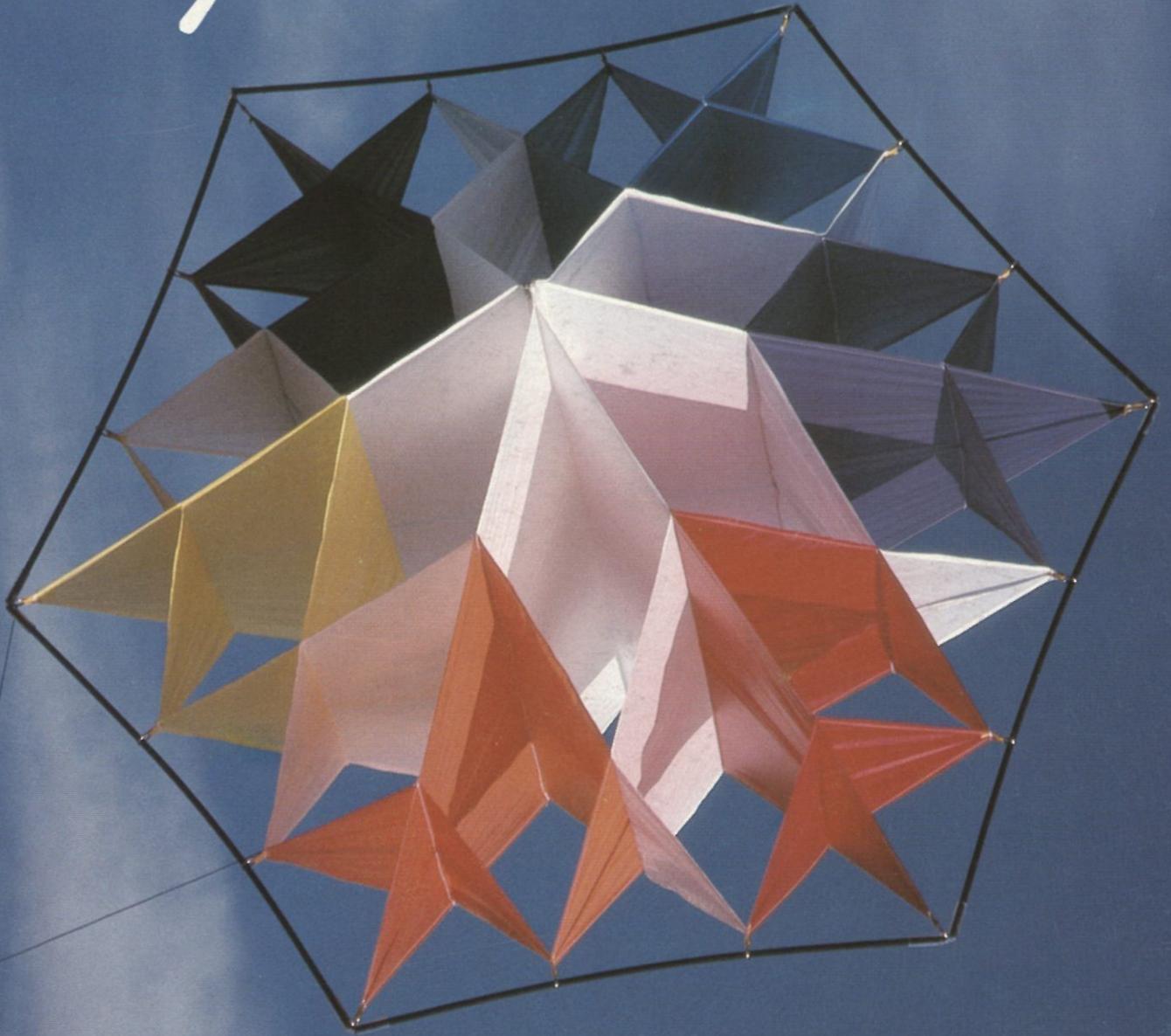


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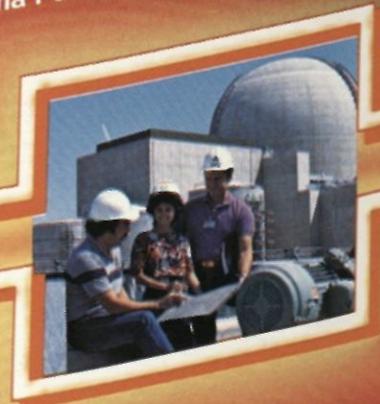
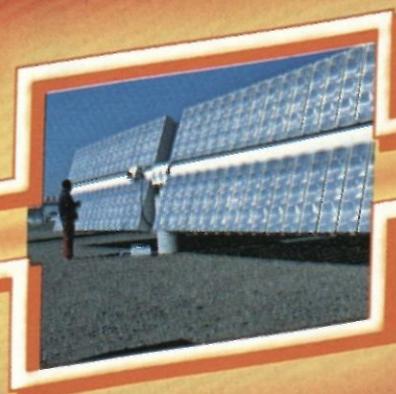
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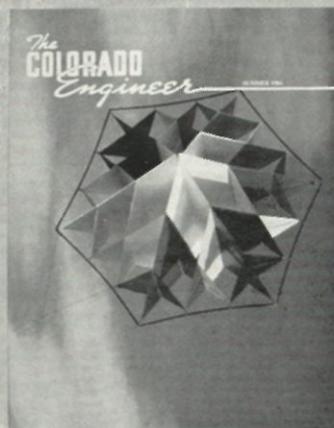
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A magnificent sight in the sky, the Summer Snowflake turns heads wherever it flies. Its eight yards of brilliant rip-stop nylon are supported by a ring of high-tech graphite fiber tubes. Measuring 56 inches by 56 inches, this kite is lightweight; essentially unbreakable. Stable in strong gusty winds, it virtually flies itself.

As the end of the semester approaches, the days get longer and warmer — ideal for kite-flying. Our cover story, "Go fly a kite," begins on page 14.

From the Editor



Almost everyone I know can name at least one personal pet peeve. These tend to cover a wide range of subjects, from slow drivers to incessantly barking dogs to hair in the sink. These annoyances can be small or large depending on their frequency of occurrence in everyday life. When a particular peeve reaches gigantic proportions, it often prompts one to expound on its evils rather vocally.

I have always had somewhat of an aversion to labels, for example, "radical," "right-winger," "Greek," "feminist," as they seem to lead to biased evaluations of the person on whom they are tacked. Lately, one label in particular has claimed the honor, rather the dishonor, of being placed on my heretofore essentially non-existent pet peeve list. I have developed a real dislike for the label of "engineer."

There is one main reason why it bothers me to be called what, in reality, I am striving to become. Being known as an engineer seems to exclude me from being regarded as a regular member of society. I have become aware of several images that people associate with an engineer. One, the nerd image (need I elaborate?), would be found offensive by anyone to whom it was applied. The second image—that of a person who cares only for himself, has getting a high-paying job at the top of his list and ethics at the bottom—does not appeal to me either. But then neither does the other alternative. I've often found that even mentioning that I am an engineering major conjures up an idea in people's minds that my brain is somehow superior to their's. In other words, I am instantly considered a superbrain, to be placed on a pedestal far above those members of society who do not have the "good fortune" to be an engineer. The connotations derived from these images are not very positive. They set the engineer off as a rather elitist persona, one who is not a member of society at all.

It is almost as if, having chosen engineering as a career, one, often unknowingly, becomes separated from the community as a whole, and enters a sort of elitist corp. There seems to be an "elitism myth," which exists in people's minds. One first becomes aware of its existence at freshman orientation; we are the chosen few, and most of us will probably end up shamefully not making the grade. I constantly hear comments concerning the inferiority of the other colleges at the University. Granted, some of this is in the spirit of competition, but it often becomes excessive and frankly offensive.

