagination to open whole new fields of research. One recent development has been the application of lasers to medicine and biology; it has been used in the destruction of certain types of cancers, specifically skin cancer such as Melanoma, which is easy to get at, and which is pigmented so that it can absorb the laser radiation. In this instance the laser has been shown to be a clean and painless surgical instrument. Other investigations along these lines include the repair of damaged retinas by "welding" about small holes, and the drilling of teeth whereby the dark decay material is painlessly removed leaving the rest of the tooth unharmed.[1]

Sometime in 1963, Ken Lang, then a graduate student in Electrical Engineering, came up with the idea of applying the laser at the microscopic level, that is, to living cells, groups of cells, or even parts of cells. So he, along with Dr. Frank Barnes of the EE Dept., and Dr. Joseph Daniel of the Biology Dept., began an investigation of this topic. They achieved several successes, and were thus encouraged to try further experiments. This line of research is continuing now at the university and elsewhere, and its possibilities are not likely to be exhausted in the near future. This work has been so well regarded that Dr. Barnes was selected to give the annual faculty research lecture in 1965, the first time an engineer has ever received this honor.

This article will review some of the work which they have done, in three parts; first, a description of the equipment; second, the experiments and their results; and finally, a discussion of the results, including some theoretical attempts to construct models for cell destruction.

The Equipment

I will not discuss in detail the principles behind the operation of the laser. (For a discussion of these properties see Arthur L. Schawlow,

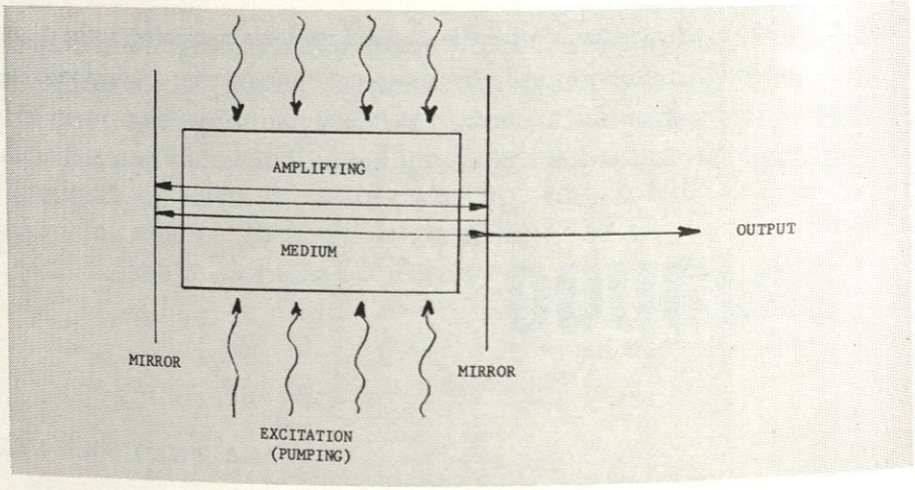


FIGURE 1: THE OPERATION OF THE LASER.

ABOUT THE AUTHOR

JIM HAMILTON

James Hamilton is a senior in EE. He belongs to HKN, Sigma Tau, Tau Beta Pi and the Men's Marching Band; also, like all good EE's, he is a member of IEEE. He was recently selected for Who's Who Among Students in American Colleges and Universities and is presently chairman of the Dedication Convocation Committee for E-Days.

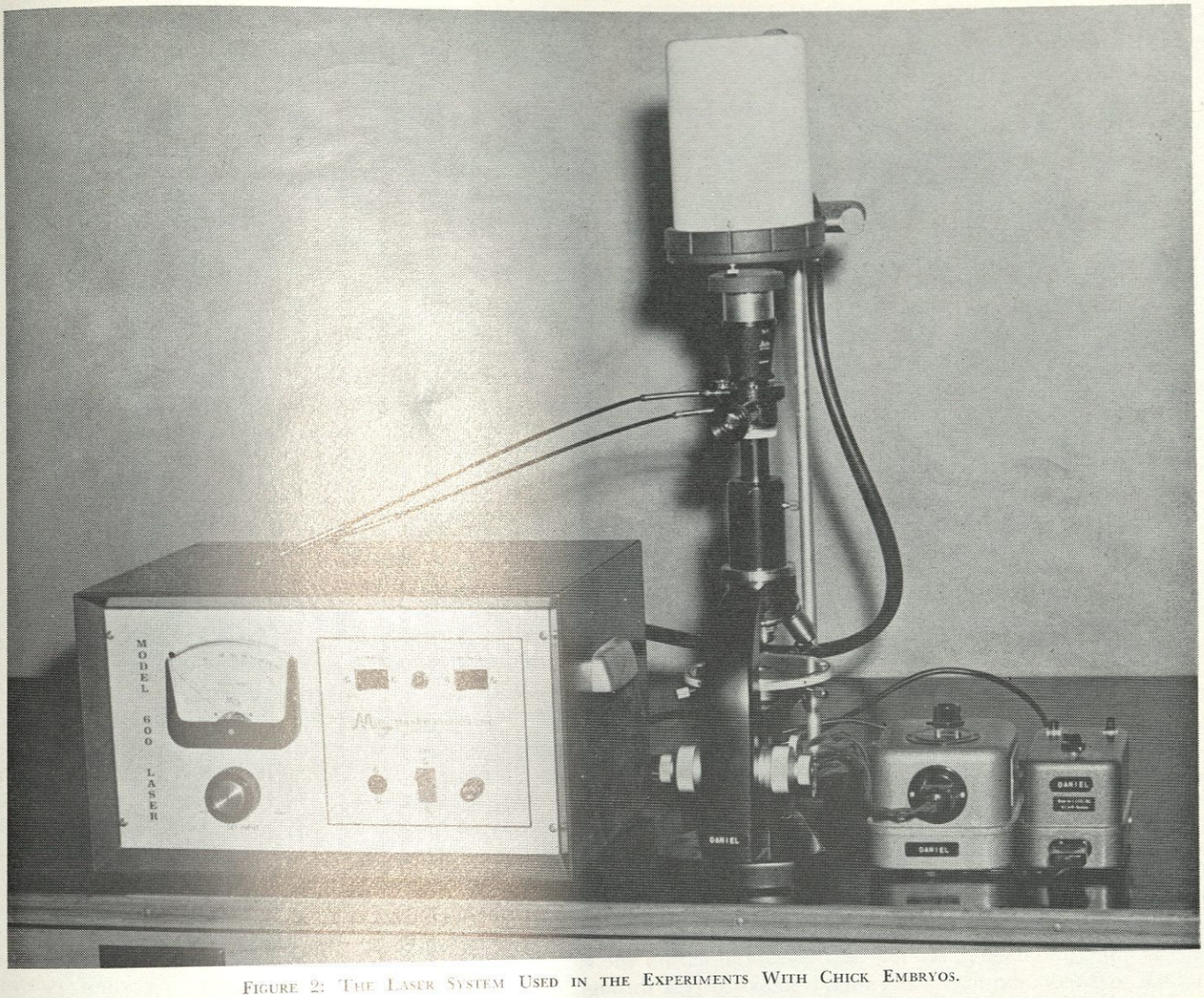


FIGURE 2: THE LASER SYSTEM USED IN THE EXPERIMENTS WITH CHICK EMBRYOS.

"Optical Masers," *Scientific American,* 204:52-62, June, 1961). It will suffice to say that it consists of a medium, generally a solid or a gas, which has been placed in an excited state so that it is capable of amplifying light waves. Feedback is then added in the form of two parallel mirrors, placed such that the light is reflected back and forth continuously through the medium, being amplified on each passage. This arrangement is illustrated in Figure 1. Some of the light is allowed to pass through one of the mirrors, thus becoming the output of the laser. Since only an integral number of wavelengths can exist between the mirrors and be amplified, the output is restricted to a very small range of frequencies. The medium itself is very restricted in the frequencies which it can amplify, but the above restriction is a much greater one. The mirror arrangement is, in fact, capable of producing oscillations at several different frequencies and in several space configurations, all of which can be amplified by the medium. This causes undesirable extra modes, which may have to be eliminated.

Apparently then, this light has several properties which are distinctly different from those of ordinary light. These include: 1) a high degree of monochromaticity, 2) Coherence, the ability to specify phase relations and polarization at any point in space, as opposed to ordinary light which is composed of a large number of unrelated "wave trains," and 3) Concentration of all the energy into a highly collimated beam. All three of these properties are important in the ability to focus the beam into a very small spot. All lenses and other optical devices have imperfections such as chromatic and spherical aberrations whose effects are greatly minimized when the light has the above properties. Without these properties the various imperfections would make it impossible to focus the beam as accurately as is necessary for these experiments. The third property is also very important in getting enough power concentrated in one spot to cause the destruction of biological material.

There have been two types of lasers used in these experiments. One is a gas laser, using a Helium-Neon mixture, and having a continuous power output of about 1 milliwatt at a wavelength of 6328 A. The other is a small ruby laser, a Maser Optics Model 600, shown in Figure 2, which operates at a wavelength of 6943 A. Because of the large amounts of power developed in a ruby laser, it can only be operated in very short pulses, but can cause correspondingly greater damage than the He-Ne laser. The laser used here has an output of from 1-10 millijoules delivered in 2.2×10^{-3} seconds, or a power of up to about four watts during that time.

In some of the experiments the

laser was used directly, with only a single lens to focus the beam. In later experiments a microscope was used with the beam being sent through backwards and thus being focused on the material under observation (which was then in a position for visual observation of the results.) Various microscope configurations were set up to accomplish this. One of the earlier methods consisted of a movable ocular which could be rotated to a position for observation and adjustment, or to another position in line with the laser head. Another arrangement used a prism in the microscope, which, when in place would provide a path for visual orientation, and when removed would provide a path for the laser beam. A more recent setup involved a binocular microscope, with one ocular for the laser beam, and the other allowing for simultaneous visual observation or photographing. The laser beam must be carefully positioned to avoid damage to the microscope. If this is not done, it is possible for the laser beam to shatter the lenses, which in fact happened on one occasion.

Temperatures Reached

It was found that using a microscope of magnification 400X, the He-Ne laser could be focused into a sphere of a diameter of about 1 micron, or 10^{-6} meter. It was calculated that less than 5% of the total energy appeared outside this volume. To illustrate the size of this spot compared to biological materials, it was shown during a series of experiments involving HeLa cells, a type commonly used in the laboratory, that the beam could be focused inside the nucleolus, a small part of the nucleus of the cell. The ruby laser could only be focused to about 20 microns however, due to the presence of some undesirable modes, as discussed earlier, as well as a larger beam width to begin with. There are methods of reducing the unwanted modes, but for the work done here this was not necessary. A series of tests were made for the ruby laser, using various metals, whose melting points were known, in the focused beam to determine the temperature distribution around the spot by measuring the size of the melted area after exposure to the laser. The results of these tests are shown in Figure 3. Clearly, very high temperatures are reached; these temperatures must be adjusted to account for losses due to reflection and transmission of the biological material in question. The adjusted temperatures are also shown, and are still high enough to cause considerable damage.

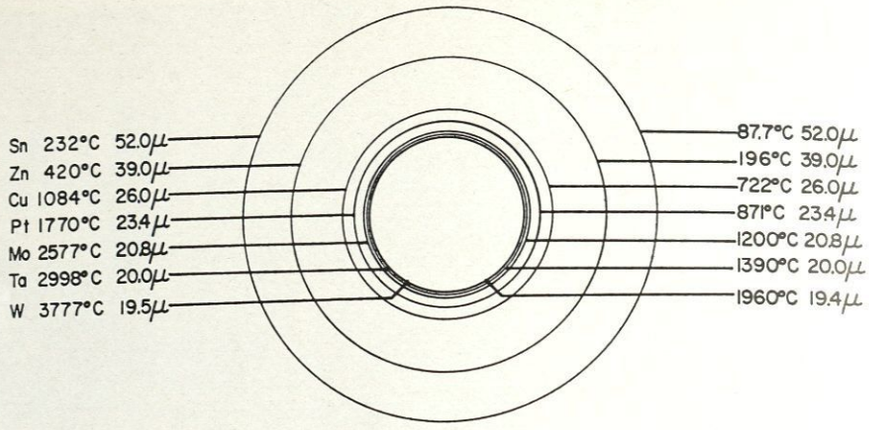


FIGURE 3: TEMPERATURE PATTERNS OF THE FOCUSED LASER BEAM AS DETERMINED FROM THE MELTING POINTS OF VARIOUS METALS (LEFT) COMPARED WITH TEMPERATURES REACHED IN A STRAINED BLASTOMER (RIGHT). (5)

Experiments

The early work, which was done mainly in an effort to demonstrate the possibilities of the laser in embryology, consisted of lasing of chicken and quail eggs at various stages of incubation. To do this, a lens was used to focus the beam from the ruby laser at the position of the embryo within the egg, requiring the beam to pass through the shell. The first group of chicken eggs subjected to this treatment were lased prior to incubation, and several showed limb deformities such as splay leg, or club foot (examples are shown in Figure 4.) In Figure 5 is a table of the results, and there is little definite pattern suggested by these figures. This is mainly because conditions were poorly controlled at this early stage. There was not a high probability of even hitting the embryo, and some later work suggested that the humidity in the incubator was a factor—that in a high humidity, the moisture could be regained. Quail eggs, treated in a similar manner, showed similar deformities. In addition, the quail eggs were lased at various times during incubation, and it was definitely shown that the highest percentage of deformities occurred in eggs lased during the third day of incubation, the first day of limb development, which is what one would expect. The results are illustrated in Figure 6. These early experiments gave few conclusive results, but clearly served to demonstrate that laser radiation can have deforming effects on embryos.

Further work with chicken eggs involved picking away part of the shell so that the embryo could be lased directly, and with much greater accuracy. The eggs were then lased as before, but in this case none of the lased eggs developed normally. In most cases the only identifiable tissue-organ system to develop was that of the heart and associated vessels. This so-called "heart island" formation is shown in Figure 7 along with a normal embryo. In several cases this heart was beating when removed from the egg. This work suggests that the cells which are to develop into the heart are already present at the time of lasing, and that they are more resistant to radiation than the other types of cells.

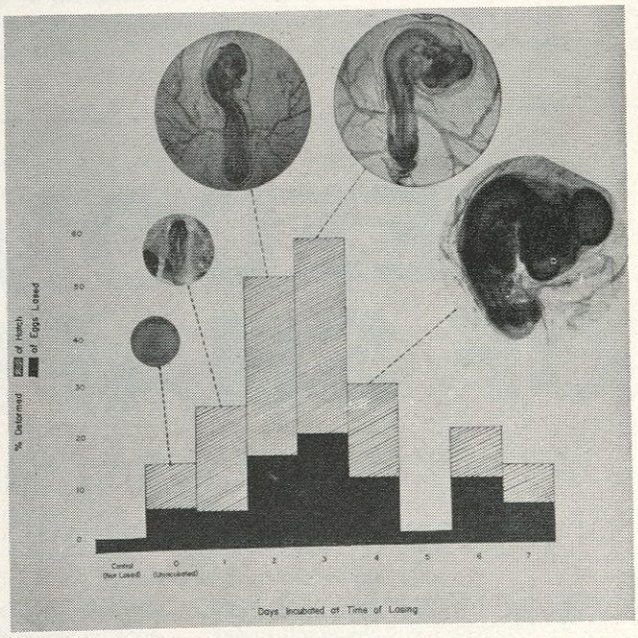
Cell Differentiation

This result leads well into a discussion of another series of experiments. A major question in the field of embryology is this: At what point in the development of the embryo does cell differentiation take place? That is, at what point is a specific cell destined to become a part of a particular section of the animal, such as the heart or the nervous system? There has been a great deal of research done on this problem, and as yet very little has been found in the way of an answer. Specifically, Seidel, a German, showed some time ago that he could take a rabbit ovum at the two cell stage, destroy one of the cells with a hot needle, re-implant the ovum in a rabbit, and obtain a full grown normal rabbit. In the same

FIGURE 4: LEFT: A NORMAL QUAIL CHICK; RIGHT: A CHICK WITH LASER-INDUCED DEFORMITIES.

LASER INTENSITY (joules input)	NUMBER OF EGGS	NUMBER HATCHING	PERCENT HATCHING	NORMAL	DEFORMITIES		
					Splay leg	Club foot	Visceral protuberance
0 - Control	22	11	50	11			
72 - 1 shot	22	7	31.8	6	1		
72 - 2 shot	22	6	27.2	3	2	1	
312.5 - 1 shot	22	10	45.4	7	3		1

ABOVE: FIGURE 5: RESULTS OF LASER RADIATION OF UNINCUBATED EGGS."



RIGHT: FIGURE 6: RESULTS OF LASER RADIATION OF INCUBATED EGGS.

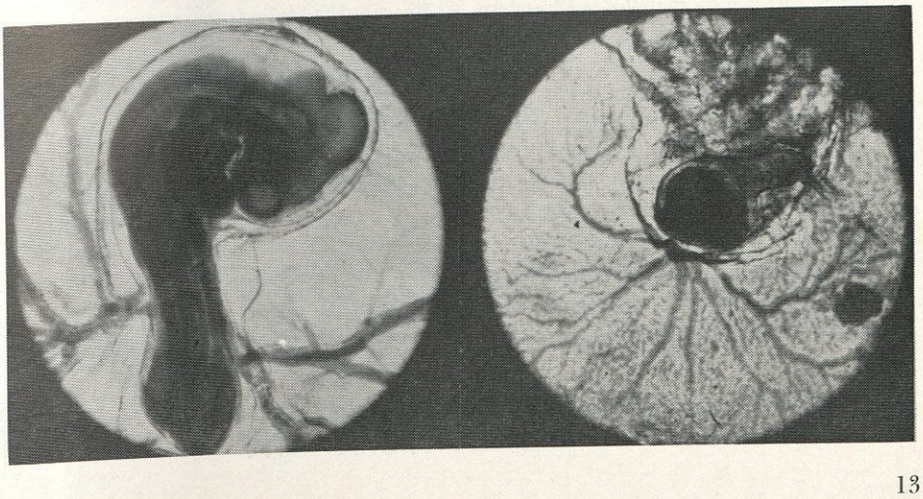


FIGURE 7: A NORMAL EMBRYO (LEFT) COMPARED WITH A LASER-INDUCED "HEART ISLAND"

way he was able to destroy three out of four cells and obtain growth for about eight days, but this was considerably more difficult, and the results were inconclusive. Now, with the use of the laser, the selective destruction of cells becomes a much simpler task. Experiments were performed with the ruby laser on rabbit ova as suggested by Seidel's work, and an example of these is shown in Figure 8. One of the two cells lased collapses completely, and the other is unaffected, and continues to divide many times. It has been possible to get this single. remaining cell to cleave to the 64-cell stage. At other stages the following results were obtained: destruction of three out of four cells—regularly cleaved three times to produce eight cells; seven out of eight—remaining cell will cleave twice; and on two rare occasions with 15 out of 16 cells destroyed, the remaining cell cleaved twice. At the 16-cell stage, the geometry of the cells makes it very difficult to destroy all but one of them. Clearly the next step in this experiment is to re-implant these cells in a rabbit and see what kind of development can be obtained. The reason for this is that up to this time it has been impossible to obtain a great deal of growth of embryos in culture.