Maybe some are born into an atmosphere which makes the elitism myth more a truth than an actual myth. I, for one, had fostered an unknown ignorance of what engineers were most of my life. As a young child, engineers were simply waving figures in the trains that sped across my picture books or past the car window on family trips. In the interim before high school the word "engineer" had no meaning at all. High school itself only brought a vague realization of what engineers were—designers, builders, inventors, etc. My role models were teachers of biology and psychology, a housewife, a musician, farmers; people who were intelligent, inquisitive, and caring. They were people who considered me a human being and as such worthy of their time and attention. I refuse to believe that being an engineer gives one a corner on the intelligence market, or an especially wonderful value to society.

I feel it is time to change the connotations behind the label "engineer." Being an engineer should not exclude one from society; engineers should rather serve the society, as others do, by reflecting the concerns of society, working to improve people's lives and the environment around them. Engineers need to be able to communicate their views to the layperson; engineers should have the communication skills it takes to explain what they do, to children, to teenagers, to adults. Engineers must be able to convey to others what their designs, buildings, and inventions actually do to serve the community. It is time to relinquish the elitism myth.

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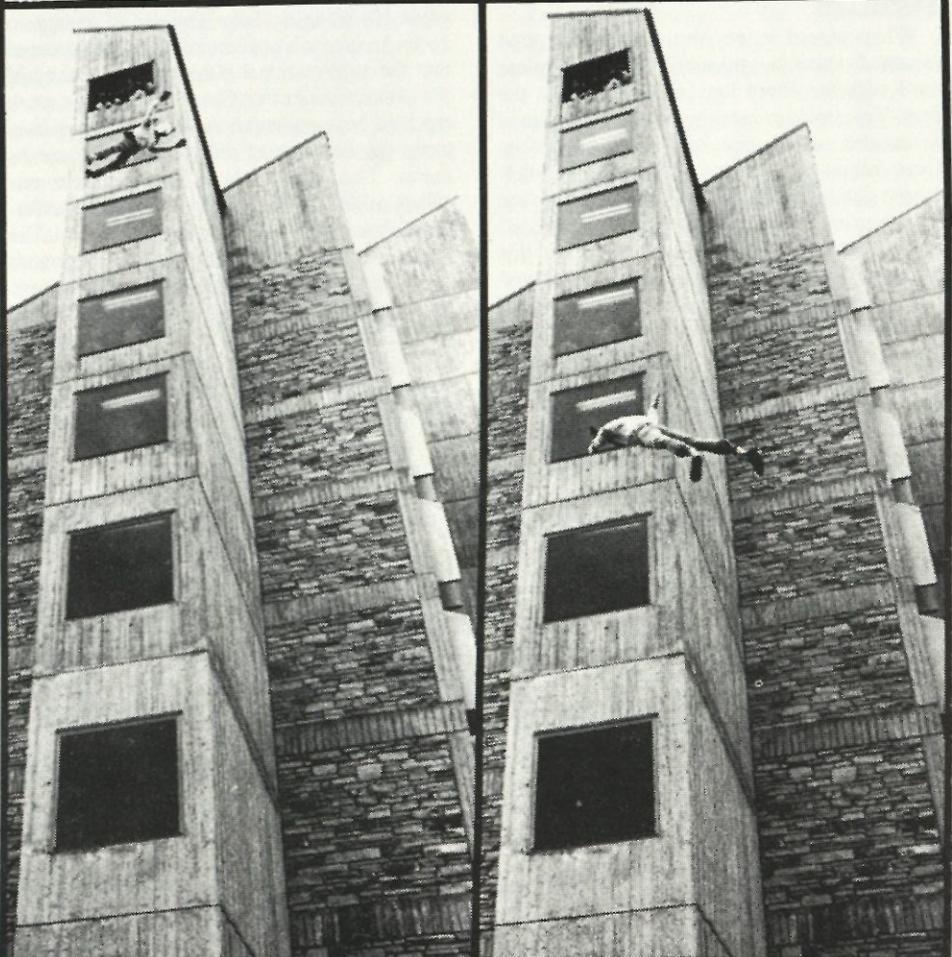
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Lift Enhancement Potential of Autorotational Devices

by Nancy Searby

ABSTRACT

When placed in an airstream, a flat plate mounted about a symmetric axis will orient itself with the chord line perpendicular to the flow. This stable orientation can be transformed to another stable state by initiating rotation. Once begun, the rotation will continue indefinitely due to the lifting force generated by the retreating edge vortex which extracts all needed energy from the air stream. Because of this continuous vortex generation, the autorotational plate could become a candidate as an unsteady flow lift enhancement mechanism to be added to aircraft wings. Wind tunnel observations using stroboscopic flow visualization revealed flow field dependencies upon both tunnel speed and externally imposed drag. Rotational frequencies were linearly related to tunnel speed regardless of the amount of superimposed drag. Fixed amounts of drag linearly decreased rotational frequencies. The major flow field effect of increased rotational frequency due to increased tunnel speed was delayed vortex initiation on the retreating plate edge. Neither the shedding phase nor the free shear layer vortex characteristics varied. The possibilities as well as the limitations of autorotating devices for lift enhancement are presented in view of this new understanding of underlying plate/flow interactions.

NOMENCLATURE

c = Plate Chord Length
 n = Rotational frequency in Hz
 T = Period of Rotation
 U_∞ = Freestream velocity
 $V = \pi n c$ = Plate Tip Speed
 α = Phase Angle in Degrees
 $\omega = 2\pi n$ = Frequency of autorotational cycle in Hz

INTRODUCTION

Unsteady flows are encountered frequently, both in nature and in man-made mechanisms. The devastating effects of wind shear and trailing vortices are well known in general aviation. Blade slap in helicopter rotors is an example of such flows creating both acoustical and structural havoc.¹ On the other hand, it appears that such flows may be used in beneficial ways. Insects, for example, use such flows to support hovering flight.² Recently, experimentalists have shown that the controlled generation of such flows may provide transient periods of lift enhancement.^{1,3}

In the present study I have attempted to understand the means through which (1) beneficial, lift enhancing flows could be generated

while (2) using no large amount of energy to do so. In my review of the literature it appeared that the autorotational plate possessed many of the characteristics that I sought.^{4,5,6,7} The work reported here represents my attempt to characterize the behavior of this aerodynamic mechanism. This work, I hope, complements our efforts at the University of Colorado to understand a variety of unsteady separated flows. The intrinsic autorotational frequency may represent some new insight into "natural" unsteadiness. The fluid mechanics of this system will be contrasted with that of "forced" unsteadiness usually produced by a harmonic pitching of an airfoil. Also, the application potential of an autorotating plate will be discussed in terms of the new observations I have made.

METHODS

Experiments were conducted in the 2' x 2' test section of the low speed, low turbulence (0.03%) wind tunnel at the University of Colorado. A 6" chord, 2' (infinite) span, 1/4" thick, sharp edged aluminum flat plate was mounted in the test section along its longitudinal axis at midchord. Shafts extended from both ends of the plate through double bearing supports to allow the plate to rotate freely with minimal

frictional drag (see Figure 1).

Flow visualization was obtained using a vertical smoke rake constructed of a NACA 0015 airfoil section with 1/8" diameter tubes extending from the trailing edge. The smoke rake was located at the start of the contraction chamber to minimize flow disturbances in the test section. Rake position could be varied vertically for the best streakline placement. Dense white smoke generated by heated theatrical fog fluid (ROSCO) was delivered to the rake through tubing at modest (<5 lbs ft⁻¹) adjustable pressure. This flow visualization system produced a single vertical plane of nonturbulent smoke lines (~0.5 in. apart) which bisected the wind tunnel test section.

To synchronize data acquisition with specific phase angles of the flat plate during rotation, a small reed switch was fixed to the bearing mount outside the wind tunnel. A matching magnet was carried by a collar affixed to the support shaft of the flat plate. The collar could be rotated to align the magnet to the plate angle where a trigger signal was desired. The reed switch was set to close when the plate was geometrically parallel to the air stream. From the reference angle all other angles were deter-

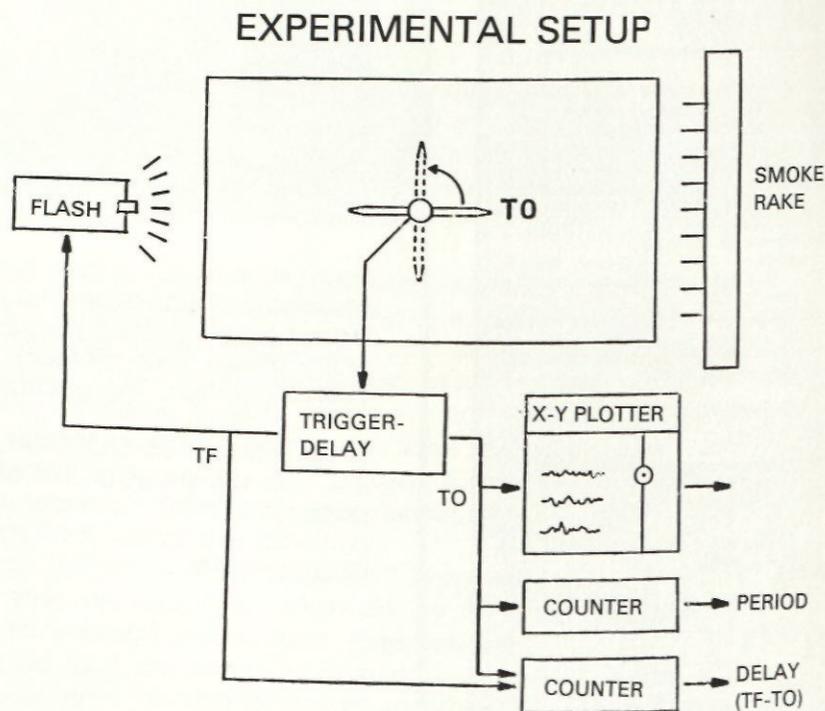


Fig. 1: Schematic of experimental apparatus.

mined incrementally in the direction of rotation throughout the remaining cycle. At these selected rotational phase angles, each Strobrite Mdl. 305 (U.S. Scientific) strobe produced a seven microsecond flash to momentarily illuminate the flow field. Two strobe units were used and were placed six chord lengths downstream inside the wind tunnel test section. No major flow disturbances occurred upstream to confound the flow visualization.

Photographs were taken of the flow field using a Pentax SLR camera (50mm lens) placed outside the tunnel four feet away from the plane of smoke. With a 2.8 F-stop setting, the camera shutter was held open for 20 to 30 strobe flashes to highlight the repetitiveness of the flow perturbations. Kodak Tri-X panchromatic film was used and developed at 800 ASA. Prints were made on polycontrast paper exposed through a number of four contrast filter to maximize the contrast between the tunnel walls and the streaklines.

The reed switch signal was connected to an x-y plotter through the y channel. The internal time base was then used to generate a plot of the variation in rotational frequency as the plate accelerated (initial torque applied) to its stable autorotational speed.

To obtain an overview of the flow fields elicited by the autorotational flat plate, a range of tunnel speeds were tested. A minimum speed

of 27 ft/sec, corresponding to a Reynolds number of 70,000 was chosen as it was the lowest speed that would support autorotation. A maximum speed of 43 ft/sec, corresponding to a Reynolds number of 110,000, was chosen as the limit to clear flow visualization.

The effects of varying amounts of drag were evaluated on the autorotation. To add frictional drag, weights were suspended from the rotating support shaft that extended outside the tunnel. Plate chord size was not varied as past research indicated that an aspect ratio greater than three was the only requirement for consistent autorotation.⁷ A six inch chord was chosen both to meet this requirement and to produce easily visible flow structures.

The acceleration history was examined to give some indication of the time required for autorotation stability to occur after an initial torque was applied.

From the rotational periods it was possible to calculate both the rotational frequencies and tipspeeds of the flat plate. A note must be made on this point. As the plate is a symmetric body, flow field disturbances occur twice in each complete cycle of 360°. The complete events characteristic of autorotation occur every 180°. The frequencies and tipspeeds calculated subsequently are based on a complete autorotational cycle, or half a full cycle.

Figure 2a shows a schematic of the rotating

plate at a representative phase in the cycle, with the associated flow structures behind it. With the flow from left to right, and in the rotational direction shown, the upper edge of the plate is called the retreating edge and the lower, the advancing edge. After surveying the flowfields generated by the autorotating plate, three important plate/flow interactions were selected for investigation. The first and most important event was the initiation of a clockwise vortex at the plate edge retreating from the flow (see Figure 2b). Across all tunnel speeds and superimposed drags, the phase in the autorotational cycle for the initiation of this vortex was recorded by waiting for the occurrence of a cohesive circular structure at 16.7% chord over the retreating plate edge. The shedding of this vortex was the second event recorded. Shedding was considered to have occurred when the vortex was no longer circular but had elongated and began to disperse into the wake (see Figure 2c). The last event investigated was the formation of a counterclockwise vortex out of the free shear layer vorticity behind the advancing plate edge. The criterion for this measurement was a flow curled ($> 90^\circ$) in the counterclockwise direction (see Figure 2d). From these measurements, the duration of the vortical interactions with the plate was calculated.