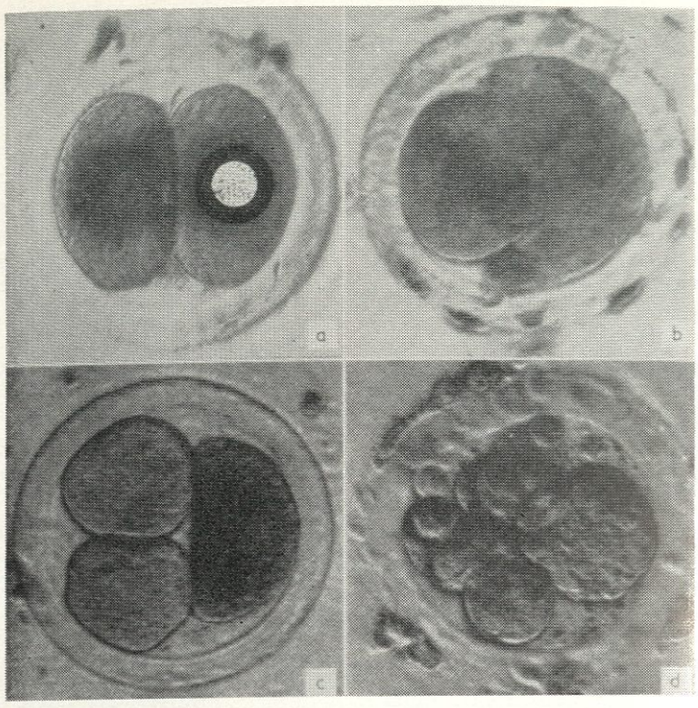
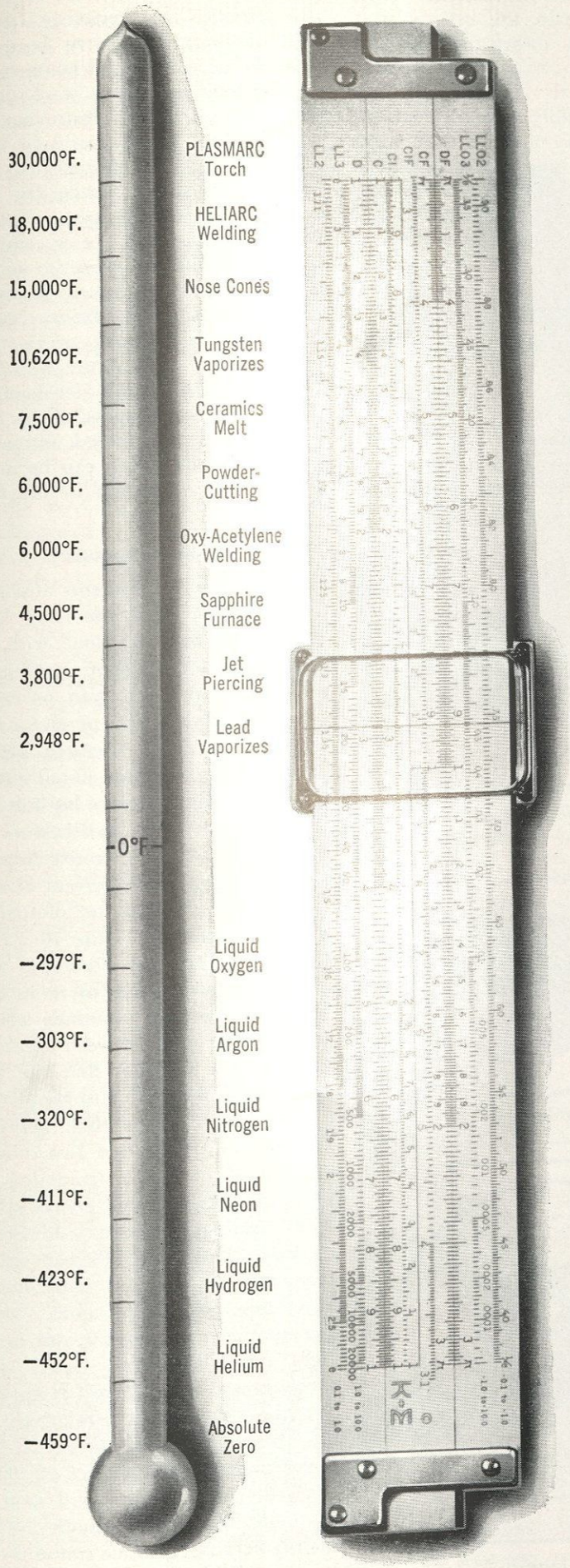


FIGURE 8: RESULTS OF LASER DESTRUCTION OF ONE CELL IN THE TWO-CELLED STAGE. (5) "

(Continued on page 16)



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(Continued from page 14)

The normal development of a typical vertebrate embryo is diagrammed in Figure 9. Beginning as a single cell (1), it goes through a process of cleavage (2). After a large number of cleavages, a large spherical mass of cells has been formed (3). At this time, a small area on one side of the ball, called the blastocyst, begins to develop. It is at first circular in shape and then becomes more triangular, forming the so-called primitive streak, the beginning of the central nervous system. Following this, the embryo begins to take on a definite shape, at the same time forming somites, the small rows of circles, along the primitive streak, suggesting the beginnings of the vertebrae of the backbone (4). It would be desirable to destroy certain parts of this formation at various stages of its formation. Unfortunately, in the case of the rabbit ova, there are problems. The cells of the rabbit ova are almost completely transparent, and in their normal state they will not absorb any laser radiation. It is necessary to stain the cells with a dye so they will absorb the light, but the dye must necessarily not interfere with their growth. In the early stages this can be readily accomplished. In the later stages, however, the same dye, methylene blue, causes all growth to stop. Many other dyes were tried, and none but red, which still wouldn't absorb the light since it is the color of the laser beam itself, were successful.

The chicken embryo, however, has enough natural pigmentation that it can be selectively destroyed by the laser radiation. Some investigation has been made into the process of somite formation. There has been some controversy over this matter, with various researchers suggesting different parts of the embryo as controlling somite formation. These suggested areas include what is called Henson's node at the front of the primitive streak, another area called the neural tube, and the primitive streak itself. It has also been suggested that the somites are sequentially induced by previously formed somites, since they have been observed to develop in this manner. All of the above suggestions were investigated by selectively destroying the various areas, using the ruby laser. Destruction of the neural tube had no effect on somite formation. Destruction of either Henson's node or the primitive streak causes complete disruption of development, so no conclusions could be drawn regarding somite development. Destruction of the last formed somite or the area in which the next somite will form has no effect on somite development. So two of the four possibilities have been definitely eliminated, and, while no definite conclusion can be made, this is certainly a step in the right direction.

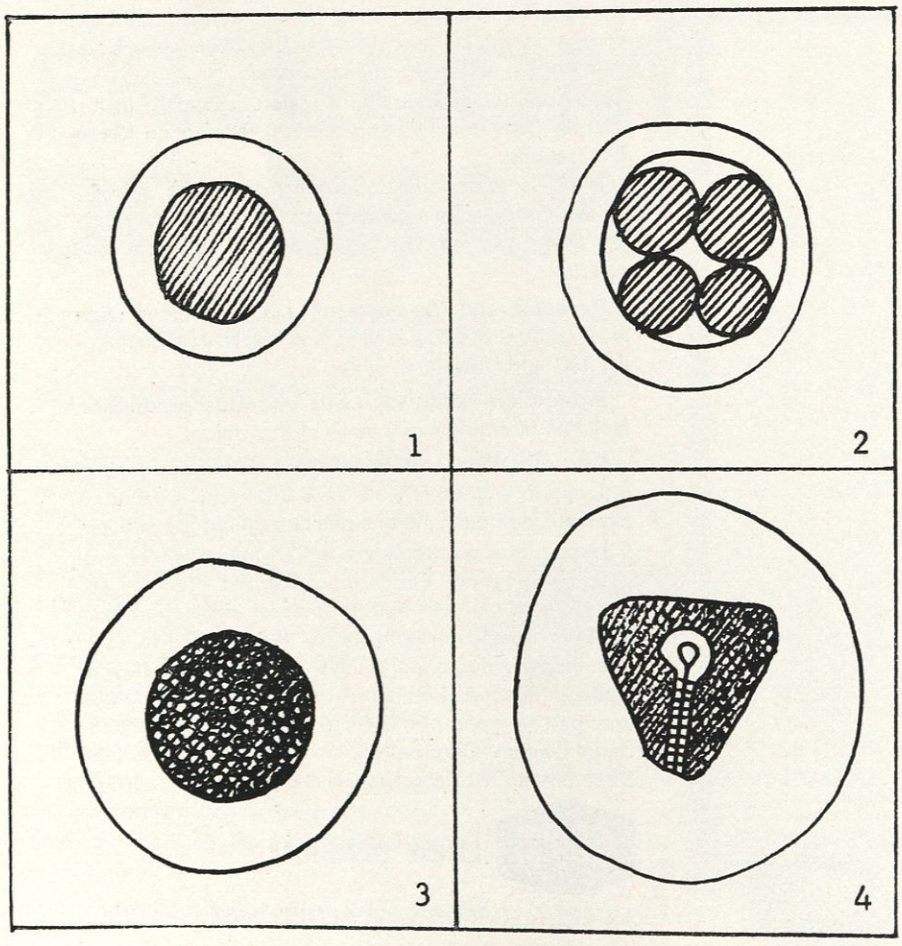


FIGURE 9: DEVELOPMENT OF A TYPICAL VERTEBRATE EMBRYO.

Periodic Immunity

All of the experiments discussed thus far have used the ruby laser. Some work was also done with the continuous He-Ne laser, specifically on frog eggs and once gain, on rabbit ova. Also, small parts of HeLa cells were irradiated as discussed before, but with no noticeable visual effects. Groups of frog eggs were lased at various intervals after fertilization, resulting in dead or deformed tadpoles upon hatching. If the percent of dead or deformed tadpoles are plotted vs. the time of lasing (Figure 10), a definite periodicity is observed, with minima corresponding to times during cleavage and maxima corresponding to times between cleavage. This clearly indicates that the frog eggs are less susceptible to laser radiation during cleavage than between. Finally, one of the first two cells of the rabbit ovum was irradiated for three minutes, with no effects, while further radiation caused a slowing of cleavage. This result was expected on the basis of previous experiments, also done by Dr. Daniel, which showed that rabbit ova grown under light developed more slowly than those grown in the dark. It appears that the He-Ne laser is relatively ineffective in the destruction of biological material, but power of 50-100 times the present value will soon be available, making it more useful, mainly because it can be concentrated in a much smaller area.

Discussion

In what follows I will present a summary of some of the theoretical work which has been done following the experiments which have been described, and which represents the majority of the work which is continuing at present. To a large extent, this has no direct bearing on the preceding research, but is an attempt to clarify the physical processes involved in the destruction of biological material, thus allowing future laboratory work to proceed under more careful control. It also should allow prediction of some of the results. In addition, this work will suggest its own experiments, some of which are being investigated at present.

It is desirable to investigate some of the methods by which cells can be destroyed. There are many possibilities, most of which are intricately interrelated. The most important categories are temperature, mechanical effects, and chemical reaction. Perhaps the first step is to define what is meant by destruction of a cell. A cell may be disrupted to such an extent that it collapses completely, as in many of the experiments described earlier, or it may only have its metabolism altered, as in the case of the slowdown of cleavage in rabbit ova exposed to the He-Ne laser. A practical definition is that a cell is dead when it ceases to develop and reproduce; this makes it possible to count dead cells.

At this point I will degress slightly to discuss a topic which I have found very interesting (so by definition everyone else will also find it interesting) —that of survival curves, which I think suggests some possible experiments.[2] If a group of cells is subjected to some harmful effect, such as high temperature for varying lengths of time, the number of cells surviving can be plotted, usually logarithmically, as a function of this exposure time to give a survival curve. This curve is generally observed to be of the form

$$\frac{N_S}{N_o} = e^{-k't}$$

where N_s is the number of surviving cells, N_o is the original number, and k^1 is an inactivation rate constant,

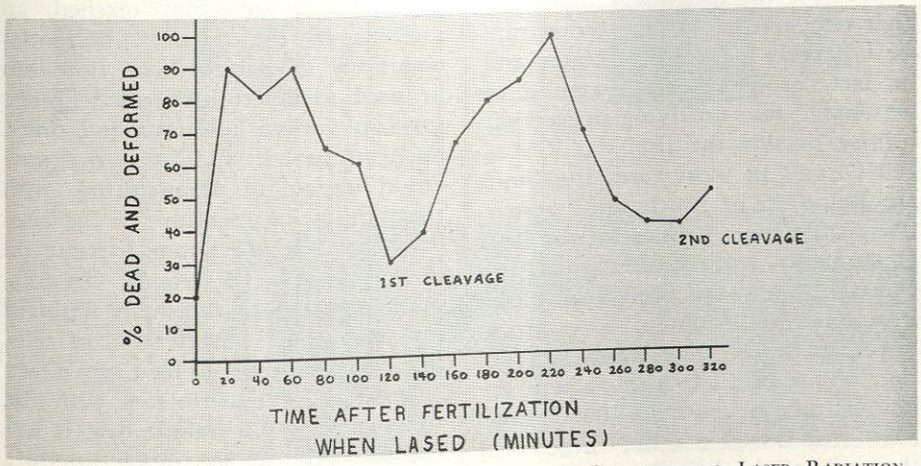


FIGURE 10: RELATIONSHIP BETWEEN CELL CLEAVAGE AND IMMUNITY TO LASER RADIATION.

dependent on several factors which will be considered later. Now a mathematical model can be set up to explain these curves as follows. Suppose a cell contains a number n of a certain constituent, perhaps protein molecules, and to kill the cell requires that m or more of the constituent be destroyed. Suppose also that the probability of a random unit being damaged is p, and that the probability of its not being damaged is q or 1 - p. The probability that r of the total n units will be destroyed is given by

$$P_r = \frac{n!}{r!(n-r)!} \cdot p^r \cdot q^{n-r}$$

Thus, the probability of survival of the cell, or the probability that m or fewer units will be damaged is

$$S_{n,m} = \sum_{r=0}^{m-1} P_r$$

$$= \sum_{r=0}^{m-1} \frac{n!}{r!(n-r)!} \cdot p^r \cdot q^{n-r}$$

If the constituents involved are fairly simple, they usually will obey several assumptions, from which it can be shown that their survival is exponential in the same manner as discussed previously. Thus, for q we can substitute e^{-kt} in the above expression to obtain.

$$S_{n,m} = \sum_{r=0}^{m-1} \left[\frac{n!}{r!(n-r)!} \cdot (1-e^{kt})^r (e^{-kt})^{n-r} \right]$$

This relation is plotted in Figure 11 for several values of m and n. It is apparent that only those curves for which m equals 1 give an exponential survival curve for the entire cell. This places far reaching restrictions on the types of damage which may cause the death of a cell. If a type of cell is to have an exponential survival curve, then its death must be due to the destruction of a single component. This tends to eliminate, for example, many types of chemical reactions which would involve a large number of molecules. It seems to me that the laser could be used to verify many of the questions raised by this discussion, through its ability to operate not only on cells but also on parts of cells.

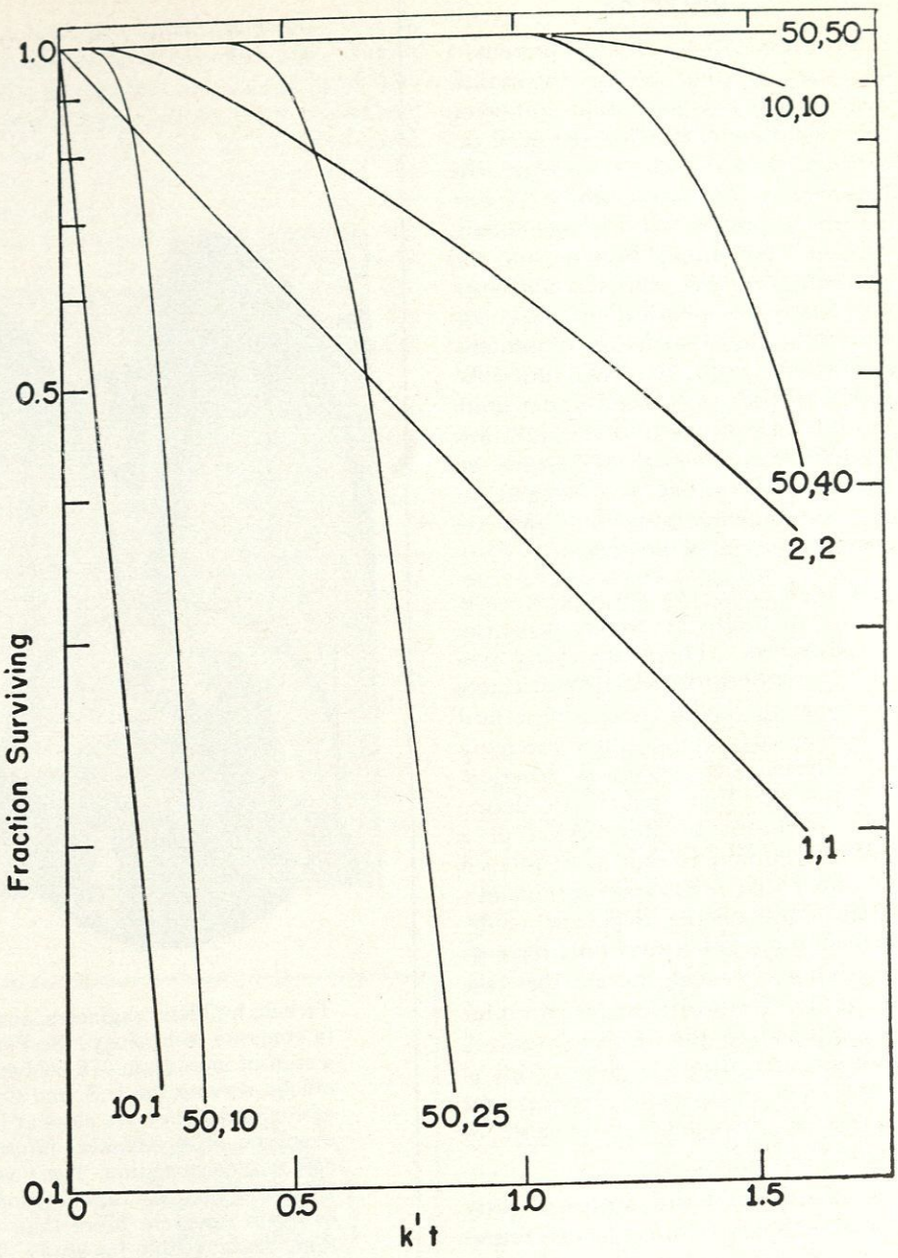


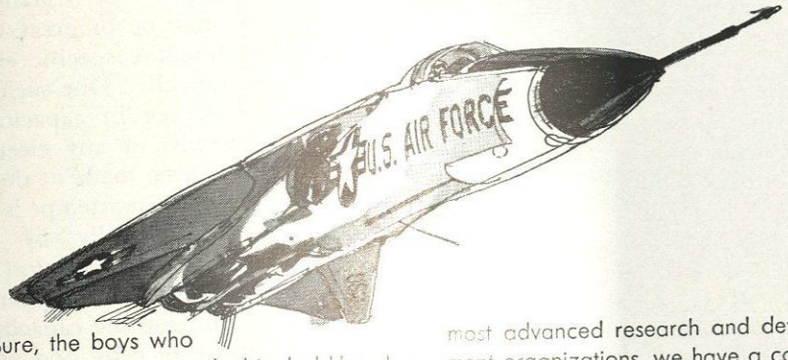
FIGURE 11: HYPOTHETICAL SURVIVAL CURVES. (2)

The most important single effect responsible for the death of cells is high temperature. Since living matter is largely made up of water and, in fact, evolved from water, it is reasonable that no living matter will survive outside the limits of O°C.—100°C, and in most cases the limits are found to be much more restrictive than these. In most of the laser experiments, temperatures greatly in excess of this were present resulting in a considerable amount of vaporization, and hence, mechanical disruption of the cell. In cases where the temperature is less than 100°C. however, such as points not directly in the path of the beam, or in the case of the He-Ne laser, with which high temperatures were not reached, an analysis of the partial differential equations describing heat flow can be used to determine peak temperatures at various positions and times. Such an analysis indicates an exponential decay of temperature with time, following exposure to the laser beam with a maximum lifetime on the order of 10^{-2} seconds. In comparison with times normally required for the thermal inactivation of cells, this is far too short to have any effect.