RESULTS

The flow visualization was first used to pro-

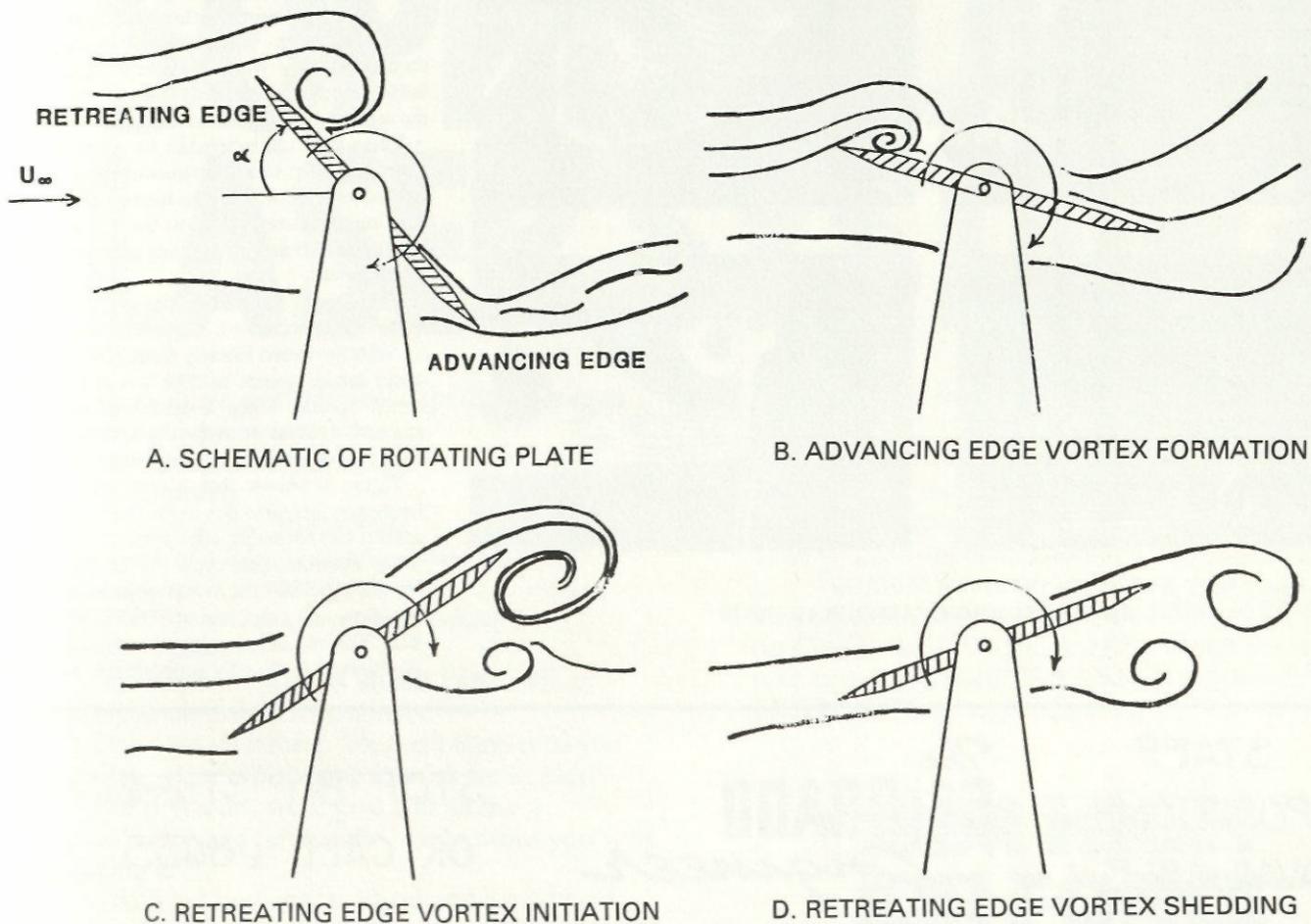


Fig. 2: Autorotational plate.

vide a qualitative look at the flowfield generated by an autorotating flat plate. For comparison, a static flat plate was photographed at 0° , 45° , and 90° as shown in Fig. 3. At 0° , the flow follows the plate with a small Karman vortex street behind it. At both 45° and 90° the flow is dramatically separated from the plate. Figure 4 depicts a characteristic autorotational cycle for this plate. The plate rotation depicted begins at an instantaneous angle of 0° and goes to 180° , which is back to the start of the autorotational cycle, in 30° increments.

In Fig. 4a, the plate is parallel to the flow. The streaklines over the upper plate surface follow the plate contour with no perturbations. Structures generated from the previous cycle can be seen in the wake.

Figure 4b illustrates the flow over the plate phase locked at an angle of 30° . As the plate rotates from 0° to 30° , the flow accelerates over the top surface, forming a small bubble at the tip of the retreating edge. A shadow begins to form on the left side of the plate due to the plate obstructing the strobe light.

As the plate rotates to 60° , Fig. 4c, the small bubble at the retreating edge has grown and the flow has begun to swirl inside it. The rest of the flow still follows the surface of the flat plate, while the plate's shadow grows.

By the time the plate has rotated to 90° , Fig. 4d, the bubble has become a full blown vortex rotating in a clockwise direction. This retreating edge vortex causes reversed flow up the plate so that the flow is still fully attached to the plate surface. This reversed flow causes a free shear layer to develop near the advancing edge as flow comes around this edge to interact with the reversed flow.

Figure 4e shows the plate as it rotates to 120° . The retreating edge vortex still increases in magnitude with a readily visible vortex core. The reversed flow on the plate surface appears to continue to nourish vortex growth. The shear layer has become thinner and more diffuse in appearance.

By this time the plate has rotated to 150° , Fig. 4f, several changes have taken place. The free shear layer has begun to develop into a counterclockwise vortex structure, while still interjecting flow into both the forming advancing and the retreating edge vortices. The free shear layer has begun to interact with the retreating edge vortex, destroying its circular pattern.

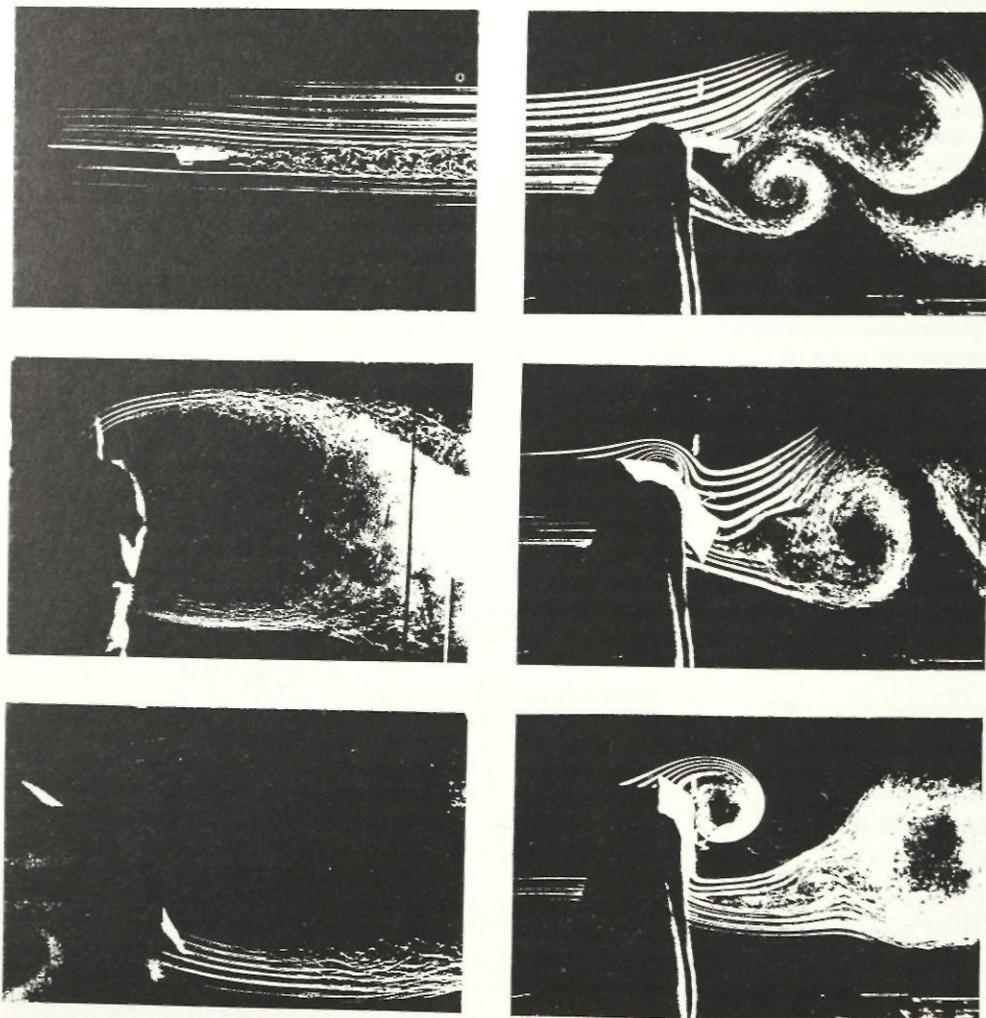
As the plate rotates to 180° (0°) the advancing edge vortex has grown and now fully interacts with the retreating edge vortex. The two counter rotating vortices are both clearly wake structures. When these structures then shed off into the wake, they do so in a tandem fashion with the retreating edge vortex leading the rapidly growing advancing edge vortex.