During the experiments with the ruby laser on the rabbit ova, it was observed that if too much intensity

(Continued on page 20)

Have astronauts made pilots old hat?



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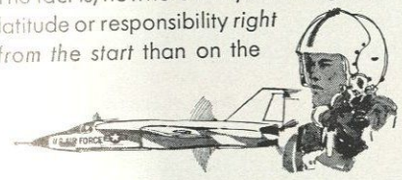

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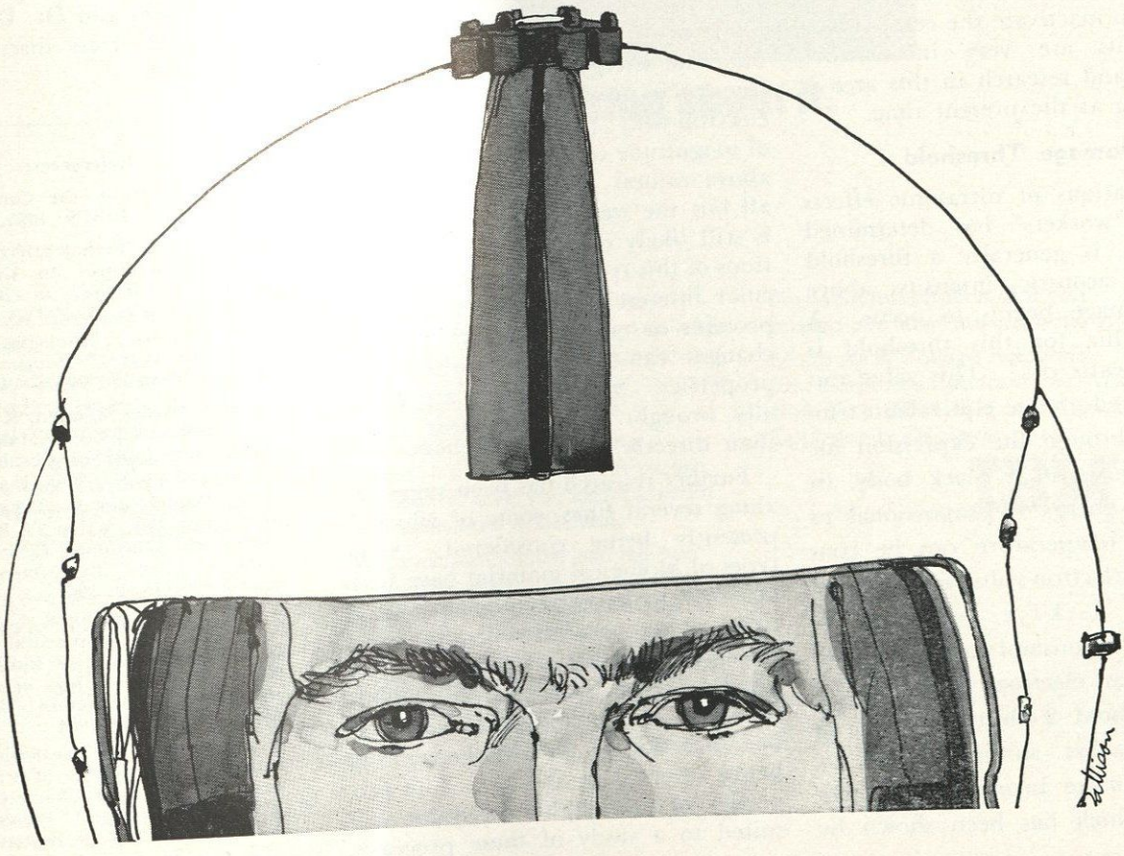


(Continued from page 18)

was applied to the destroyed cell, the remaining cell failed to reproduce. Now this cell was very likely out of the range of temperatures exceeding 100 C, so it is necessary to consider other effects. A possible explanation might be that the destroyed cell released some chemicals which inactivate the remaining cell; but a far more interesting possibility is that of inactivation of cells by an acoustic wave. It is to be expected that the laser beam will generate an ultrasonic wave in the material, and this has been shown to be the case in a series of experiments in which this wave was measured by a quartz crystal transducer at various distances from a target. Ultrasonic waves definitely have lethal effects on biological material, but the mechanisms involved are rather complex, including such effects as mechanical resonance, cavitation (an effect involving the formation of gas bubbles), and acoustic power density.[3] Research has been done in an effort to determine the effects of these acoustic waves on rabbit ova. Exposure to a source of ultrasonic waves had no effect. Exposure to static pressures as high as 750 atmosphere, had no effect. Finally, by placing the cell very close to a target composed of carbon, and hitting the target with the laser beam, it was possible to inactivate the cell. These experiments are very inconclusive however, and research in this area is continuing at the present time.

Damage Threshold

Investigations of ultrasonic effects by other workers[3] has determined that there is generally a threshold value of acoustic intensity above which damage begins to occur. A typical value for this threshold is about 50 watts/cm.^{2} This value can be converted to an equivalent temperature through the expression for energy density in a black body, in which the energy is proportional to T^4. This temperature can be converted to electron-volts through the expression $E=kT/e$, where k is Boltzmann's constant and e is the charge on an electron. This gives a value of about 2 electron-volts. As discussed earlier, survival curves for thermal damage involve a rate constant k^1 which has been shown by thermodynamic reasoning to be of the form

$$k' = \frac{kT}{h} e^{-\Delta F/RT}$$

where k is again Boltzmann's constant, T is absolute temperature, h is Planck's constant, R is the gas constant, and ΔF is an activation energy, which has been determined experimentally to be on the order of 2 electron-volts. It is perhaps only coincidence that these values are very close, but it would seem likely that a single model might be devised to explain both thermal and acoustical damage, as well as other possible effects. It is suggested that these effects could be combined to give a rate constant of the form $\Delta E \div [k(T_t + T_a)]$ where T_a is an effective temperature for acoustic damage, proportional to the fourth root of energy density, T_t is proportional to the absolute temperature, and ΔE is a threshold or activation energy determined experimentally. Once again, the possibilities of investigation using laser techniques are many.

For the Future

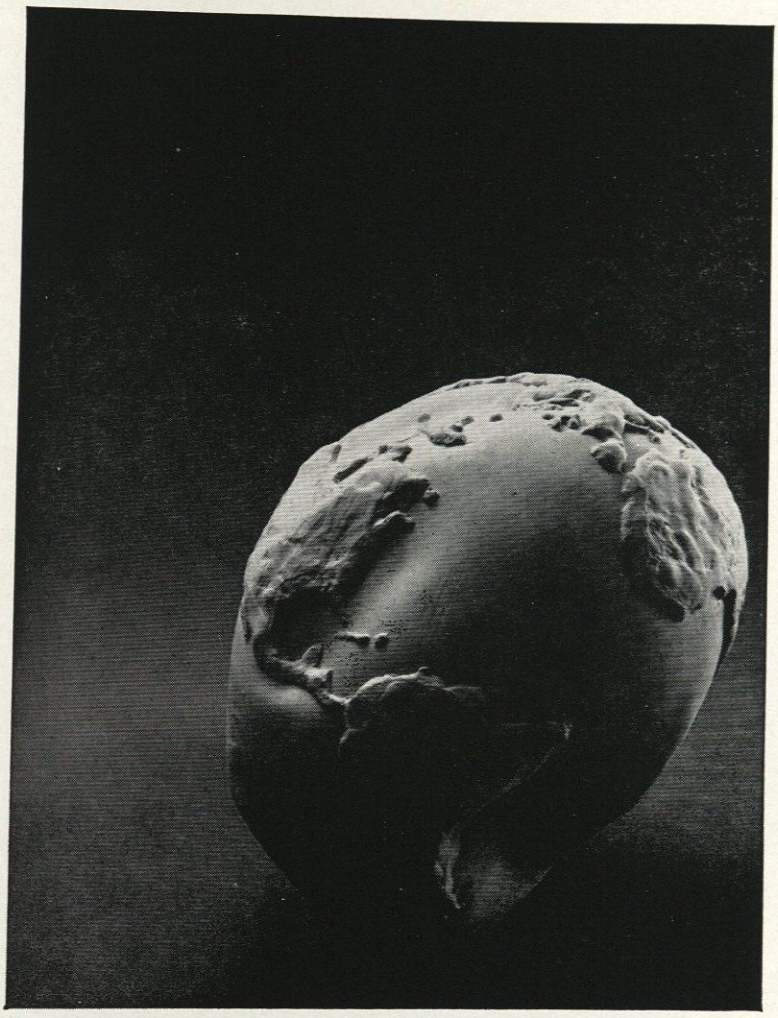
There are, in addition, possibilities of chemical reactions caused directly by the laser radiation. Investigation of bonding energies involved in typical organic molecules indicates that these are mostly somewhat higher than the energy of a photon at the frequencies used, which is about 1.78 electron-volts (note again the order of magnitude comparison of this with above values). Hence, this rules out all but the weakest bonds, though it is still likely that in some cases reactions of this type will occur. Of particular interest are reactions involving proteins or enzymes, in which small changes can completely alter their properties. Such changes are generally brought about by heat rather than directly by light.

Further research has been suggested along several lines, some of which is presently being considered. Some types of biological material have been observed to be extremely light sensitive, particularly the chemical reactions in plants, which involve chlorophyll. These reactions are highly frequency dependent, proceeding in one direction at one frequency, and being reversed at another. The properties of laser light are quite well suited to a study of these processes. One of the few biological materials which naturally absorbs visible light is hemoglobin, an extremely complex molecule with many possibilities for chemical changes upon absorption of light. Experiments with hemogoblin are now under consideration. Some cell changes may not be visually observable, but may be of great value in understanding the specific effects of laser light on cells. One such possibility is a change in capacitance. Few measurements of any electrical properties have been made at the microscopic level, but an attempt is now being made, principally by Ken Terada, a student in Electrical Engineering, to construct an apparatus capable of measuring the capacitance of a small group of cells, and at the same time provide a path for the laser beam, so that measurements can be made both before and after irradiation, to detect any small changes. One could go on and on just listing possible experiments using the laser, but this research has, I think, accomplished a great deal in the way of setting guidelines for future research in this wide open field, and has proven, beyond any doubt, the value of the laser as a tool for biological research.

(The majority of this article has been taken from four papers written by Dr. Barnes and Dr. Daniel,[4, 5, 6, 7] as well as from discussions with them.)

References:

1. Anon., "Laser on the Cancer Frontier," *Life*, 59:70-1, July 9, 1965.
2. T. H. Wood, "Lethal Effects of High and Low Temperatures on Unicellular Organisms," *Advances in Biological and Medical Physics*, Vol. IV, 1956.
3. Pierre Grabar, "Biological Actions of Ultrasonic Waves," *Advances in Biological and Medical Physics*, Vol. III, 1953.
4. Frank S. Barnes, Kenneth R. Lang, Joseph C. Daniel and John C. Maisel, "Lasers as Tools for Embryology and Cytology," *Nature*, 201:675-7, Feb. 15, 1964.
5. J. C. Daniel and K. Takahashi, "Selective Laser Destruction of Rabbit Blastomeres and Continued Cleavage of Survivors in Vitro," *Experimental Cell Research*, 39:475-82, 1965.
6. J. C. Daniel, Kenneth R. Lang and Frank S. Barnes, "Developmental Disturbances of Vertebrate Embryos Induced by Laser Radiation," *Proceedings of the First Annual Rocky Mountain Bioengineering Symposium*, May 1964.
7. F. S. Barnes, K. Takahashi and J. C. Daniel, "Applications of Lasers to Embryology and Some Characteristics of the Biological Damage," Presented at the NEREM Meeting in Boston, Nov., 1965.



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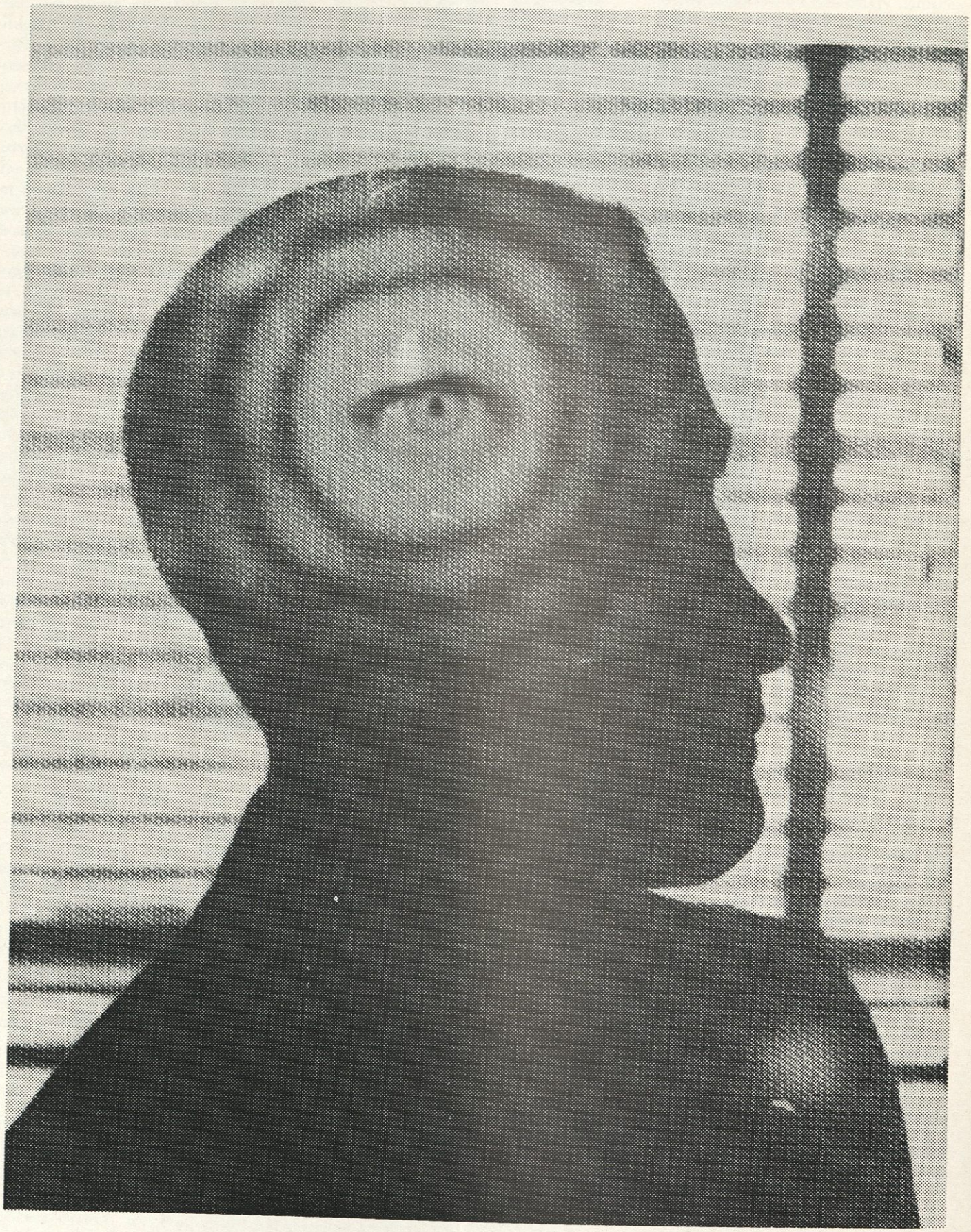


—Photo by Laird Stanton and Kathy O'Donoghue

HALLUCINATIONS

And How To Get Them

KATHY O'DONOGHUE

Why should a man, whose blood is
warm within,
Sit like his grandsire
cut in alabaster?

The Merchant of Venice
William Shakespeare
Act I, Scene i

Man has long searched for the perfect way to escape reality when the going gets rough, a way to learn more while expending less energy, a genie from a magic lantern to do his work for him. From the ancient Greeks and their mystic mandrake to the belladonna tea parties and glue sniffers of today, there has been an endless search for a new source of "kicks." College students take pep pills ranging from No-Doz to benzedrine hoping to increase their ability to cram for finals. Many other drugs affect mental behavior; some are beneficial —others, destructive. The field of psychopharmacology is a new one; the possibilities are unlimited and they are frightening. Hopes and fears are being raised: Can we now really conquer mental illness? Will the power to control the mind be misused?

Schizophrenia

The main concern in the study of hallucinogenic drugs is the possibility of the experimental reproduction of abnormal human behavior under stress which may lead to a greater understanding of mental illness, especially schizophrenia.