These flow characteristics for a typical rotational sequence were then quantified by examining the effects of first the tunnel velocity and then superimposed drag on the rotational frequency as well as the retreating edge vortex flow development.

The speed of the plate tip increased as the tunnel speed increased, as shown in Fig. 5. The tip velocity varied linearly from $30\% V_\infty$ at the lower tunnel speeds to $50\% V_\infty$ at the higher tunnel speeds. Once a given tip speed was attained, it remained stable throughout testing or until the tunnel velocity was changed.

Figure 6 shows that as the autorotational frequency increases due to the increasing tunnel speeds, the retreating edge vortex initiates later in the autorotational cycle. As the plate rotates from 0° to 180° the vortex appears at 31° for low flow velocities and at 60° for high velocities. The rotational angle at which the vortex is observed is directly proportional to the au-

Fig. 3



STATIC VS. AUTOROTATING FLAT PLATE

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Lift Enhancement Potential of Autorotational Devices

torotational frequency. The y-intercept reveals another important fact. If the plate could theoretically be brought to an autorotational frequency of 0, the retreating edge vortex would form at approximately 16° . The stall angle for the plate used was determined to be between 6° - 8° . Therefore, it seems the vortex requires a finite time to roll up once the stall angle has been exceeded. One can imagine that beyond stall angles vorticity occurs and the flow begins

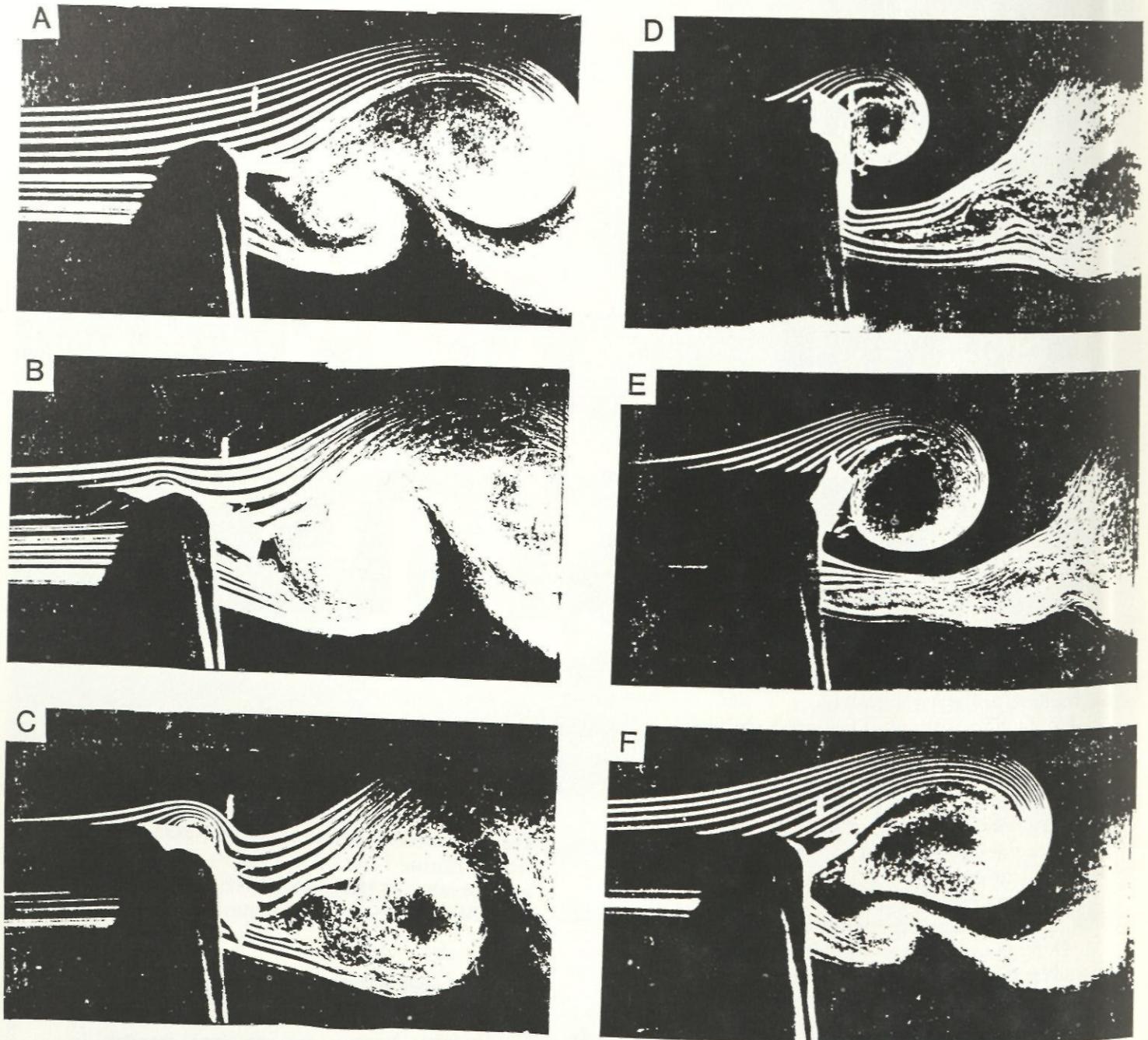
to react to this condition by the formation of the vortex which can be observed.

The shedding of the retreating edge vortex was not so well correlated with the tunnel speed (see Fig. 7). A sizeable data scatter was introduced due to the uncertainty of the measurement. As the shedding values did not vary by more than 10% of the rotational cycle across all test conditions, the average was taken to determine approximately when this vortex was

shed. The retreating edge vortex shed at approximately an angle of 150° regardless of the tunnel speed.

The vortex initiation and shedding relationships determined the duration of the retreating edge vortex interaction with the plate. As the tunnel speed increases, the duration of interaction decreases. This suggests that there should be a tunnel velocity where the retreating edge vortex no longer forms to support autorotation. Figure 8a shows a summary of the retreating edge vortex characteristics and the actual time

Fig. 4



TYPICAL HALF-CYCLE OF AUTOROTATING FLAT PLATE

EFFECTS OF TUNNEL SPEED ON PLATE TIP SPEED

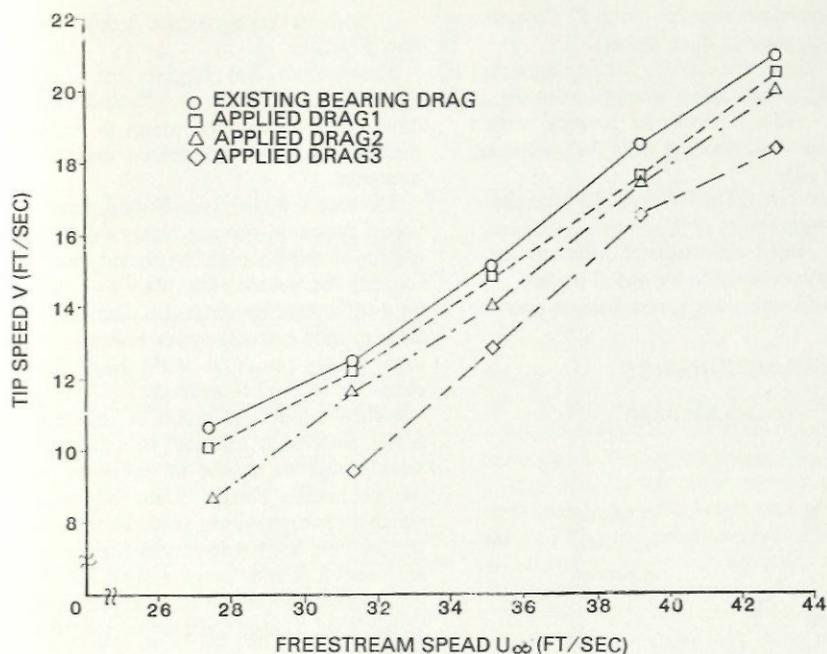


Fig. 5: Effects of tunnel speed on plate tip speed.

that they occurred at increasing autorotational frequencies. The lines representing the initiation and shedding will intersect off the graph, and the duration will intersect the zero axis. Both intersections imply that the duration of vortex/plate interaction will go to zero and the plate will no longer autorotate. Due to the data scatter in the shedding and therefore the duration of the vortex, the actual frequency where this would occur is uncertain, but should be in the range of 40-60 Hz. Tunnel speed limitations prohibited testing for the actual frequency value.