The causes of schizophrenia, which affects one percent of mankind, are unknown. Original research pointed to a genetic predisposition accentuated by the "childhood trauma of ambivalent, inconsistent parents" (3, 86), which sounds pretty hopeless. In recent years, however, interest in explanation of schizophrenia on a chemical basis has arisen. The possibility was first explored about seventy-five years ago and has received much attention lately in connection with mescaline and LSD.

In schizophrenia, there is a profound disorder of the emotions, causing disintegration of the normal thinking process into one that is unrealistic and bizarre. The attention is turned inward and in conversation, the schizophrenic may respond according to the sound or association of words rather than their meaning. Hallucinations, usually auditory but many times accompanied by visual apparitions, are concerned with past experiences and may be the external symbolization of internal conflicts.

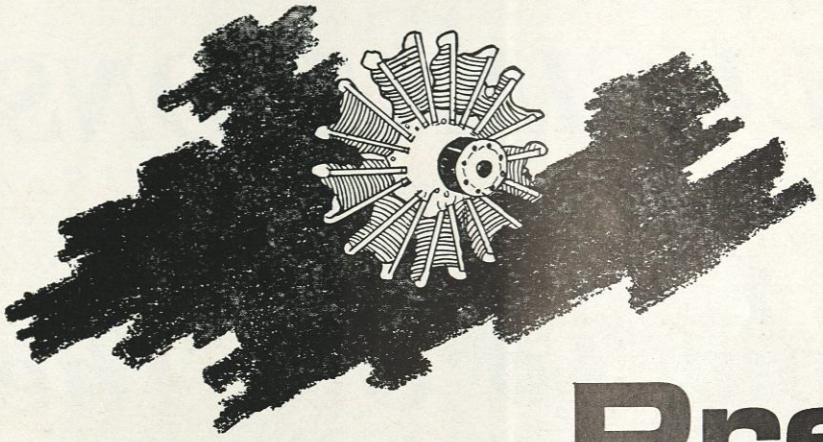
(Continued on page 26)

ABOUT THE AUTHOR

KATHY O'DONOGHUE

Kathy O'Donoghue, a junior in EDEE, is Assistant Editor of the *Colorado Engineer,* which may have something to do with why her article is in this issue. To keep her busy, she works part-time as a Research Assistant in the Department of Testing and Counseling.

Past



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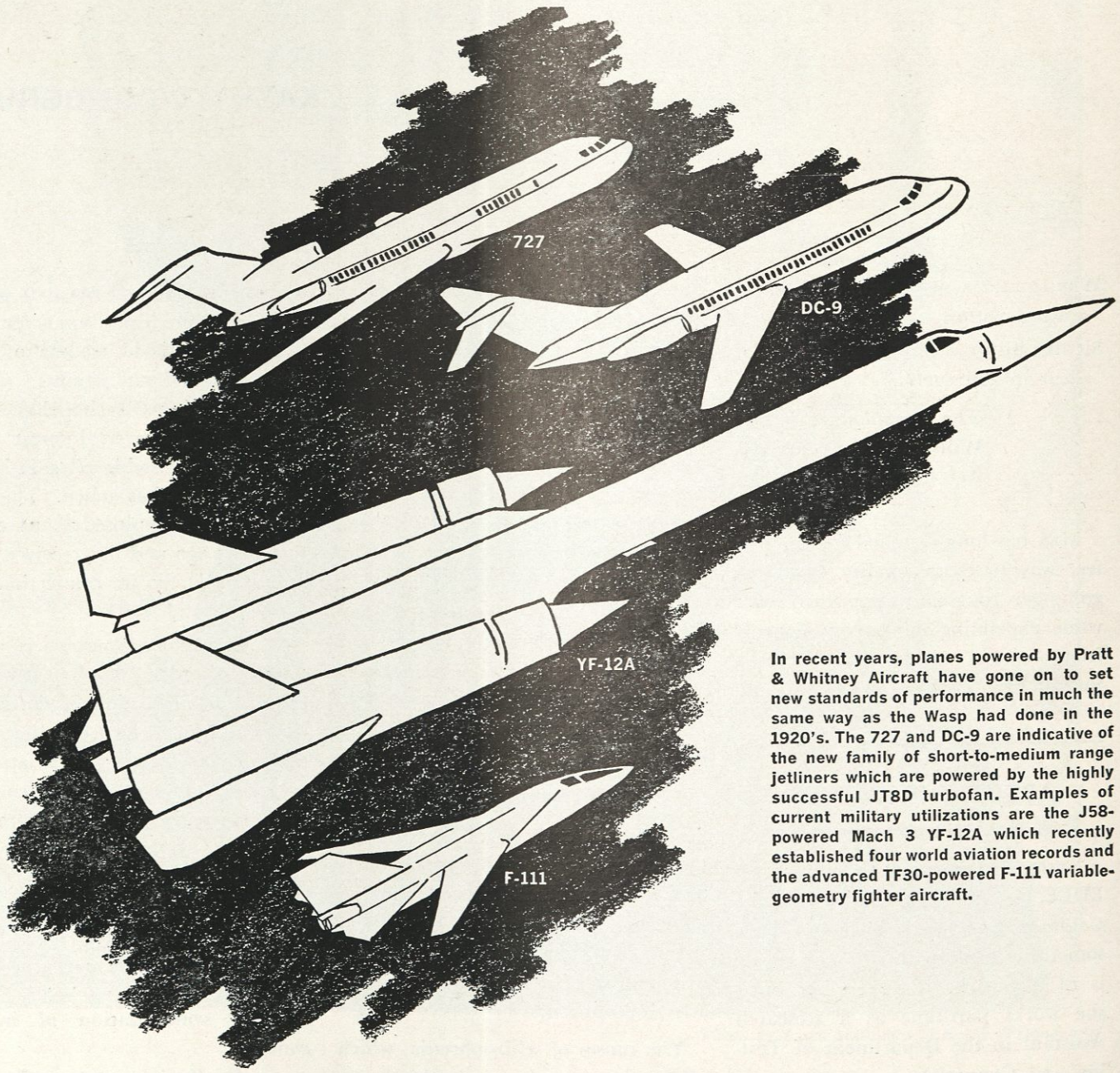
Present



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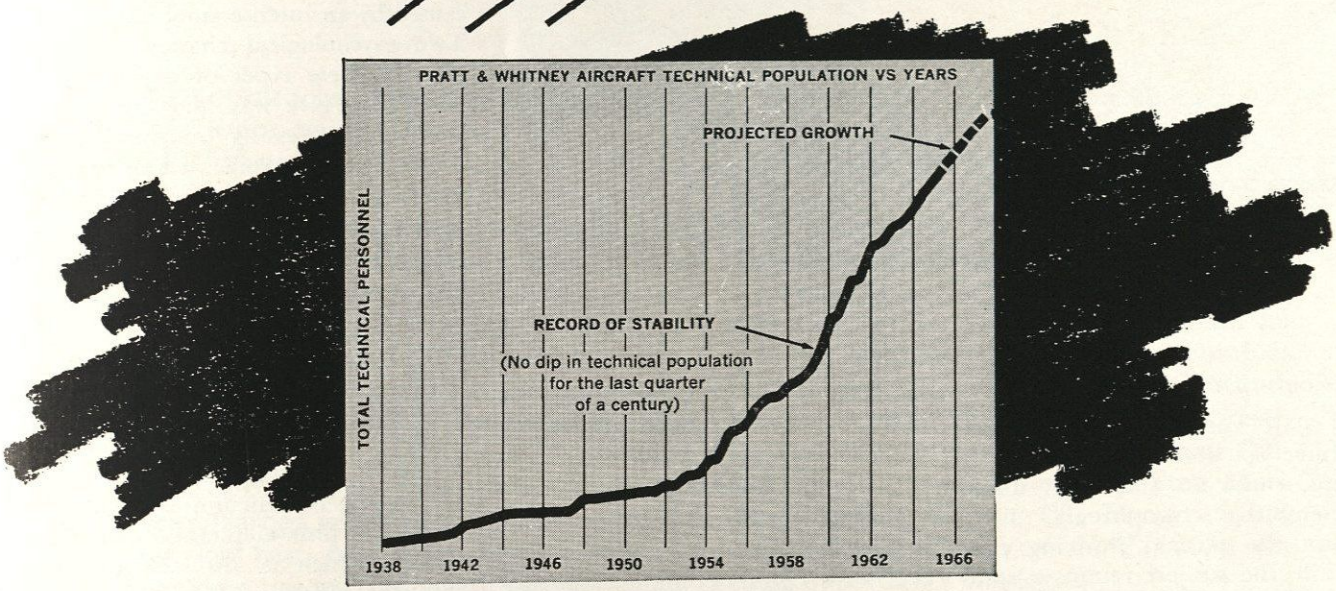
Your and the Future



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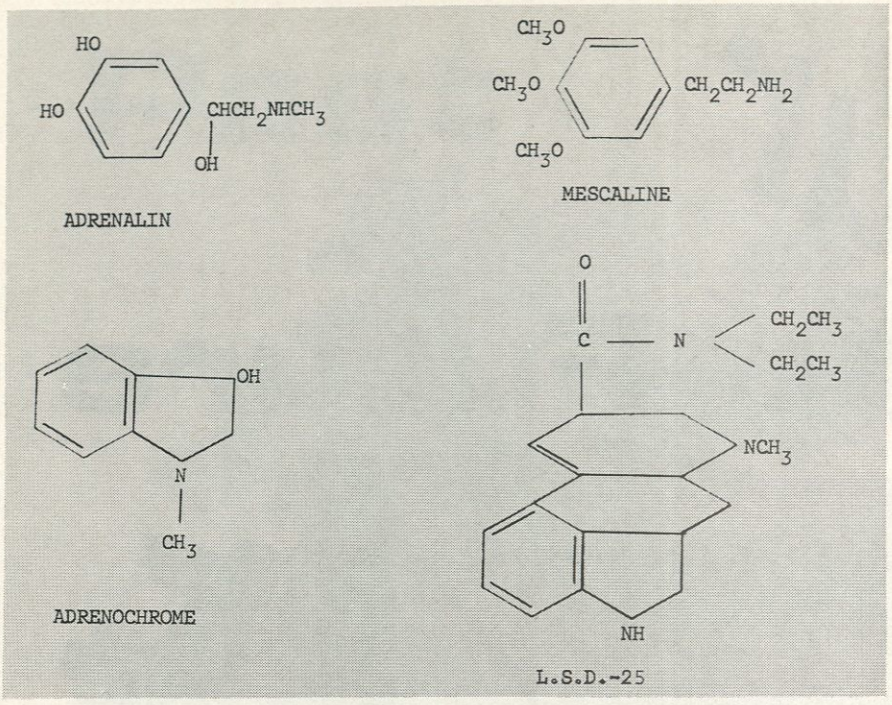

FIGURE 1: STRUCTURAL FORMULES.

(Continued from page 23)

The states induced by LSD and mescaline, as well as other hallucinogens, cause an emotional disorder resembling schizophrenia. They interrupt the normal thinking process while the subject retains a state of clear consciousness. Until about thirteen years ago, only hypotheses could be offered to explain why or how these drugs affected the human mind so strikingly. In 1952, an English psychiatrist noticed the similarity in chemical structure between mescaline and adrenalin. LSD also has a close bio-chemical relationship. Further research revealed that a product of the decomposition of adrenalin, adrenochrome, which occurs spontaneously in the human body, has properties similar to the hallucinogens. Since it appears that the human body is capable of producing a substance that causes profound changes in the mind, the feasibility of a physiological cause for schizophrenia is further enhanced. (See Figure 1)

Although this drug-induced "model psychosis" resembles schizophrenia in many areas, there seems to be something else "inside" the schizophrenic, something concerned with motivation and emotion, which is affected most strongly. But study of the model may provide much insight into the mind affected by mental illness. "Just how precise this mimicry is is not yet clear. This capacity may not even be their most important action." (2, 288)

Perception

Hallucinogenic drugs produce most importantly changes in sensory perception without causing a major disturbance in the autonomic nervous system. Drugs induce mainly visionary "experiences" although auditory changes as well as modifications of the touch sensation are frequent. Just what causes these changes in sensation—how do drugs affect the psyche? To understand a little of what happens, we must first examine perception in a normal situation. "It is important to realize that the world as we see it is far from an exact image of the physical world. Perception is highly variable and quite often erroneous. One limiting factor is that we perceive only what we can conceive; knowing is a prerequisite to seeing and strongly determines what is seen. We tend to see what can be incorporated into our established frame of reference and try to reject that which does not fit in." (3, 45)

Because of the way our optic nerves transmit images to the brain, we do not see things as they are. When our eyes reflect an image, the light waves are converted to minute electrical currents which are transmitted to the visual cortex along nerve fibres. Before this image focuses on the cerebral cortex, it is halved, reduplicated, inverted, transposed, and distorted. The eye itself is in constant micromotion to maintain continuous vision. When an image falls on the same retinal cells for more than one-fifth of a second the image will disappear. The perpetual movement of the eye permits different cells to reflect the image, thus allowing the used cells to recover.

Hallucinations

Visionary experiences may be caused by an intense emotional event. Two psychological changes are evident in these types of experiences—inhibitions give way and the mental action of processing information becomes less rigorous. The person gains the ability to focus absolute attention on the event and the event takes on a seemingly profound meaning.

The causes of hallucinations range from a physical blow (i.e., seeing "stars" after hitting the head) to a powerful upset in body chemistry produced by drugs. Perhaps the most frequently occurring hallucination in our society is delirium tremens, the "parade of pink elephants" caused by alcohol, which is also considered a hallucinatory drug. This occurs, however, only in acute alcoholics who have absorbed prodigious quantites of alcohol over a period of years.

Almost any drug, if ingested in large enough quantities, can produce a confused state of delusions marked by hallucinations. A common barbituate, taken in small quantities, acts as a seditive. Increasing the dosage increases the effect; it acts as a hypnotic, pain reliever, ego-depressant, and finally, as an anesthetic. Somewhere between the ego-depressant stage and anesthesia occur the hallucinations. The psychotomimetic drugs, those capable of producing psychotic reactions, are a heterogeneous group; asprin, caffeine, hormones, nutmeg, and even toxic amounts of water can all cause hallucinations.

The drug-induced hallucinations could originate from an effect on the eyeball. Retinal cells "fire" without light stimuli under the drugs. On the subject's private visual "screen," he sees multicolored fantastic patterns of swirling indescribable objects. These could very well originate from physiological causes.

(Continued on page 29)

How do you test a product that's six miles long? Or reduce the size of something almost too small to see?

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(Continued from page 26)

Whether the visions are blissful or frightening must, however, depend on the psychic condition of the subject.

LSD-25

Lysergic acid diethylamide (LSD-25), the newest and most interesting of the hallucinogenic drugs, was discovered by accident in 1943. Dr. Albert Hofmann, a Swiss chemist was working with lysergic acid, a derivative of ergot, a purple parasitic fungus that grows on rye, and accidentally inhaled or swallowed a minute quantity of the diethylamide. He reported the experience that followed:

> Last Friday, the 16th of April, I had to leave my work in the laboratory and go home because I felt strangely restless and dizzy. Once there, I lay down and sank into a not unpleasant delirium which was marked by an extreme degree of fantasy. In a sort of trance with closed eyes (I found the daylight unpleasantly glaring) fantastic visions of extraordinary vividness accompanied by a kaleidoscopic play of intense coloration continuously swirled around me. After two hours this condition subsided. . . . (3, 27)

Suspecting that the diethylamide was the cause, he took a small amount (250 micrograms, a much larger dose than required to produce an effect) and within an hour, he noted

> . . . mild dizziness, restlessness, inability to concentrate, visual disturbance and uncontrollable laughter . . . I had the greatest difficulty speaking coherently and my field of vision fluctuated and was distorted like the reflections in an amusement park mirror. I also had had the impression that I was hardly moving, yet later my assistant told me that I was peddling at a fast pace. (3, 29-30)

(Dr. Hofmann had started home with his assistant and the only available vehicle was a bicycle because of the war.)

> So far as I can recollect, the height of the crisis . . . was characterized by these symptoms: dizziness, visual distortions, the faces of those present appeared like grotesque colored masks, strong agitation alternating with paresis, the head, body and extremities sometimes cold and numb; a metallic taste on the tongue; throat dry and shriveled; a feeling of suffocation; confusion alternating with a clear appreciation of the situation; at times standing outside myself as a neutral observer and hearing myself muttering jargon or screaming half madly. . . . Everything seemed to undulate and their proportions were distorted like the reflections on a choppy water surface. Everything was changing with unpleasant, predominantly poisonous green and blue color tones. With closed eyes multihued, metamorphizing fantastic images overwhelmed me. Especially noteworthy was the fact that sounds were transposed into visual sensations so that from each tone or noise a comparable colored picture was evoked, changing in form and color kaleidoscopically. (3, 30)

Dr. Hofmann concluded that in lysergic acid diethylamide he had discovered a new hallucinatory drug, similar to mescaline, but potent in a dosage one-five thousandth as large.

The initial responses to LSD have been described as close to those of alcohol—the same feeling of lightheadedness, of being high. But with LSD, there is a marked absence of the dulling of sensations which alcohol causes. Instead, the subject remains clearly, even more conscious of what goes on. He feels a definite sense of suspense and excitment.

Certain psychic limitations, analogous to the physiological ones of eating, respiration, and digestion, are deemphasized under LSD. The synapses, which regulate the flow of sensations to the brain, appear to be greatly affected. It is as though at the same time concentration is greatly increased, and yet, is impossible be-

cause of the increased responsiveness of the nervous system. Most notably affected is the time sense. How time is thought of depends upon how the time is filled. Under LSD, the subjective clock races, responding, perhaps, to the increased tempo of experience which is felt.

Each object seems to acquire a perfound significance. Like a child gazing in awe at his first Christmas tree, so too, the LSD subject feels the wonder of newness. Objects are seen from a perceptional, rather than a rational viewpoint; they regain the meaningfulness that a child senses, the meaningfulness that repeated exposure has dulled. Ideas spring, unbidden, seemingly from nowhere and flood the mind with images. Thoughts generate other thoughts, creating a complex web where emotion and thinking are inseparable. Memories become vividly, almost frighteningly real.

The state induced can be blissful, as Dr. Hofmann described, or it can be terrifying.

> . . . Over my shoulder I could vaguely see what looked like a winged animal. It reminded me of a pterodactyl and it frightened me considerably. I was quite scared of it. We went on with the test though I still felt somewhat terrified of this thing. It seemed that instead of being in the room, it shifted outside as if I was too scared to have it inside with me and I put it outside. I felt often that it was beating its wings out there trying to get in. I could see through the window the flickering shadow of it. And once or twice I heard its wings. I was so terrified by this thing that I just couldn't move. Another pecuilar reaction was that every time I heard this thing, the tester would turn a pale green color and his face would assume the consistency of cream cheese with his eyebrows and hair being very finely etched against his pale face. It was the most frightening experience I've ever had. (3, 9)

But words are not adequate to describe the drug-induced experience. When description of the feeling is attempted the mental state becomes chaotic—just as the electron changes its path when measurement is attemped. What is felt is indescribable; it is something that you must experience to understand.

The long-range effects of a large amount of LSD are unknown. It is not addictive (very few hallucinogens are). There does exist, after consumption, a long period of latency (LSD is almost completely metabolized in the body), and there are side-effects, varying with the individual, such as nausea, vomiting or aches and pains. Many times the subject feels anxiety and panic because he is clearly conscious of the changes that LSD is causing and although he struggles to maintain self-control, the situation overpowers him. Other subjects, however, have a feeling of regret with the waning effects of the drug because they will soon return from their blissful euphoria to vexing reality.

Mescaline

In the dry barren regions of Mexico grows a small, round, dark green cactus whose innocent-looking tufts of hair contain a powerful drug. This cactus, Lopophora Williamsii, is the source of mescaline (3, 4, 5—trimethoxyphenylethylamine), one of the twenty-seven derivatives of peyote, and the only one with hallucinatory powers. The effects of mescaline have been known, but not understood for centuries; Indians in Mexico and the Southwestern United States practice a religion based on peyote, think-

ing it a source of mystic contact with the Divine.

Mescaline produces a hallucinogenic state similar to that of LSD. Neither produces an intoxication, but mescaline upsets the equilibrium so that the gait is staggering and muscular weakness develops. It is innocuous and leaves no addictive craving. For most mescaline subjects, the experience is blissful—very rarely does one experience a distressing reaction. Time does not race; it becomes fragmentary and discontinuous. Motivation is considerably reduced. The subject prefers to "mind his own business" (and such an intriguing business it is), rather than be concerned with what goes on around him.

Sensory perception is affected more acutely than with LSD; often occurring with mescaline is synesthesias transitions of sensation from one sense to another. Subjects speak of the scent of music, or say they can hear color. Synesthesias is thought to arise from an overflow of the nerve currents to the brain. The perception of one sense is so keen that its sensory circuit is overloaded and the overflowing sensations are directed to other sense circuits from which they are ordinarily suppressed.

Under mescaline, the subject feels "detached from himself," so to speak. This sense of depresonalization or "egolessness" gives the subject an objective look at himself; he comes as close as he ever will to seeing himself as others see him. Flights of ideas are "forced" into the mescaline influenced mind. These thoughts, individually visualized, produce a characteristic phenomenon of schizophrenia—"double thought." The mescaline subject is unable to follow one train of thought to completion; he has several trains chugging along on parallel tracks. His mind wanders contentedly through mazes of images, not grasping and not really caring to grasp.

The Hallucination

Aldous Huxley, in the spring of 1953, swallowed four-tenths of a gram of mescaline. In *The Doors of Perception* he described what he felt.

> . . . An hour and half later I was sitting in my study, looking intently at a small glass vase. The vase contained only three flowers—a full-blown Belle of Portugal rose, shell pink with a hint at every petal's base of a hotter, flamier hue; a large magenta and cream-colored carnation; and, pale purple at the end of its broken stalk, the bold heraldic blossom of an iris. Fortuitous and provisional, the little nosegay broke all the rules of traditional good taste. At breakfast that morning I had been struck by the lively dissonance of its colors. But that was no longer the point. I was seeing what Adam had seen on the morning of his creation—the miracle, moment by moment, of naked existence. . . . what rose and iris and carnation so intensely signified was nothing more, and nothing less, than what they were—a transsience that was yet eternal life, a perpetual perishing that was at the same time pure Being, a bundle of minute, unique particulars in which, by some unspeakable and yet self-evident paradox, was to be seen the divine source of all existence.
>
> I continued to look at the flowers, and in their living light I seemed to detect the qualitative equivalent of breathing—but of a breathing without returns to a starting-joint, with no recurrent ebbs but only a repeated flow from beauty to heightened beauty, from deeper to ever deeper meaning. Words like Grace and Transfiguration came to my mind, and this of course was what, among other things, they stood for. My eyes travelled from the rose to the carnation, and from that feathery incandescence to the smooth scrolls of sentient amethyst which were the iris. The Beautific Vision, 'Sat Chit Ananda,' Being-Awareness-Bliss—for the first time I understood, not on the verbal level, not by inchoate hints or at a distance, but precisely and completely what those prodigious syllables referred to. . . .
>
> The books . . . with which my study walls were lined . . . glowed, when I looked at them, with brighter colours, a profounder significance. Red books, like rubies; emerald books; books bound in white jade; books of agate, of aquamarine ,of yellow; topaz; lapis lazuli books whose colour was so intense, so intrinsically meaningful, that they seemed to be on the point of leaving the shelves to thrust themselves more insistently on my attention.
>
> . . . the perspective looked rather odd, and the walls of the room no longer seemed to meet in right angles. But these were not the really important facts. The really important facts were that spatial relationships had ceased to matter very much and that my mind was perceiving the world in terms of other than spatial categories. At ordinary times the eye concerns itself with such problems as 'Where?—How far?—How situated in relation to what?' In the mescaline experience the implied questions to which the eye responds are of another order. Place and distance cease to be of much interest. The mind does its perceiving in terms of significance, relationships within a pattern. I saw the books, but was not at all concerned with their positions in space. What I noticed, what impressed itself upon my mind was the fact that all of them glowed with living light and that in some the glory was more manifest than in others. In this context, position and the three dimensions were beside the point . . . The mind was primarily concerned, not with measures and locations, but with being and meaning. (7, 11-14)

It is easy to see from Huxley's description how the Indians who first discovered its powers attached a religious significance to mescaline. They could not comprehend the changes they felt and thus, they revered it. The feeling of complete and serene detachment was attributed to communion with the Divine.

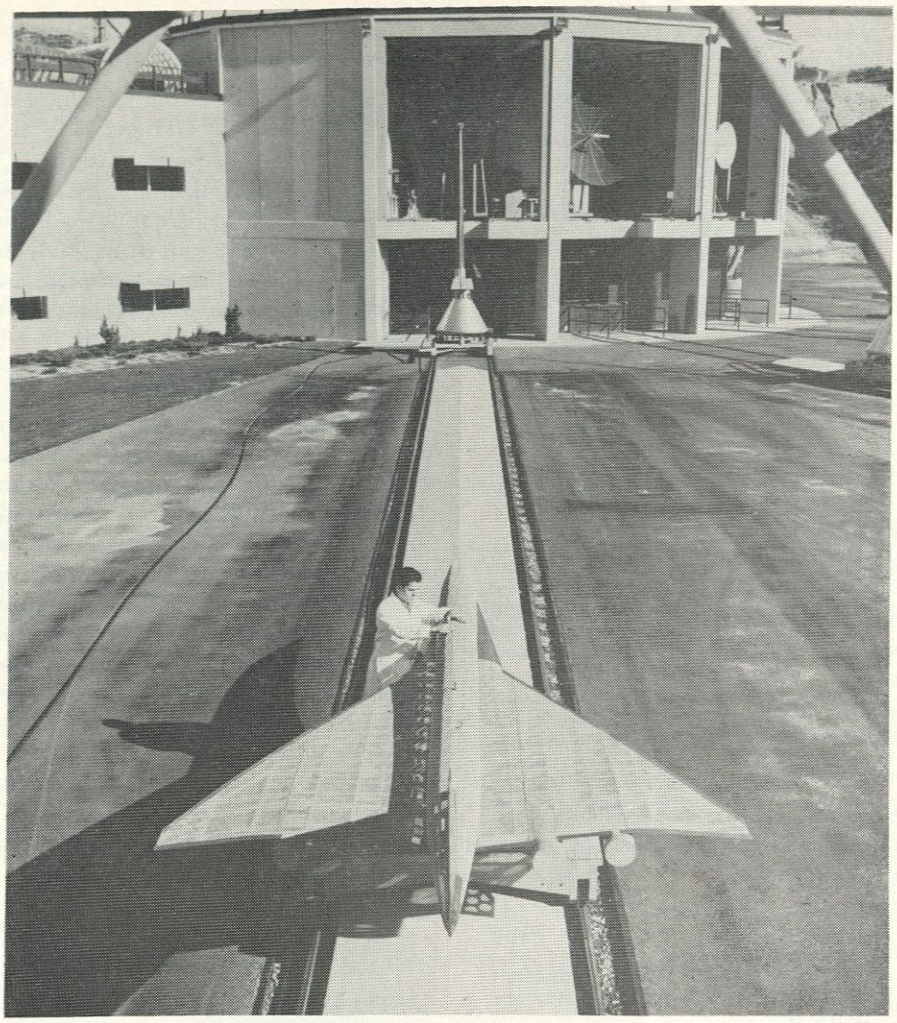
The Future?

No longer are we dependent on nature's intermittent supply of a cactus, mushroom or fungus for hallucinatory drugs; most of them can be synthesized. What man will do with this unlimited supply of drugs which so drastically affect the mind is a question that cannot be answered. Perhaps he will discover the causes of mental illness and find a cure. But the possibility of psychological warfare is ever-present and just as important as the possibility of nuclear annihilation. We have come very close to the "Brave New World" —we must avoid it.

BIBLIOGRAPHY

The author wishes to thank Professor Siegfried Mandel of the Engineering English Department for his assistance and suggestions.

1. Beckman, Harry, *Drugs: Their Nature, Action and Use*. New York: W. B. Saunders Company, 1958.
2. Beecher, Henry K., *Measurement of Subjective Responses: Quantitative Effects of Drugs*. New York: Oxford Press, Inc., 1959.
3. Cohen, Sidney, *The Beyond Within: The L. S. D. Story*. New York: Atheneum, 1964.
4. de Ropp, Robert S., *Drugs and the Mind*. New York: St. Martin's Press, 1957.
5. Garattini, S. and V. Ghetti, *Psychotropic Drugs*. Amsterdam: Elsevier Publishing Company, 1957.
6. Grollman, Arthur, *Pharmacology and Therapeutics*. Philadelphia, 1960.
7. Huxley, Aldous, *The Doors of Perception*. London: Chatto and Windus, Ltd., 1954.
8. Pennes, Harry H., *Psychopharmacology: Pharmacologic Effects on Behavior*. New York: Hoeber-Harper, 1958.
9. Talalay, Paul and Jane H. Murnaghan, *Drugs in Our Society*. Baltimore: The John Hopkins Press, 1964.
10. Uhr, Leonard and James G. Miller, *Drugs and Behavior*. New York: John Wiley and Sons, Inc., 1960.
11. Welsh, Ashton L., *Psychotherapeutic Drugs*. Springfield, Illinois: Charles C. Thomas, 1958.



SST Model Being Tested at Lockeed Rye Canyon Research Laboratory.

EYES, EARS, AND VOICE

"Eyes, ears and voice" for the delta-wing supersonic transport of the 1970's are being tested at Lockheed-California Company's Rye Canyon Research Laboratory. A tenth-scale model of the L-2000 SST is seen being fitted with antennas designed and developed at the company's electromagnetics laboratory. Communications from 70,000 feet-plus with ground stations thousands of miles away may be relayed through proposed stationary satellites positioned 24,000 miles out in space. The waffled appearance of the SST model in the foreground is caused by the surface covering of special hardware cloth to simulate the titanium skin of the proposed Mach 2.7 airliner. The entire SST model serves as a conducter for high frequency energy paths between the aircraft and the parabolic "dish" antenna in the background laboratory. As many as twenty-eight antennas for voice communication, navigation, and complete "blind" landing may be mounted in the supersonic transport to provide the most reliable communications ever put into commercial aircraft.

NEW RECORDING TECHNIQUE DEMONSTRATED

A new approach to tape recording head technology has been demonstrated by Fairchild Camera and Instrument Corporation. This technique incorporated in the newly released W-7000 series recorders, provides for significantly improved recorder performance, coupled with elimination of all record signal electronics circuitry.

This new technique represents a dramatic breakthrough in the state-of-the-art in tape recording. Two separate magnetic circuits permit separation of the bias and record signals, make possible the elimination of the electronics circuitry associated with record heads, and, even more significantly, provide for a sharper magnetic gradient on the tape.

SUB-NANOSECOND MONOLITHIC CIRCUITS

High-speed integrated circuits — forerunners of a class of circuits that could help make tomorrow's computers more than twice as fast as today's—were described here today by an IBM engineer.

The experimental monlithic circuits function at sub-nanosecond—or picosecond (trillionths of a second) — speeds. They can complete a logic operation in 7-tenths of a nanosecond (700 picoseconds). By comparison, the fastest logic circuits in today's computers function in nanoseconds (billionths of a second). The fastest in an IBM computer operate in less than 1.5 nanoseconds. The sub-nanosecond speed of these circuits was achieved by applying the electronic principle of delayed negative feedback. The use of feedback brings the circuits to their functioning threshold, that is, to the brink of switching from "off" to "on." This operation is roughly analogous to a runner building up a lead in a relay race which he, in turn, passes on to the next runner.

In operation, the critical part of the circuit never turns completely off. Thus, the time required to turn "on" is reduced. This "semi-on" condition also contributes to circuit stability, an inherent advantage of this circuit. The feasibility of using ultra-fast circuits in future computers will be highly dependent upon the ability of such circuits to power—or communicate with—other circuits with minimal losses of speed. These experimental circuits have been able to function in less than a nanosecond, while powering up to four other circuits.

The experimental versions of these devices are fabricated on 32-by 64-thousandths of an inch "chips" of silicon. Each tiny chip contains all circuit elements, including six transistors, eight resistors, and electrical interconnection paths. Subsequent versions may have several such circuits on a single chip.

THIS TODAY

JERRY ZIMMERMAN

COMPUTER DESIGNS COMPUTER

An experimental computer program which determines how to interconnect eighty electronic circuits on a wafer of silicon, and then controls fabrication of the interconnections, was described by an International Business Machines Corporation scientist.

The program permits for the first time, automatic by-passing of any faulty circuits on the wafer; thus, most wafers are usable despite the occurrence of faulty circuits at random positions. In present integrated circuit technology, faulty circuits are eliminated by cutting up the wafer into small chips, testing each chip, and discarding the bad ones.

The IBM computer program is a key step toward far higher levels of circuit integration than are feasible with present technonogy, which cannot reliably produce 100 per cent yields of perfect circuits on large semiconductor wafers. Computer control of interconnections makes practical the use of a silicon wafer containing hundreds of circuits as the first-level package in electronic systems, since faulty circuits can be automatically by-passed. The program can also generate patterns that permit a standard wafer to be interconnected in different ways to perform different functions.

"Eighty Interconnected Circuits Designed by an IBM Computer."

POROUS GLASS

Water separator plates made of porous glass have played a key role in the fuel cells aboard the Gemini spacecraft. Fuel cells aboard each spacecraft combine hydrogen and oxygen to generate electricity. A by-product of the chemical reaction is water—about a pint per kilowatt-hour Unless the water is removed, the cells will drown themselves and cease to operate.

A unique porous glass, developed by Corning Glass Works, is used to separate gas and water in fuel cells made for the Gemini program. Moisture-absorbing wicks collect the water formed on the oxygen side of the fuel cell and channel it to the inside surface of the glass water separator plates. The porous glass absorbs water rapidly from the wicks. The water passes through the glass plates and is stored outside the fuel cell. But the plates will not permit oxygen to enter the water system. A positive pressure differential inside the cell prevents water from being reabsorbed and re-entering the cell.

Each cell uses three water separator plates approximately 5¼ x 7¼ inches. Plate thickness is about ¼-inch. Pore size is approximately 5½ microns. For other applications this porous material can be fabricated in various flat shapes or as tubing, and pore size can be varied from about one to 200 microns.

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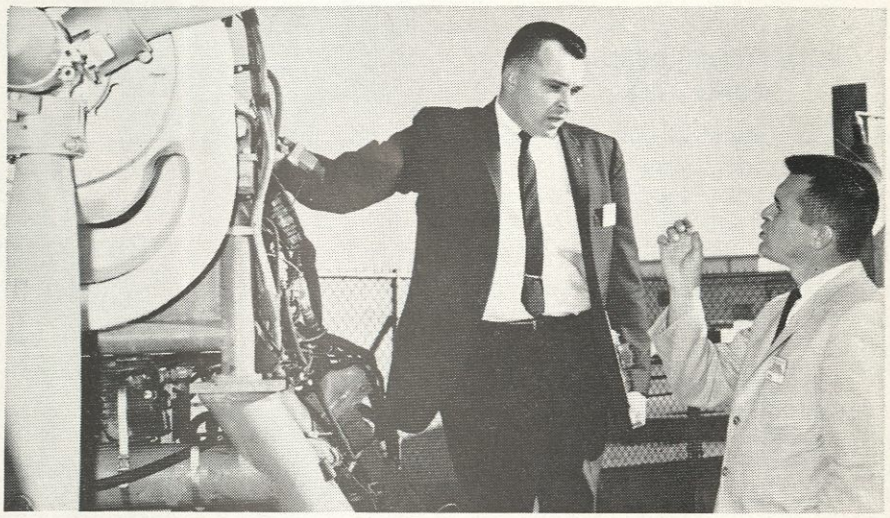

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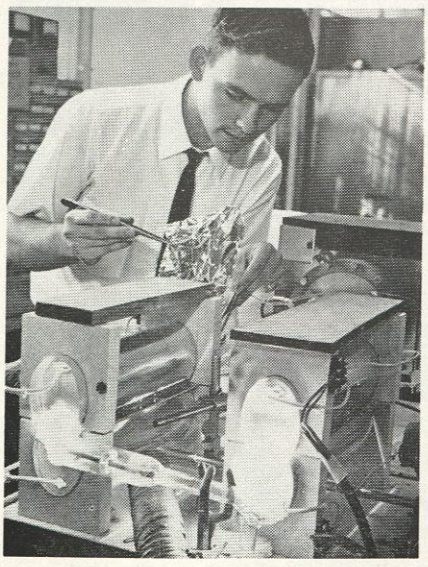

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THERMOELECTRIC GENERATORS

ALAN HICKENBOTTOM

Since its discovery, man has relied more and more on electrical power. This power lights our cities and moves our machines. Recently, the east coast experienced a major electrical power failure. The blackout would possibly be a forecast of things to come if technology does not advance as fast as do power requirements.

Today, only two major sources of energy produce electrical power: water power and fossil fuel. Water power produces electricity by utilizing the kinetic energy of falling water to turn turbines which drive generators. The sources of the water power are limited by geographic location. The other source, fossil fuel such as coal and oil, is used to produce heat, subsequently driving generators by steam turbines or internal combustion engines. Fossil fuel is not infinite in supply. New sources of these fuels are being discovered daily, but established, as well as all new sources, may be completely exhausted in the foreseeable future. It has been estimated that man will have used up the earth's supply of fossil fuel in the next thousand years if the current rate of consumption is maintained. However, consumption in the last century has grown tremendously due to industrialization. If this increase in the rate of fuel consumption is also projected into the future, man's fuel supply may last only an estimated one hundred years.