The effects of applied frictional drag were nominal for all dependent variables surveyed. Increased frictional drag decreased autorotational frequencies and associated plate tip speeds. This is illustrated by the downward but parallel shift in the curves shown in Fig. 5. The resulting characteristics of the retreating edge vortex accordingly shifted due to the autorotational frequency decrease. Fig. 8b shows a summary of these characteristics. The limit for autorotation would still be in the range of 40-60 Hz.

The advancing edge of the plate appears to produce a free shear layer as it moves into the flow. Small ($< 10\%$ chord dimension) vortices shed from the tip directly into the wake. The formation of a large (> 0.5 chord) advancing edge vortex corresponded to retreating edge vortex shedding and was similarly difficult to relate to specific rotational phase angles. This vortex always rolled up counterclockwise soon after the retreating edge vortex shed. As the two counter rotating vortices are only seen in the wake, the advancing edge vortex never actually interacts with the plate. However, it does affect the flow/plate interactions. As the two vortices

shed off into the wake, the advancing edge vortex is displaced downward by the retreating edge vortex. The result is that the retreating edge flow separates from the lower side of the plate.

To complete the analysis the acceleration history of the plate from initially applied starting torque to stable autorotation was examined across increasing autorotational frequencies and tunnel speeds as seen in Fig. 9. The percentage of stable autorotational frequency obtained as the plate accelerated up to its stable autorotational value was plotted against increasing numbers of cycles for various tunnel speeds. As the tunnel speed increased, the number of cycles

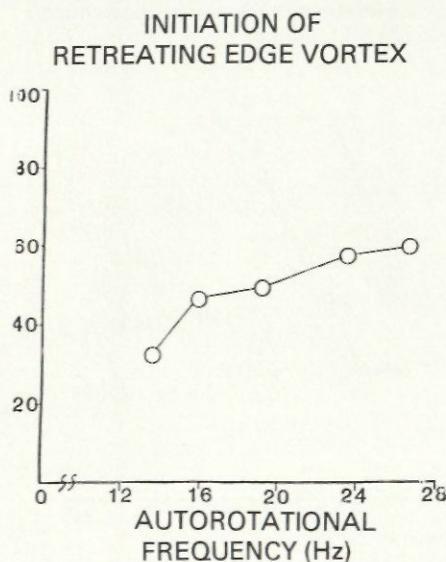


Fig. 6: Effects of rotational frequency on retreating vortex initiation.

and therefore the time the plate required to accelerate to a stable frequency decreased.

DISCUSSION

With flow visualization I have documented that, across a range of tunnel speeds and frictional drags, the vortex structure formed at the retreating plate edge dominates the autorotation of a symmetric flat plate. For autorotation to occur, this vortex must be allowed a finite distance beyond the static stall angle to initiate. The shedding of this vortex must also occur in a certain angular region. Thus an upper bound exists on autorotation frequency as the vortex must reside on the plate surface for some time period in order to cause the plate to rotate. A lower bound also exists. The plate must be able to overcome existing drag to initiate and sustain autorotation.

The secondary advancing edge vorticity plays a smaller but still important role in the autorotation phenomenon. Before any roll-up of an actual vortex structure occurs, reversed flow is created by the swirling clockwise retreating edge vortex. This reversed flow feeds the retreating edge vortex, allowing it to grow. The shear layer formed as flow comes around the advancing edge does not develop into a large scale vortex until the plate has almost returned to a position parallel with the flow. The reasons for the roll-up to occur at this plate position appear to be twofold: 1) the plate no longer provides an obstruction from the flow for the retreating edge vortex, so that it is being pushed off the plate edge, and 2) the advancing edge is now able to benefit from the flow accelerating over it. This combined effect allows an advancing edge vortex to form. Its effect on the plate is minimal because it has formed in the wake and appears considerably less strong than the retreating edge vortex.

The key to the asymmetric flow field in an otherwise symmetric flow situation lies in the initial torque provided. Regardless of the rotational direction of the applied force, if it is

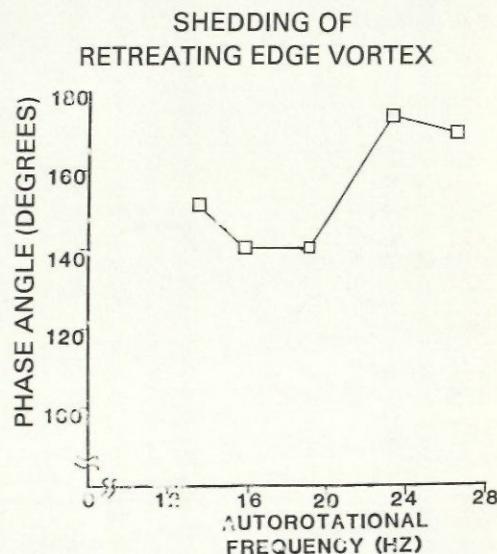


Fig. 7: Effects of rotational frequency on retreating edge vortex shedding.

sufficiently strong the plate will begin to rotate in that direction. This initial force forces the creation of a separated flow over the corresponding retreating edge. This separation generates vorticity which drives the growth of a retreating edge vortex. The other edge of the plate has to advance into the flow. The reversed flow established to support retreating edge vortex growth decreases the net flow acceleration around the advancing edge. The result is a large retreating edge vortex and a flow-starved advancing edge shear layer. By the time the advancing edge reaches an advantageous position in the flow, the retreating edge vortex already completely dominates the flow field.

From this new physical understanding of autorotation, several similarities were found between the "naturally" induced flow about an autorotating plate and the "forced" flow due to harmonic pitching of an airfoil.

- 1) Both show that rapidly pitching an airfoil past the static stall angle, whether naturally or forcibly, elicits a clockwise rotating vortex from the flow accelerating over the retreating, or leading edge.
- 2) As the rate the airfoil is pitched increases, the initial appearance of this vortex is delayed.
- 3) This vortex, once formed, produces transient lift enhancement to the airfoil surface.
- 4) In both cases, this vortex induces another

vortex in the opposite direction and both structures shed into the wake together in a tandem fashion.

5) Both methods produce highly repeatable flow structures.

These similarities suggest that a resonant condition exists even for "forced" unsteady flows where minimum energy is required to elicit and control the desired unsteady flow structures.

The fact that the autorotating plate creates vortex structures that are highly repeatable and similar to those caused by forced mechanisms suggests the autorotating plate as a candidate for a lift enhancement device. The requirement for very little external power makes it attractive to an energy conscious world. High speed use, of course, remains a problem.

Before actual application of such autorotational devices to existing aircraft, additional work would be needed to determine whether the geometric design could be optimized, whether the deployment could be arranged and whether the improvements in flight envelopes are justified. A wide range of applications could, of course, be found in other aerodynamic devices; wind energy generation machines, for example.