Clearly, technology must devise other methods of producing electrical power. Among the methods that are currently being developed is a group of power producing devices called direct energy converters. These use various forms of energy and convert that energy directly into electricity. The form of energy used and the method of conversion differs from one type of device to another, but all have one common factor; that is, the energy used does not require a mechanical mechanism such as a turbine to convert it to useful power, rather, the energy is converted directly to electrical energy due to the properties of the materials of which the converter is composed.

Basically, there are five types of direct energy converters. Their names convey the general method of energy conversion and are: (1) Thermoelectric Generators, (2) Photovoltaic Cells, (3) Thermionic Generators, (4) Magnetohydrodynamic Power Generators and (5) Fuel Cells. Each has its own individual history, development, analysis, and application. A detailed summary of the Thermoelectric Generator follows a brief sketch of the other types of direct energy converters.

PHOTOVOLTAIC CELLS: Commonly called a solar cell, this power generator normally consists of silicon semiconductor materials. The materials produce an electric current when subjected to light energy or photons. These cells are currently in use to produce power for space satellites, portable radios, and other applications, requiring only light from the sun to operate.

THEROMIONIC GENERATORS: These are essentially diodes or vacuum tubes familiar in electronic circuits. There is an anode or electron receiver and a heated cathode or electron producer separated by a vacuum or a plasma. When the cathode is heated to a very high temperature, electrons leave it and travel through the vacuum or plasma to the anode creating an electric current. At the present time, only small prototype units for laboratory tests have been developed and technological advances in materials are needed to build anodes and cathodes for thermionic systems that will operate at higher efficiencies than are currently available.

ABOUT THE AUTHOR

ALAN HICKENBOTTOM

Alan D. Hickenbottom, a senior in Mechanical Engineering, is interested in direct energy conversion devices and methods. He is married and has a four-year old daughter.

MAGNETOHYDRODYNAMIC POWER GENERATORS: This relatively new concept of power generation groups many converters into the MHD category. All of the converters in the MHD category utilize a conducting fluid passing through a magnetic field to produce electricity. This concept is contrasted to the commonly known generator that produces electricity by passing a solid or wire through a magnetic field. The conducting fluid in the MHD generator varies widely from one type generator to another. Liquid metal, such as mercury, or ionized gases are used for the conducting fluid. The most feasible of the conductors is the gaseous or plasma conductor. Working models of MHD generators are generally high temperature, high output, large, bulky devices that limit their applications mainly to that of an additional device to boost the output of steam power plants. MHD generators powered by nuclear fuels possess attractive features also, because of the rapidly advancing technology of nuclear power plants. The concluding paragraphs of a paper by Richard J. Rosa and Arthur Kantrowitz, discuss a few of the features of an MHD generator:

> First, in order to obtain sufficient gas conductivity, quite high gas temperatures are required. However, due to the absence of hot, highly stressed moving parts, an MHD generator should be able to handle even higher temperatures thereby permitting high thermodynamic efficiency. Although high temperatures should pose relatively few problems in the generator itself, they clearly present difficult problems for other components of the cycle, principally the thermal energy source itself. It follows that the ultimate performance and range of usefulness of MHD generators depends in part on developments in high temperature technology . . . The present rapid growth of this field justifies considerable optimism on this score.
>
> An MHD generator would probably be restricted to relatively high power applications. Present indications are that it would not be particularly competitive with other conversion schemes in applications requiring less than about one megawatt of power. However, for the production of power in excess of one megawatt it shows promise of being more compact and possibly orders of magnitude lighter than other devices.[1]

FUEL CELLS:

> The fuel cell is an old concept and research work on this subject has been in progress on a limited scale for approximately 100 years. A fuel cell may be defined broadly as an electrochemical device for the continuous conversion of a portion of the free-energy change in a chemical reaction into electrical energy. It is distinguished from a battery in that it operates with continuous replenishment of the fuel and the oxidant at the active electrode areas and thus does not require recharging.[2]

The fuel used in a fuel cell may be the same as that used in an internal combustion engine. A combustion reaction takes place in the cell, but by a different method than commonly thought of, thereby directly producing an electrical current. Combustion in an engine mixes the fuel and oxidizer molecules, which chemically react to produce heat. A fraction of the thermal energy is converted to mechanical work which may then turn a generator to produce electricity. In the fuel cell, fuel does not mix directly with the oxidizer. The fuel transfers electrons to the anode through an oxidation process; the electrons travel through a load circuit to the cathode; the oxidizer at the cathode is then chemically reduced by the electrons.

Fuel cells have been a subject of growing interest and technology has produced hundreds of prototype cells with as many different fuels used in them. One striking application should be mentioned. This is the hydrogen-oxygen fuel cell used to produce power for the Gemini space capsule. Researchers in the field of fuel cells predicted this type of application as early as 1959.[3] The future will certainly find an increase in the use of the fuel cell as a source of electrical power.

The first type of converter, the THERMOELECTRIC GENERATOR, consists of two different materials joined together at a junction with the other end of the materials connected by a wire into an external closed loop or circuit. Because of the nature of these materials, a current flows from one material to the other at the junction when heat is applied. This is the nature of a thermocouple which measures temperature at the junction of two dissimilar metals by measuring the minute current produced at the junction.

This effect was first noticed in 1821 by Thomas Johann Seebeck when he found that the needle of a compass was diverted when held near a circuit consisting of two conductors. He erroneously attributed the compass deflection to a temperature difference rather than the small current flowing in the circuit. In the course of his studies of this effect, he investigated a number of materials including metals and metal oxides, some of which are now classified as semiconductors. A property of these materials now bear his name, the Seebeck coefficient, which relates thermoelectric power in terms of potential difference per degree Centigrade.

The Peltier Effect

Jean Charles Athanase Peltier discovered thirteen years later that by passing a current through a circuit of two different conductors, heat or a refrigeration effect, depending upon which direction the current flowed, occurred at the junction. He also misinterpreted his findings and it was not until 1838 that Emil Lenz correctly described the phenomena. Using a bismuth-antimony junction, Lenz demonstrated that water could be frozen at the junction by passing a current through the junction. When the current was reversed, the ice at the junction was melted.

Lord Kelvin derived the relationship between the Seebeck and Peltier effects thermodynamically. His work led him to discover what is known as the Thompson effect. In the early 1900's, Altenkirch derived the basic theory of themoelectric generators and refrigerators, but materials that would effectively produce the desired results were not known or in very limited supply. With the increased technological gains in the past 50 years, materials with the desired properties of high Seebeck coefficients, high electrical conductivities and low thermal conductivities have been made readily available. These materials, because of their unique nature of high electrical and low

thermal conductivities, are known as semiconductors.

Thermoelectric Generators

Semiconductor materials are used to effectively produce current in the thermoelectric generator. Electron movement from one of these materials to another produces the current flow in the circuit. The electron movement occurs from a p-type semiconductor to an n-type. The atomic structure of the p-type material is such that a few of its electrons are at a high energy state, and the n-type material is able to accept electrons. With the addition of thermal energy from a heat source at the junction of the p and n materials, the electrons in the p-type gain enough energy (Peltier heat) to leave their normal state and flow to the n-material. This creates an excess of electrons in the n-material. The electrons flow through the n-type material and into the circuit. As the electrons leave the p-material, they cause a deficiency or "holes" in the electron structure. Other electrons in the p-material fill these holes, causing new holes. The general effect is that the holes migrate to the circuit end of the p material. These holes are then filled by electrons from the n-type material which have flowed through the external circuit. When the electrons from the circuit enter the p-material, energy is released in the form of heat (again Peltier heat) to a heat sink or a region of lower temperature than the heat source. This temperature difference is what "drives" the thermoelectric generator.

Second Law Limitations

Because a temperature differential is required to produce electricity in the thermoelectric generator, the efficiency of this device is limited by the Second Law of Thermodynamics. The law, as it applies in the case of the thermoelectric device, states that the ideal efficiency is related to the temperature differential. The larger a differential that may be maintained, the greater the ideal efficiency. However, a larger temperature differential may decease the actual efficiency due to the properties of the semiconductor materials used.

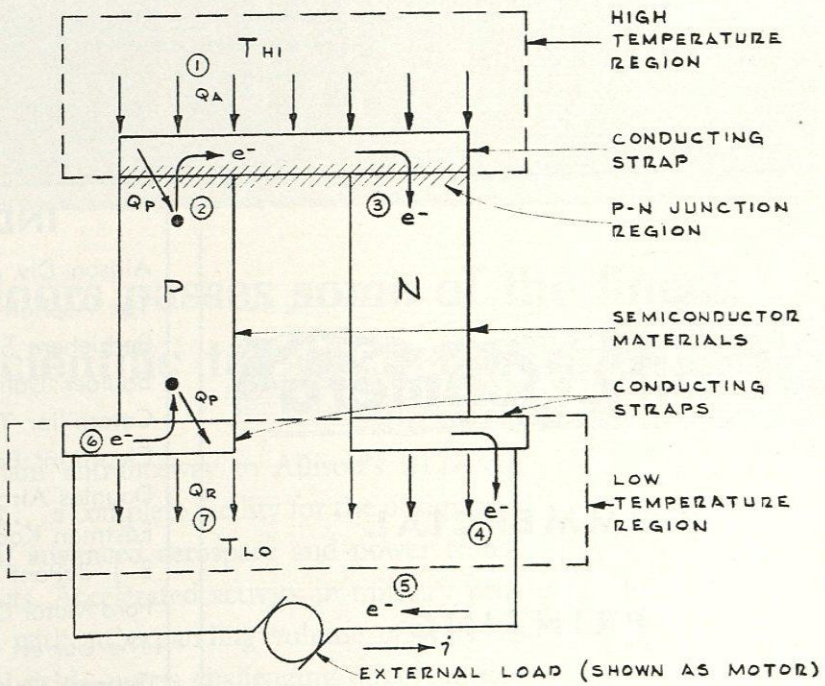
If a power source in the external circuit causes a current to flow, the p-n junction will act either as a refrigerator or a heater, depending on which direction the current is flowing. This is merely the reverse of a temperature difference causing a current to flow in the external circuit. Because of this characteristic, devices that can be classified as thermoelectric generators have been investigated as sources of heat and refrigeration. Their practical application cannot at this time be extended over a wide range of the commercial market. Refrigerators for household use are more economical when conventional refrigerant systems are used. However, there are many specialized applications for a refrigerating device of the thermoelectric type.

Thermoelectric Refrigerators

Among the people investigating the practical applications of the thermoelectric devices are those with the Whirlpool Corporation, who have stated:

> . . . household appliances based on the thermoelectric principle [are] still several years away because of present capacity limitations and economic considerations. In specialized applications similar to the constant temperature device and in areas where the desirability of having flexible spot heating or cooling without noise and without large cooling or heating units, the thermoelectric process is useful today. Areas can be envisioned, particularly in connection with electronic equipment, within a submarine, missiles, or aircraft, where the specific application should be investigated and the feasibility of thermoelectric processes determined.[4]

Practical applications of the ther-



Q_A = HEAT APPLIED
Q_P = PELTIER HEAT
e^- = ELECTRONS
i = ELECTRICAL CURRENT
● = HOLES (ELECTRON VACANCIES)
Q_R = HEAT REJECTED

① HEAT APPLIED TO P-N JUNCTION
② PELTIER HEAT RELEASES ELECTRON FROM P MATERIAL
③ ELECTRON ENTERS N-TYPE MATERIAL
④ ELECTRON ENTERS EXTERNAL CIRCUIT
⑤ ELECTRON MOVEMENT CAUSES CURRENT TO FLOW
⑥ ELECTRON FILLS HOLE, RELEASING PELTIER HEAT
⑦ HEAT RELEASED FROM GENERATOR

DIAGRAM OF A THERMOELECTRIC GENERATOR

moelectric device as a generator are also very specialized. When compared with a commercial power generating system, the thermoelectric device is seen to be very costly for the amount of power produced. For small power requirements in other than standard environments, the thermoelectric generator offers more advantages than does a commercial system.

One example of this is the power source for a satellite. Among the requirements for such a power source are these: (1) Lightweight, (2) Able to function in the vacuum of space, (3) Maintenance free (4) Long life, (5) Withstand shock of launching, (6) Small in size. The first commercial system that may be thought of to supply satellite power is a battery. While a battery will fulfill requirements 2 and 3, an enormous battery system would be necessary to fulfill requirement 4. Consequently, the first or lightweight requirement and the size requirement would eliminate the use of ordinary batteries. The thermoelectric generator fulfills all six requirements and would actually function more efficiently in space than on earth due to the environment. Concentrated radiation from the sun could supply the thermal input with the necessary thermal energy rejection radiated into space. This temperature gradient of hot to cold is then produced more easily in space than on earth.

No Maintenance Problem

Any commercial system of power that has moving parts would violate the maintenance requirement to some extent. A thermoelectric generator has no moving parts. This is a large factor in applications other than satellites. Isolated, unmanned data recording and reporting stations would require a power source that needed no maintenance also. These advantages are summarized by R. W. Fritts:

> Thermoelectric generators offer a number of advantages over direct current power sources such as batteries and rotating machines. They are of simple structure requiring no moving parts; they are silent in operation and capable of virtually endless shelf life when used as emergency stand-by power sources. To what extent thermoelectric generators will replace conventional means for generating electricity will depend largely upon the efficiencies that can be obtained in the "semi-metal" materials now under intensive study in many laboratories.[5]

Design of efficient thermoelectric generators must deal with many basic problems. Some of these are the materials to be used, the source of a temperature gradient and the actual configuration of the device. There are many problems that must be solved before a final design is established and the areas mentioned will illustrate typical examples of these problems.

The materials or semiconductors used in a thermoelectric generator are the bases of its ability to produce electric power and, therefore, of prime consideration. There is a wide variety of semiconductors available for use today. The final decision of which one to use will depend largely on the application to which the generator will be applied, but all of

(Continued on page 40)

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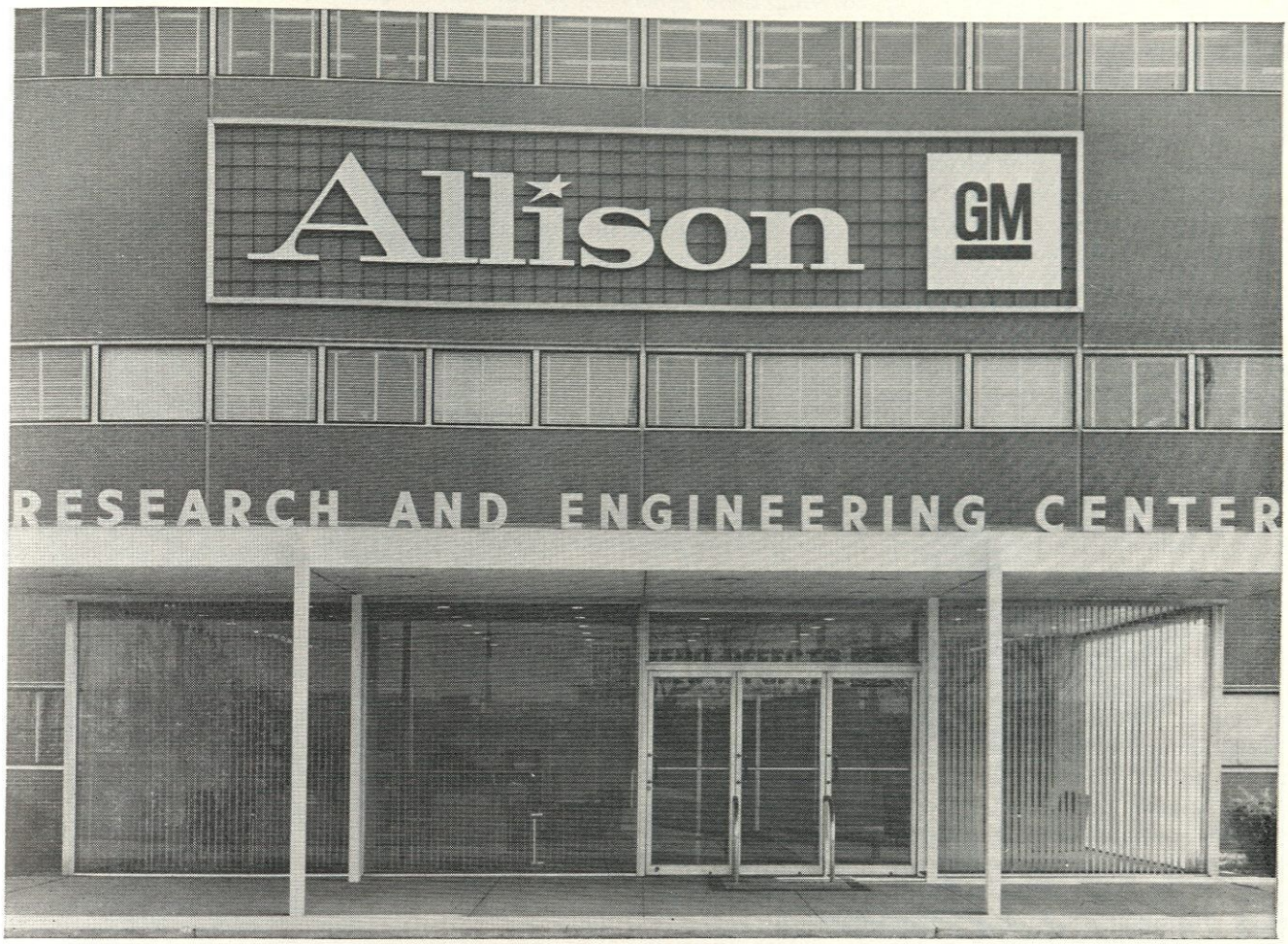

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(Continued from page 38)

these materials have properties and problems in common. As previously stated, high electrical and low thermal conductivities are desirable. These two effects are closely related and, for most metals, a high electrical conductivity is associated with a high thermal conductivity. Also interrelated with the conductivities is the Seebeck coefficient. Semiconductors ideally suited for use in thermoelectric generators are materials which have maximized electrical conductivity and minimized thermal conductivity while retaining a relatively high Seebeck coefficient.

Efficiency Problems

To calculate efficiencies of the generator, a thermodynamic approach is used. Losses due to characteristics of the materials seriously affect efficiencies. Since all materials have some thermal conductivity, there is a loss due to the conduction of heat through the generator from the hot junction to the cold end of the generator. Another significant factor is the resistance or Joule heating of the generator due to the current generated. A detailed analysis of all the factors involved is complicated and covers more facets of the subject than is necessary for a basic understanding.

The source of a temperature gradient is involved with where and how the generator is to be used. Prototype generators have been constructed using the heat from a kerosene lantern and room temperature to supply the necessary temperature gradient. These generate enough electric current to power a radio. Heat from the sun as well as nuclear initiated temperature gradients have been theorized if not already constructed as prototypes. Any conceivable method for producing a temperature gradient may possibly be used for a thermoelectric generator.

The configuration of the device also depends upon the use to which the generator is intended. Usually a number of individual generators are grouped together to produce the power required. The grouping may be in series or side by side with all generators working from the same temperature differential or the grouping may be of a cascaded type. Cascading generators are arranged such that one generator is on top of another. The temperature difference driving these generators in the cascade is the hot temperature of the generator immediately below it. The cascading of generators requires a separate analysis of each level of the cascade and the generators on different levels are generally not made of the same materials due to the different temperatures involved at the different levels. Materials usually have an optimum high and low temperature, so with different temperatures different materials give greatest performance.

Each individual generator also has problems concerning configuration.

Utilizing the expanding technology associated with the transistor industry, researchers working on thermoelectric materials developed intermetallic compounds with good thermoelectric properties. At that time the thermoelectric device designer faced two problems almost as difficult to solve as the materials problem. They were:

(1) The fitting of thermoelectric elements with electrodes that would provide semiconductor-to-metal interfaces through which heat and electric current could easily flow.

(2) The development of a thermocouple structure that would accommodate the mechanical properties of thermoelectric materials. During thermal cycling a generator is subjected to thermal expansion and contraction due to temperature differences. Moreover, since the generator is a high heat flux device, good efficiency requires that the various interfaces be placed in compressive engagement, thereby mechanically stressing the semiconductor components as well.[7]

These two problems have been sufficiently solved by:

1) The discovery that certain materials would bond the electrodes to the semiconductors with good strength while not altering the atomic structure of the semiconductor and still permit easy passage of heat and electric current.

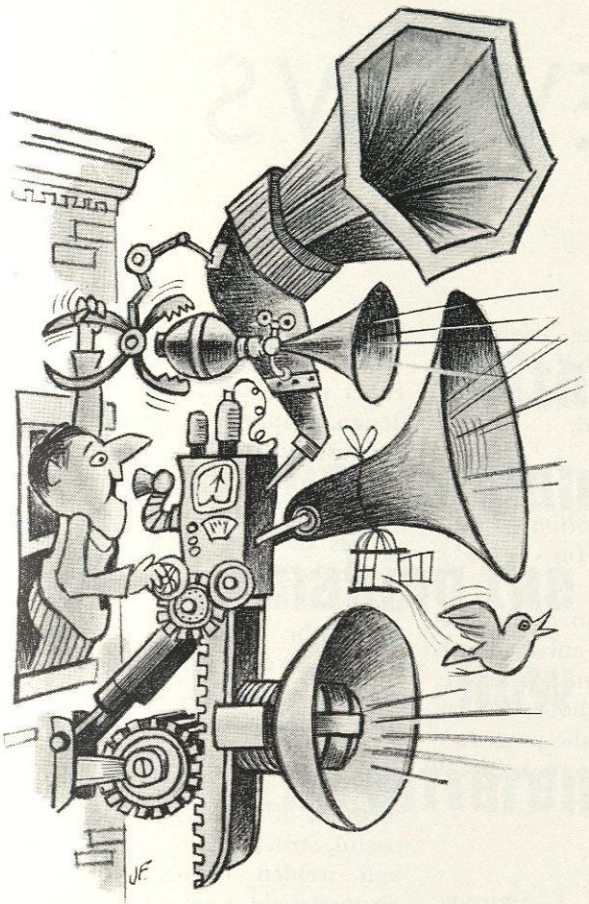
2) Compressive loading of the mechanically weak semiconductor materials. As new and better semiconductor materials are discovered, other problems of this nature will no doubt arise, but they too will be met by an expanding knowledge in the technology of thermoelectric generators.

Thermoelectricity and other direct energy converters are devices with a future limited only by technology. A few of these devices are being used commercially today. Others are being used to suit a particular need, although they are not the most economical, but are rather the most adaptable devices available. The future will no doubt see an expanding usage of direct energy converters.

Direct energy converters definitely contribute as power producers today in many varied applications, especially where ordinary power sources are not feasible. Their importance as power producers will certainly grow as technological developments occur to improve their performance. To what extent the direct energy conversion devices will be developed and used, no one can say, but they are one possible answer to man's ever expanding need for electrical power.

BIBLIOGRAPHY

1. Rosa, Richard J. and Arthur Kantrowitz. "Magnetohydrodynamic Energy Conversion Techniques," *Direct Conversion of Heat to Electricity*, Joseph Kaye and John A. Welsh, editors. New York: John Wiley & Sons, Inc., 1960.
2. Gorin, E. and H. L. Recht, "Fuel Cells," *Selected Papers on New Techniques for Energy Conversion*, Summer N. Levine, editor. New York: Dover Publications, Inc., 1961.
3. Douglas, D. L. "Advances in Basic Sciences — I. Fuel Cells," *Selected Papers on New Techniques for Energy Conversion*, Summer N. Levine, editor. New York: Dover Publications, Inc., 1961.
4. Stoll, Gerhard C., Robert L. Eichhorn and Richard G. Sichert. "Thermoelectric Device Design," *Thermoelectricity*, Paul H. Egli, editor. New York: John Wiley & Sons, Inc., 1960.
5. Fritts, R. W. "Design Parameters for Optimizing the Efficiency of Thermoelectric Generators Utilizing P-Type and N-Type Lead Telluride," *Direct Conversion of Heat to Electricity*, Joseph Kaye and John A. Welsh, editors. New York: John Wiley & Sons, Inc., 1960.
6. Von Doenhoff, A. E. and D. A. Premo. "A Brief Survey of Direct Energy Conversion Devices for Possible Space-Vehicle Application," *Selected Papers on New Techniques for Energy Conversion*, Summer N. Levine, editor. New York: Dover Publications, Inc., 1961.
7. Angrist, Stanley W. *Direct Energy Conversion*. Boston: Allyn and Bacon, Inc., 1965.



Yell it out the window!

. . . or whisper it over his MOTRAN Radio*

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MOTOROLA

BOOK REVIEWS

LARRY DAVIS
BOB ECKLAND

Simplified Hydraulics

by L. S. McNickle, Jr.; McGraw-Hill Book Company (1966); $10.00.

McNickle begins *Simplified Hydraulics* by dividing hydraulics into two classes, hydrostatics and hydrodynamics. He then tells us that he will not discuss hydrodynamics. Further, he writes almost entirely about *oil* hydraulics as it is used in industrial hydraulic system. So the title of the book is misleading—it is not concerned with the whole field of hydraulics at all.

Simplified Hydraulics is a discussion of the components of an industrial hydraulic system and the ways to avoid and discover difficulties in their operation. The physics used in the book is extremely simple—the most difficult formula given involves but one multiplication and a division. But the descriptions and terminology used in discussing hydraulic components are very technical—they appear to be aimed at a mechanical engineer. The author says in his preface that he is writing for the beginning student, in an effort to make the relationships between the components of an industrial hydraulic system simpler to understand. The trouble with his approach is that the reader must sift through the technical language in every chapter to find out anything at all about these relationships. They are nowhere summarized, and in many places they appear to be assumed already known to the reader. And McNickle's style gets in his way often. He makes frequent use of the passive, as well as many strange grammatical constructions.

Simplified Hydraulics is a good reference book for the hydraulic system troubleshooter. But the beginning student should remember that the book is not really about hydraulics, nor is it really simplified.

Engineer's Manual

Edited by A. T. Collins; Philosophical Library, Inc. (1965); $10.00.

This, the fifth edition of the *Engineer's Manual,* is an enlarged version of the fourth edition. As before, it is still *the* reference books for engineers; and, as before, the procedure given for extracting cube roots is very confusing.

Rolling Mills

A. I. Tselikov and V. V. Smirnov; Pergamon Press (1965); $25.00.

Rolling Mills is a translation from the Russian. It is a well-done book, integrating theory and practice and using frequent illustrations taken from Russian mills.

The authors begin by describing rolling mills in general and acquainting the reader with the subject. They then move to descriptions of the different types of rolling mills in current operation and discussions of the parts of rolling mills and their functions. Subjects touched on are roll stands and their parts, parts transmitting rotation to the rolls, special purpose mills, auxiliary machines, and lubricating systems.

Constructional Steelwork Simply Explained

by John Faber, Oxford University Press, 133 pages, 1966.

Mr. Faber assumes the reader has little or no knowledge of the principles or terminology of constructional steelwork. On this basis, he begins with basic instruction in elementary properties of steel such as stress, strain, elongation, and elasticity. When the reader has acquired adequate background knowledge, Mr. Faber progresses to simple structural design, employing the priniciples he has just outlined.

Constructional design involves consideration of the aforementioned properties of steel as well as bending moments, moments of resistance, and shear and web stress. Mr. Faber explains the value and limitations of various structural elements such as girders, stanchions, and beams using these considerations. Following analysis of individual members and structural units, Mr. Faber outlines methods of combing these units into useful structures by riveted, bolted, and welded connections, and the characteristic properties of connection. *Constructional Steelwork* is a British book and therefore uses British standard terminology for units of measurement.

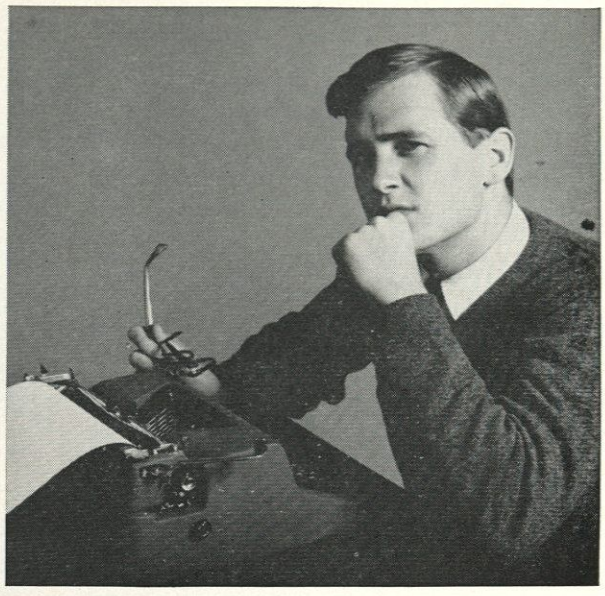
Industrial Relations in Engineering

by A. Marsh, Permagon Press, 362 pages, 1965.

Like the previous one, this book is British and also uses terms that have different connotations to an American reader. For instance, Mr. Marsh uses the term "engineer" to include workers employed in such capacities as drop forging, boilermaking, sheet metal work, general founding and automobile fabrication. This comprehensive use of the word is very misleading in that the book does not deal with labor relations of industry and engineers (used as we would use it), but rather with labor relations of industry and "workshop" employees.

Industrial Relations in Engineering is a factual, well-written book on the subject of industrial relations and attempts to extend to the reader knowledge of the actual working of collective bargaining in Britain.

Engineers & Scientists



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Note particularly the diversity and breadth of SES projects. You may advance in a technical or administrative capacity in any of these areas: ground electronics equipment for Minuteman missile sites...research and development in electronic warfare field...electronic security systems...ASW systems...special purpose airborne computers for incorporation into U.S. Air Force large scale electronic systems...laser systems...design of spaceborne electronic and optical systems...plus world-wide engineering support systems.

Note that SES has worked out three distinct routes for advancement, all with equal rewards—technical specialist, technical manager, program/project manager.

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Making promises is one thing. Making progress is another.

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PUZZLE PAGE

BRUCE DUNN

THIS MONTH'S PUZZLES:

1) If an astronaut is trying to reach a distant heavenly body which takes five days of travel time to reach, and his ship will only carry fuel for about three days travel, how long will the trip take in total? You can assume that he can store fuel at the end of any whole day's journey.

2) For a simple problem in algebra, you can try to find two different integers, the sum of whose cubes is equal to the fourth power of a third integer. After finding one pair, it should be easy to establish a system for finding combinations like this.

3) Next, let's assume that I lend a friend an amount of money equal to the amount he had. He then proceeded to spend $10.00 of this and came back for more. Again I loaned him as much money as he now had, again he spent $10.00 dollars, again I made a similar loan (I'm just a sucker for a friend) and again he spent $10.00. However, at this point he was broke. How much did my friend (???) have in the first place?

4) The last puzzle is a simple reconstruction problem. Solve the formula:

TWO x TWO = THREE

For this, the usual assumption about each letter representing a unique digit constantly the problem holds.

ANSWERS IN MAY ISSUE

ANSWERS TO JANUARY'S PUZZLES:

1) For this one I refer you to Figure 1, which should make the solution quite clear. If the rug is cut along the rather unusual line shown in Part a (it didn't take a quiz-kid to discover that a straight cut wouldn't do the job), and the two halves arranged as in Part b, then the exterior dimensions are 9'x12', and the opening in the center is 1'x8'.

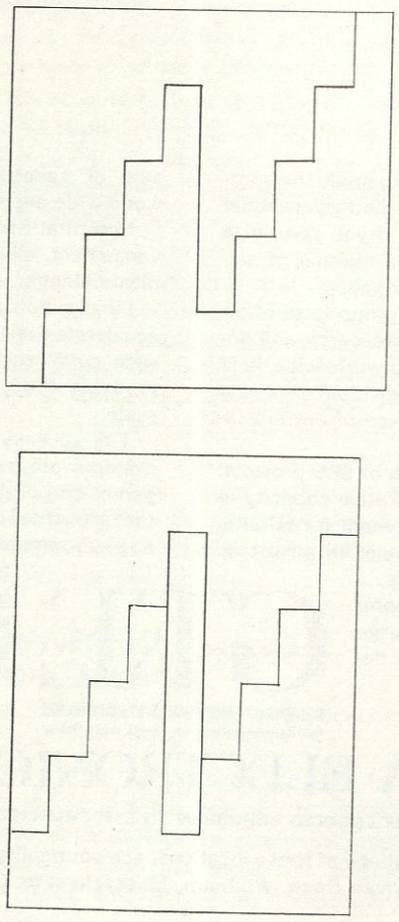


FIGURE 1.

2) A construction similar to the one shown in Figure 2 will show that the locus of points of the verticy of this triangle fall in a circle. That is, the vertices at point A represent the shortest sides and that at point B the longest. Point C is constructed randomly, and angle ACB is a right angle. The radius of this circle is 12" and so is the height of the tallest possible triangle.

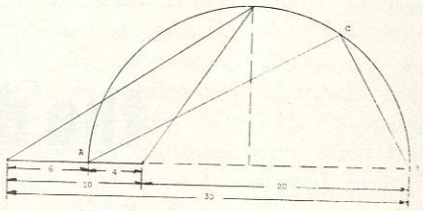
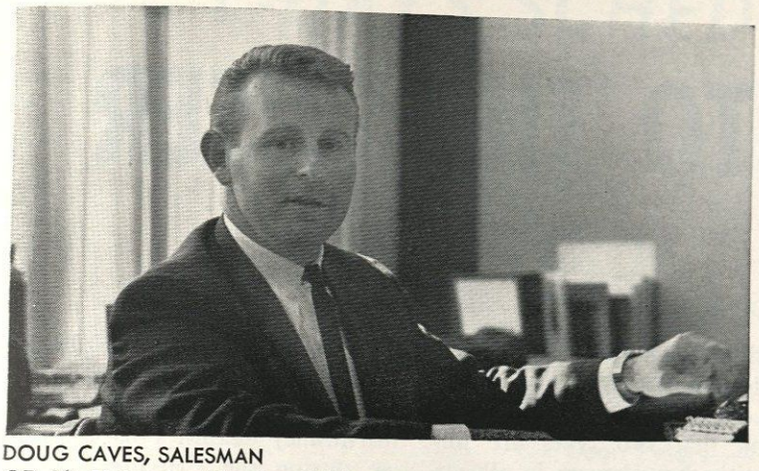


FIGURE 2.

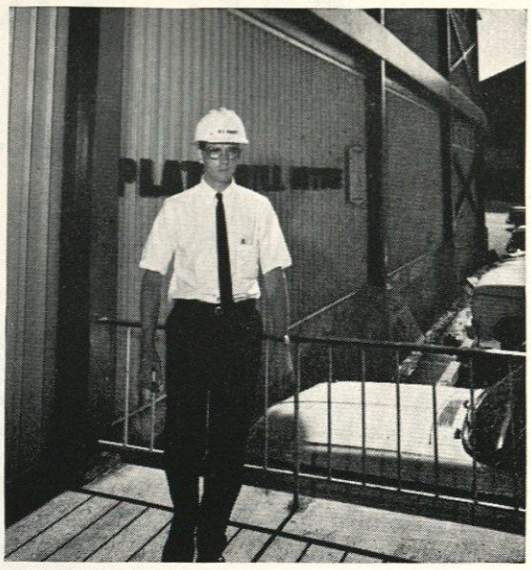
3) So I don't have to prove it, take my word for the fact that the radius of the sphere in question is equal to ¼ the height of the tetrahedron (a four sided figure made with equilateral triangles). The height of this figure is a leg of the right triangle made up of one edge and two-thirds the altitude of the base. That is, the altitude of the solid figure interects the base at its centroid. Two-thirds the altitude of an equilateral triangle with a side of 2" is $2\sqrt{3}/3$. Thus the altitude of the tetrahedron is $\sqrt{24}/3$ or $2\sqrt{6}/3$. One-fourth of this is about 0.407.

This can also be done by solving all the right triangles in the tetrahedron, which is about six, to find the relation between the length of an edge and the radius of the sphere. However, in so doing, you basically prove that the radius is equal to ¼ the altitude.

4) If you couldn't solve this one you should be ashamed! Washington gained statehood in 1889, and Oklahoma in 1907.