CONCLUSION

A more in depth understanding of the flow-fields characterizing the naturally unsteady separated flows was obtained. Increased tunnel velocities increased the tip speeds of the plate and delayed the formation of a retreating edge vortex but neither effected the shedding of the retreating edge vortex nor the free shear vorticity characteristics. Superimposed frictional drags served only to decrease the rotational frequencies observed. Rotational limits have, for the first time, been hypothesized for such autorotational devices. Applications of autorotational phenomena may be found in a variety of aerodynamic devices.

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Nancy Searby, an undergraduate student in the Aerospace Engineering Department, submitted this paper to be judged at the AIAA Region V Student Conference, April 12-13, 1984.

RETREATING EDGE VORTEX CHARACTERISTICS

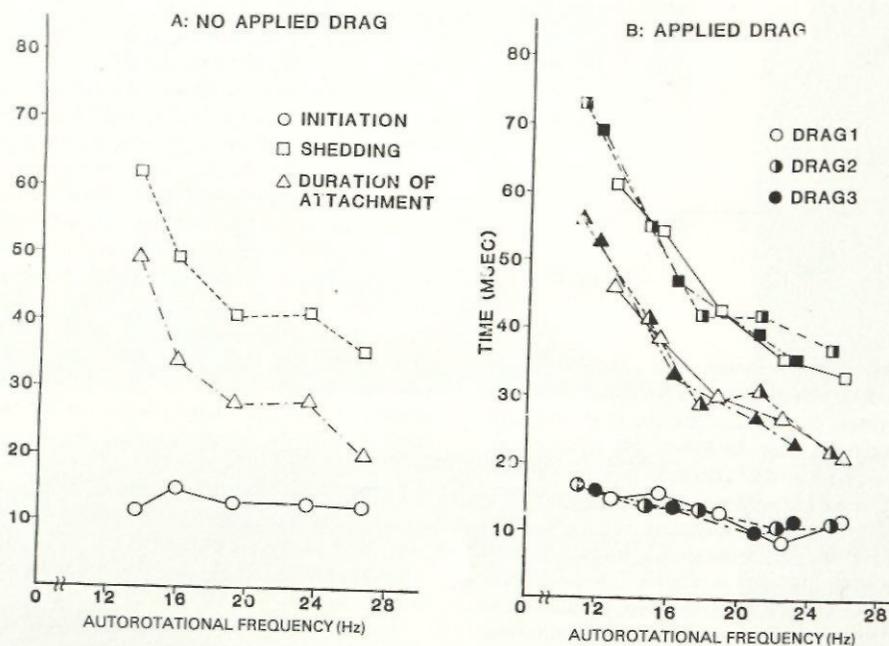


Fig. 8: Retreating edge vortex characteristics.

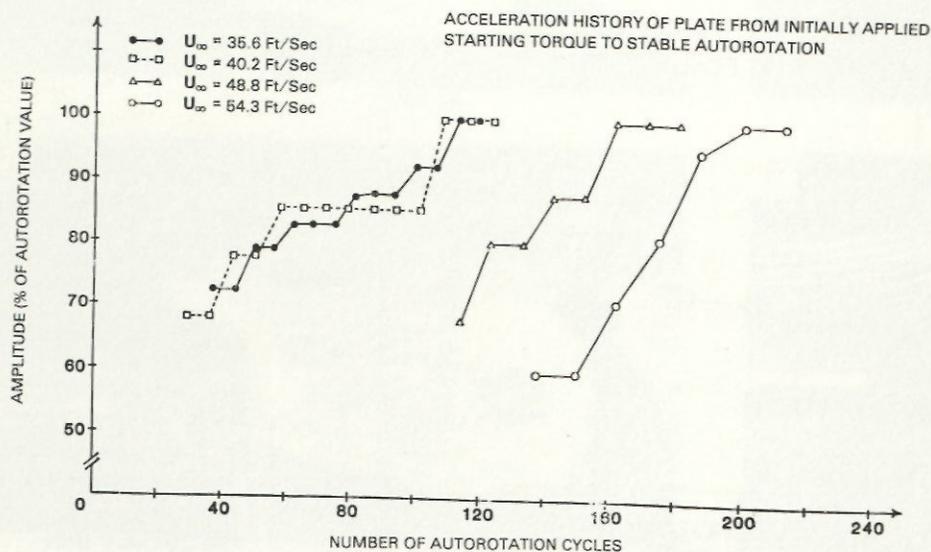


Fig. 9: Acceleration history of plate to reach stable autorotational frequency after initially applied torque.

TAU BETA PI

The national engineering honor society congratulates
its Fall 1983 Initiates and Spring 1984 Initiate Candidates.

The Tau Beta Pi Association is a national engineering honor society which recognizes engineering students and alumni who have "conferred honor upon their Alma Mater by distinguished scholarship and exemplary character."

Tau Beta Pi is thriving at the University of Colorado with over 100 active members and over 70 eligible initiation candidates for the Spring of 1984. The Colorado chapter, chartered in 1905, is one of 185 collegiate chapters which have a total initiated membership of over

257,000.

To be eligible for Tau Beta Pi at the University of Colorado, a student must be in the upper one-eighth of the junior class and have at least a 3.6 grade point average, or in the upper one-fifth of the senior class and have at least a 3.4 grade point average. All members are invited to attend our banquets, one in the fall, and one in the spring.

Tau Beta Pi is active in performing worthy projects which promote high standards of quality in the engineering profession. We sponsor

a class called "Ethical Dilemmas in Engineering" as an independent study elective which meets one afternoon a week, assist with tours of the Engineering Center, and select several award winners each year. These awards include Outstanding Freshman Engineering Student, Outstanding Sophomore Engineering Student, Outstanding Junior Engineering Student in Tau Beta Pi, and Outstanding Engineering Professor.

Our office is in Engineering Center South Tower 2-2 (Campus Box 422), and our phone is 492-8252. Stop by and talk with us.

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The Logical Suspect

Soot particle growth as it takes place in wood-burning fireplaces, diesel engines, and industrial furnaces, has been attributed to a complex set of interdependent chemical reactions.

A researcher at the General Motors Research Laboratories has demonstrated that the decomposition of a single species is primarily responsible.

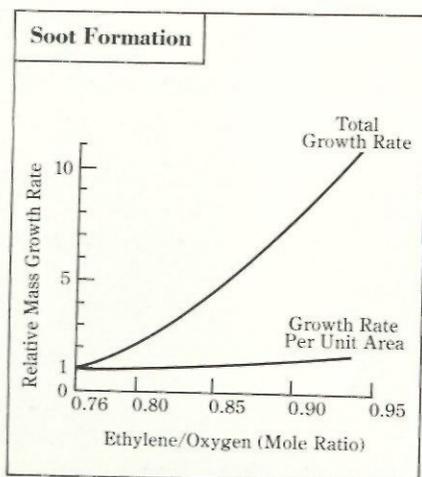
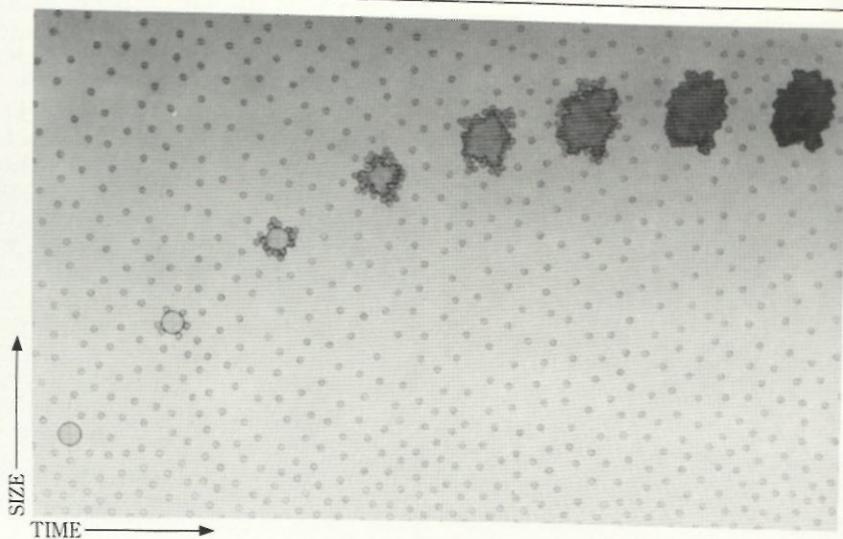


Figure 1: Total growth rate contrasted with growth rate per unit area plotted as a function of ethylene/oxygen mole ratio measured at a given height above the burner face.