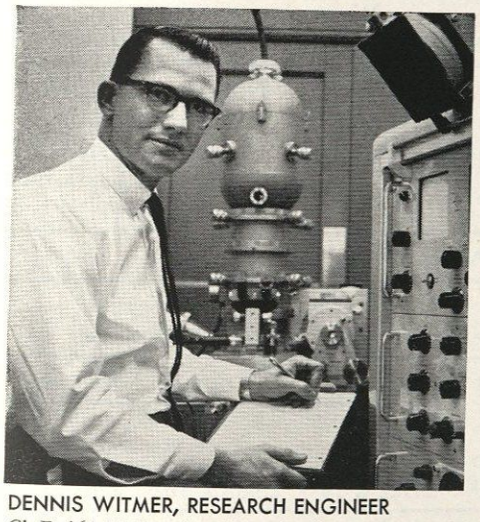
DOUG CAVES, SALESMAN
C.E., '61, University of Southern California



BOB FROST, PLATE MILL FOREMAN
I.E., '62, Penn State University

Men on the move at Bethlehem Steel

BETHLEHEM STEEL



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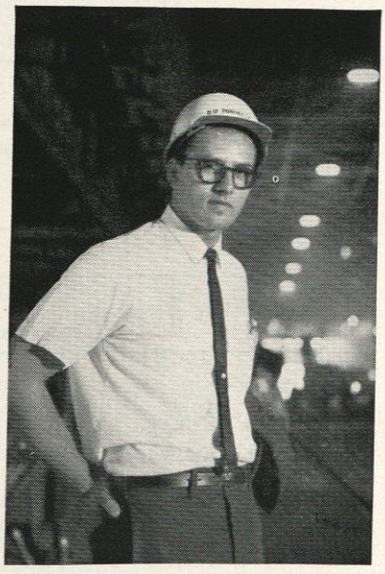
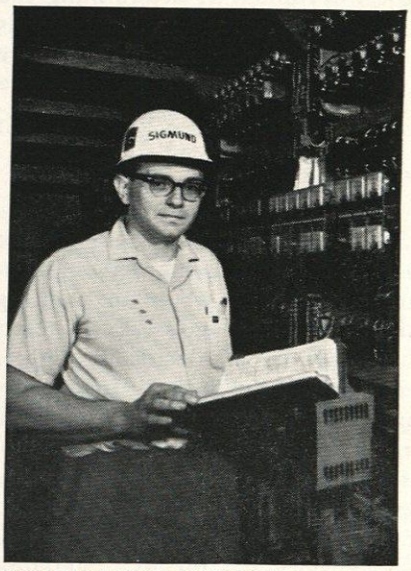
Ch.E., '61, University of Maryland



DOM TORIELLO,
OPEN-HEARTH FOREMAN
Mt.E., '63, Case Institute of Technology



DON SIGMUND ELECTRICAL ENGINEER
E.E., '62 Carnegie Institute of Technology

KARL KUGLER, MECHANICAL ENGINEER
M.E., '62, State University of New York (Buffalo)

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A WORD TO THE WISER

To: Department of Philosophy
University of Colorado
Boulder, Colorado, USA
Planet Earth

From: Ridiculous Problems Council
Ivory Tower #32
Tri-H (Holy, Holy, Holy)
Enigineering Consultants
39,277,642,069 So. St. Matthew Blvd.
Heaven

Subject: Problem of determining the maximum number of angels able to dance simultaneously on the head of a pin.

Sirs:

For several centuries, numerous philosophers on Earth have apparently been curious about the dancing ability of our angels. Even today (although in a decidedly lighter vein), the question, "How many angels can dance on the head of a pin?" arises in some philosophical discussions. We at Tri-H feel that the College of Arts and Parties at CU would benefit by having this dilemma resolved once and for all. Therefore, we respectfully submit this report so that your intellectuals may ponder other equally signifigant questions having this material as background.

Selection of the proper pin was no small task. Three different brands were tested: Acme Pins (a heat-treated, nickel-plated, fine pointed pin, but exhibiting non-uniform head construction); Clothes Pins (chrome-plated, excellent head formation and resistant to abrasion due to Angel's Corns, but possessing a small head); and Papermate Pins (silver-plated, mediumsized head, tolerable uniformity, and excellent ratio of total area to dancing area.)

Naturally, discretion was required in our determination of the angels best suited for dance demonstrations. We found that two types are undoubtedly the best dancers in all our magnificent realm. These are the angels in Platoon 3, Phalanx 7 of Legion 1 (the Famed "Big Red One"), now on R&R (Rest and Recuperation) in the Elysian Fields for their tremendous efforts in Selma, Alabama; and the angels in Airborne Division 69 of HBG (Holy Battle Group) 70763. (You surely recall their splendid action in 1123 AD (earthtime) against Polack the Saracen during the Crusades, in which they "won their wings," so to speak.)

Tabulations of this information, follow. Note that all linear measurements are in Angstroms and all area measurements are in square Angstroms.

PINS

Brand	Head Diameter	Head Area	Wear Resistance	Comment
Acme	2.54×10^{9}	5.06×10^{18}	Fair	Not recommended.
Clothes	2.51×10^{9}	4.94×10^{18}	Excellent	Recommended.
Papermate	2.526×10^{9}	5.02×10^{18}	Very good	Usable, especially when the angels have butter on their feet.

ANGELS

Type	Feet Area	Can Accomodate Number of Angels Pin		
		Acme	Clothes	Papermate
Ptn. 3, Ph. 7, Leg. 1 (large feet, but very smooth skin)	2.079 to 2.093 A^2	2.422×10^{18}	2.363×10^{18}	2.402×10^{18}
Div. 69, HBG 70763 (small feet, varied dance repertoire, but prone to corns, holy athlete's feet, etc., and thus accelerate pin-head wear and corosion.)	1.933 to 2.003 A^2	2.533×10^{18}	2.470×10^{18}	2.535×10^{18}

Our conclusions based on the above information are:

1. For pure force of numbers, choose Div. 69 angels and let them frug on a papermate pin.
2. For extended periods of time (marathon dances, FAC, etc.), choose Platoon 3 angels, and let them watusi on a Clothes Pin.

We hope this solves your problem.

Douglas Bryan
Research Director
Tri-H Engineering Consultants

Motto: NO PRAYER TOO BIG TO HANDLE,
NO WISH TOO SMALL TO NEGLECT.

E-DAYS SCHEDULE, 1966

Thursday, May 5, 1966 — Dean Hutchinson Day

10:30 - 12:00 noon — Coffee, Dean's Office

3:00 - 4:00 p.m. — ROTC Review, Parade Grounds

7:00 p.m. — Banquet, University Memorial Center Ballroom
- Dean R.C. Rautenstraus — Master of Ceremonies
- Dean Peters — Presentation of Alumni Awards

Friday, May 6, 1966 — Engineers' Days

10:30 a.m. — Honors Convocation — Macky Auditorium
- Dean Peters presiding
- Presentation of Student Awards and Scholarships

12:15 p.m. — Luncheon — University Memorial Center Ballroom
- Dean Peters presiding
- Dedicatory address — William L. Everitt, Dean of Engineering, University of Illinois

2:15 p.m. — Dedication Ceremonies (ribbon cutting) at Engineering Center
- President Smiley, Governor Love, NSF Representative, Dean Peters presiding

2:45 - 6:00 p.m. — Open House — guided tours
- Invited guests

7:00 - 9:30 p.m. — Open House — guided tours
- Invited guests and general public

Saturday, May 7, 1966 — Engineers' Days

9:00 a.m. - 12:00 noon — Open House, Engineering Sciences Center

12:00 noon - 6:00 p.m. — Picnic for students and faculty, College of Engineering
- Beard Contest Judging
- Miss Most Perfect Body Contest

9:00 p.m. — Engineers' Ball — UMC Ballroom
- Crowning of E-Days Queen
- Announcement of Meanest Prof.

Sunday, May 8, 1966 — Engineers' Days

Interdepartmental Softball Games

The mother took her young daughter to a psychiatrist and explained that the girl thought she was a chicken. The mother added that this condition had existed for nearly two years.

"Two years," exclaimed the psychiatrist. "Why did you wait so long before bringing her in for help."

"Well, Uh, . . ." the embrassed woman explained, "We needed the eggs, doctor."

The moon was yellow; the lane was bright.
She turned her face toward mine that night,
And every movement, every glance,
Suggested that she craved romance.
I stammered, fumbled . . . time went by.
The moon was yellow and so was I.

We hear that the results of a recent European experiment in genetics left something to be desired. The researcher crossed a German with a Frenchman and got a tall, blond machine-gunner who likes wine. Next he crossed a Pole and a Jew and got the owner of a chain of empty stores.

Paying alimony is like pumping gas into another man's car.

After a shipwreck, the captain's wife and a parrot were drifting about on a raft. Several days of silence had gone by until the parrot finally spoke.

"How's your fanny?" the parrot asked.

"Shut Up!!!" snapped the woman.

"Mine too," said the parrot, "It must be the salt air."

"My girl is a real beauty . . . a mirage."

"A mirage?"

"Yeah, something you can see but not feel."

The couple, after twenty years of marriage, had decided to leave on a second honeymoon. As they made their plans, the husband glanced over his shoulder at the little old lady behind them who sat knitting.

"Just once," he whispered, "I'd like to take a trip without having your mother along."

"My mother,' " the wife exclaimed. "I thought she was your mother."

"My mother always told me to be good . . . Was I?"

Hangovers The wrath of grapes.

Alcoholic—A guy you don't like who drinks as much as you do.

"Doctor, help me. I'm losing my mind. . . . I can't remember anything."

"Just when did you become aware of this problem?"

"Problem??? What Problem?"

Generally speaking, women are.

"Am I the first man you ever made love to?"

"Umm . . . might be. Your face looks familiar."

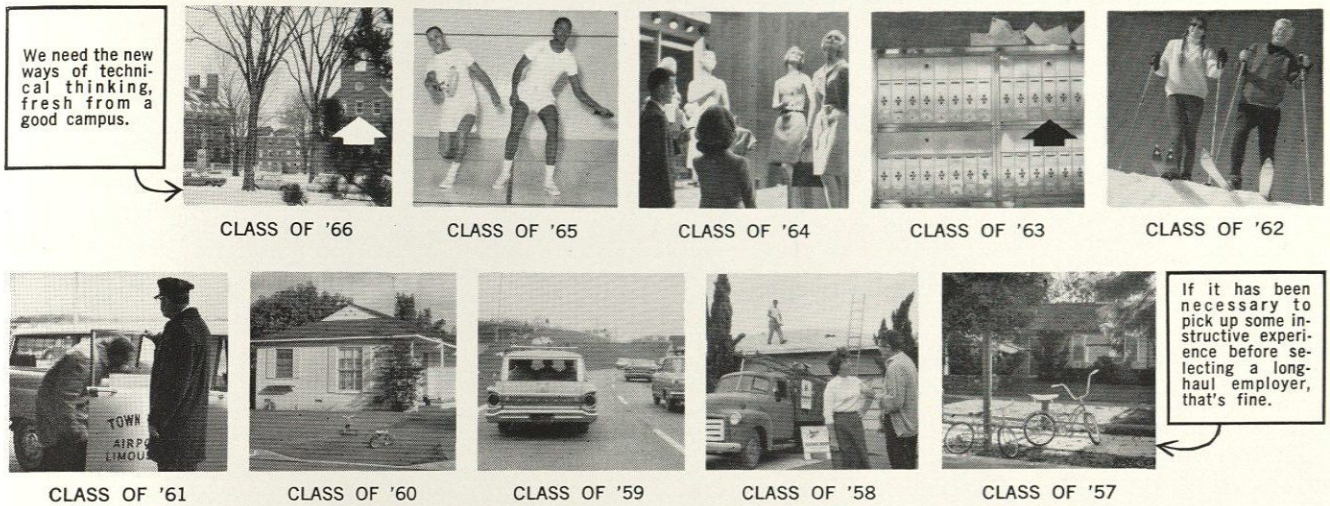
One good turn usually gets most of the blanket.

"Dear," he whispered, "Can't we leave marriage out of the picture. I mean . . . well, you're more like a sister to me."

"My God, what a home life you must have."

—Fred Love

Invitation from **Kodak** to



The box below permits a chemical engineer, just for kicks, to test himself for possible interest in our kind of problems. Bright M.E.s, E.E.s, and other engineers will pick up enough of the general idea to transpose the test to their own fields of competence. The next step would be to drop us a line about yourself and your ambitions. If mutuality of interest develops and if the mundane matter of compensation should come up, we feel that now and far into the foreseeable future we can afford the best.

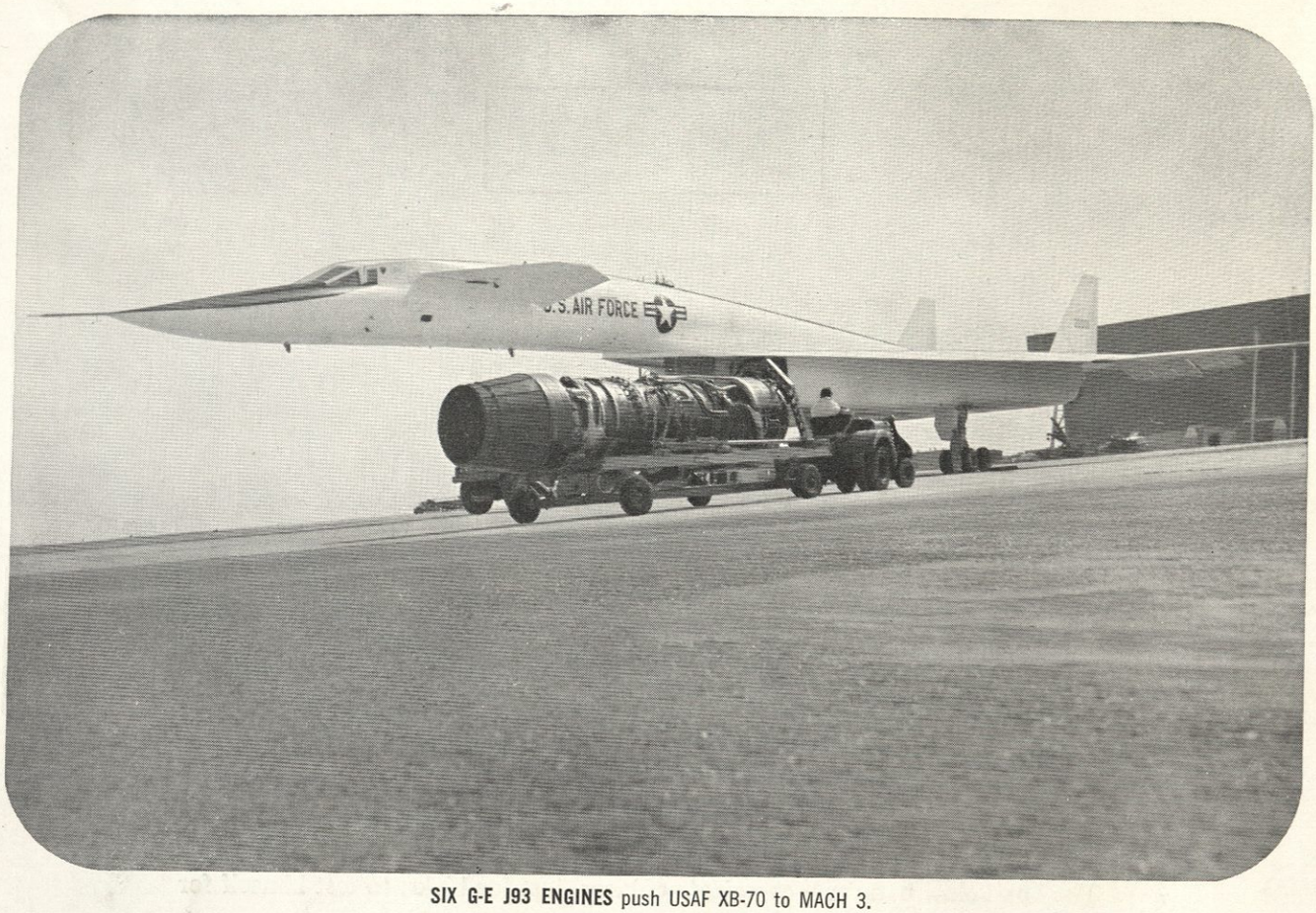
EASTMAN KODAK COMPANY, Business and Technical Personnel Dept.
Rochester, N.Y. 14650

An equal-opportunity employer offering a choice of three communities: Rochester, N. Y., Kingsport, Tenn., and Longview, Tex.

We can react diketene and tert.-butyl alcohol to tert.-butyl acetoacetate [$CH_3COCH_2COOC(CH_3)_3$] by methods that bring the price down to $3.50 a pound—about one-sixth the prevailing research-quantity price—with the usual prospect for a substantial further plunge as volume develops. A plunge to reach the price level of methyl acetoacetate and ethyl acetoacetate, two currently large-volume acetoacetic esters of ours, is unlikely. The tert.-butyl ester, however, has an advantage over the other two. When alkylated to $CH_3COCHRCOOC(CH_3)_3$, mere heating with a trace of acid catalyst drives off first $(CH_3)_2C=CH_2$ and then CO_2, leaving CH_3COCH_2R. With the cheaper acetoacetate esters for making ketones, there is no such neat cleavage. There the ethyl or methyl group has to be hydrolyzed off, and if R happens to be hydrolysis-sensitive itself, poof goes the yield. This same readiness of α-alkylated tert.-butyl acetoacetic esters to split out isobutylene and then decarboxylate opens up promising routes also to carboxylic acids, pyrroles, pyrazalones, uracils, and coumarins.

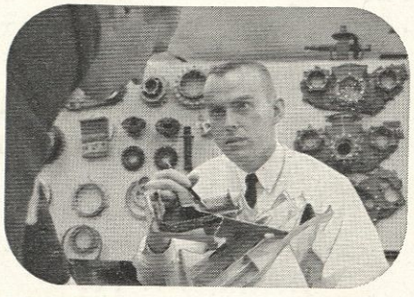
Now assume we have large supplies of diketene and tert.-butyl alcohol, as indeed we do.

The problem: multiply their combined economic value to many times the sum of their separate values.



SIX G-E J93 ENGINES push USAF XB-70 to MACH 3.

JACK WADDEY, Auburn U., 1965, translates customer requirements into aircraft electrical systems on a Technical Marketing Program assignment at Specialty Control Dept.



PAUL HENRY is assigned to design and analysis of compressor components for G.E.'s Large Jet Engine Dept. He holds a BSME from the University of Cincinnati, 1964.

ANDY O'KEEFE, Villanova U., BSEE, 1965, Manufacturing Training Program, works on fabrications for large jet engines at LJED, Evendale, Ohio.

A PREVIEW OF YOUR CAREER AT GENERAL ELECTRIC

Achieving Thrust for Mach 3

When the North American Aviation XB-70 established a milestone by achieving Mach 3 flight, it was powered by six General Electric J93 jet engines. That flight was the high point of two decades of G-E leadership in jet power that began when America's first jet plane was flown in 1942. In addition to the 30,000-pound thrust J93's, the XB-70 carries a unique, 240-kva electrical system that supplies all on-board power needs—designed by G-E engineers. The challenge of advanced flight propulsion promises even more opportunity at G.E. GETF39 engines will help the new USAF C-5A fly more payload than any other aircraft in the world; the Mach 3 GE4/J5 is designed to deliver 50,000-pound thrust for a U.S. Supersonic Transport (SST). General Electric's involvement in jet power since the beginning of propellerless flight has made us one of the world's leading suppliers of these prime movers. This is typical of the fast-paced technical challenge you'll find in any of G.E.'s 120 decentralized product operations. To define your career interest at General Electric, talk with your placement officer, or write us now. Section 699-16, Schenectady, N.Y. 12305. An Equal Opportunity Employer.

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