Figure 2: Artist's rendition of the surface growth of a single soot particle by the incorporation of acetylene molecules.



SOOT FORMATION may be divided into two stages. Microscopic soot particles are generated in the "inception" stage. They reach full size in the "growth" stage, which accounts for more than 95% of their final mass. Most scientific exploration has concentrated on particle inception which, despite all the effort, remains unexplained. Dr. Stephen J. Harris, a physical chemist at the General Motors Research Laboratories, has reversed traditional priorities. Combining experiment with logic, he has formulated the first quantitative explanation of the growth stage in soot formation.

Dr. Harris arrived at his mechanism through an elaborate process of elimination. To focus on the chemistry of soot growth, he began by eliminating from his

investigation the complexities introduced by turbulence and mixing. He limited his research to premixed, ethylene/oxygen, laminar flames with one-dimensional flow.

Previous descriptions in the literature told him that two processes take place simultaneously during growth. Incipient particles collide and coalesce into larger particles, while growing at the same time by incorporating hydrocarbon molecules from the burned gases.

The first process reduces total surface area without changing total mass, while the second, called "surface growth," increases both total surface area and total mass. Hence, the increase in the total mass of soot can be entirely attributed to surface growth.

Dr. Harris set out to identify the hydrocarbon molecules—or "growth species"—responsible for surface growth. Increasing by increments the richness of the flame, he made the key discovery that although the total mass growth rate (gm/sec) increases strongly when the ratio of ethylene to oxygen is increased, the mass growth rate per unit surface area (gm/cm²/sec) increases only slightly (see Figure 1). Thus, the controlling variable for how much soot is formed is not the concentration of growth species, but the surface area available for growth.

This finding led him to conclude that richer flames produce more total soot because they gen-

erate more particles in the inception stage. More incipient particles offer greater initial surface area for the incorporation of hydrocarbons.

Since the growth rate per unit area must depend on growth species concentration, this concentration must be similar from flame to flame. Dr. Harris went on to reason that there must either be enough growth species at the outset to account for the total soot growth in the richest flame, or the species must be rapidly formed within the flame from another hydrocarbon present in high enough concentration.

HE NARROWED his search to the four most abundant classes of hydrocarbons found in flames: acetylene, polyacetylenes, polycyclic aromatic hydrocarbons (PAH), and methane. Methane can be eliminated, because its concentration does not decrease as soot is produced. There is not enough PAH to account for soot formation in any flame. Neither of these two hydrocarbons can be readily formed from the other major species present. That left only acetylene and the polyacetylenes.

Acetylene contains enough hydrogen to account for the hydrogen content of soot measured in the early stages of growth. But among the polyacetylenes, only diacetylene could possibly supply enough hydrogen. That left acetylene and diacetylene.

There is more than enough acetylene to account for the mass of soot produced. There is not enough diacetylene, and while diacetylene can be formed from the abundant supply of acetylene, the reported rate of conversion is too slow for diacetylene to play a significant role. That left only acetylene.

Dr. Harris verified that acetylene is the growth species by determining that the slight increase in growth rate per unit area is proportional to the increase in acetylene concentration (see Figure 1). He also found that the rate constant he measured was in agreement with the reported rate constant for the decomposition of acetylene on carbon. These findings confirmed his hypothesis that soot particles grow in flames by the incorporation and subsequent decomposition of acetylene.

"Now that we know how soot grows," says Dr. Harris, "we can examine how it begins with greater understanding. Then, perhaps our knowledge will be complete enough to suggest better ways to reduce soot."

General Motors



THE MAN BEHIND THE WORK



Dr. Stephen J. Harris is a Staff Research Chemist at the General Motors Research Laboratories. He is a member of the Physical Chemistry Department.

Dr. Harris graduated from UCLA in 1971. He received his Master's and Ph.D. degrees in physical chemistry from Harvard University. His doctoral thesis concerned Van der Waals forces between molecules. Following his Ph.D. in 1975, a Miller Institute Fellowship brought him back to the University of California, this time at Berkeley, where he spent two years studying laser-induced chemistry. He joined General Motors in 1977.

Dr. Harris conducted his investigation into soot particle growth with the aid of Senior Science Assistant Anita Weiner. His research interests at GM also include the use of laser diagnostic techniques in combustion analysis, with special emphasis on intracavity spectroscopy.

Go fly a kite!

... occasionally there is the possibility that time stops when kites are flying. There are a lot of activities which produce this euphoria of stopped time. Children know them without being told. Adults have to be reminded. I often think it would be good if children started out playing golf and going fishing and ended up as adults flying kites!

— Tal Streeter

Kites have been in existence for over two and a half thousand years. A most remarkably versatile technological invention, it has been used for various purposes, including warfare, transport of goods and people, meteorological work, fishing, and pleasure.

Webster's defines a kite as "a light frame covered with paper or cloth, often provided with a balancing tail, and designed to be flown in the air at the end of a long string." The kite being an aerodyne, that is, a heavier-than-air machine, it must support itself and the cable that connects it to the ground by means of the aerodynamic forces created by the relative motion of the wind. This relative wind may arise merely from the natural motions of the air or may be caused by towing the kite. The kite is designed such that it is capable of rising to a positive angle with the horizon as the result of forces created by wind-pressure.

China is usually credited as the birthplace of kites, some centuries before Christ. From there, it spread throughout southeast Asia and the Pacific. The kite acquired religious, magical, and ceremonial significance in many parts of the world to which it spread. The kite has been associated with deities, as an external soul, and as a means of contact with heavenly regions.

The earliest well-documented account of the kite, dated about 200 B.C., places Chinese General Han Hsin to have flown a kite over a palace in order to judge the distance between his army and the palace walls, so that a tunnel of the correct length might be dug to allow his troops to enter. During the first millennium A.D., kites seem to have been used for various military purposes.

The use of the kite as a source of amusement is thought to have begun shortly after the first millennium A.D. It is traditional in China to fly kites on "Kite's Day," a festival held on the ninth day of the ninth month. A story describing the origin of the festival tells how a man called Huan Ching was informed by a fortune-teller

that on the ninth day of the ninth month a great calamity would befall his house and property. He was therefore instructed to take his family into the hills on that day, having previously provided each person with little red bag of pieces of dog-wood, tied to the wrist as a talisman. Ching, having done as he was bidden, returned to his house in the evening to find that all the domestic animals were dead. The story has it that in yearly memory of this occasion the people have continued to go into the hills, taking their kites to amuse themselves. At one time it was believed that the whole year's bad luck might be avoided in this way. The kites were also said to serve as an indication of their owners' future place in the literary hierarchy or in the civil service. The higher the kite flew, the greater would be its owner's success.

Since the earliest kites were made for practical rather than for aesthetic purposes, the Chinese built them in simple rectangular form. From these simple forms, the kite has evolved to numerous shapes, among them figure-kites



Take time to play again . . . go fly a kite!

The best places for launching a kite are flat fields, windward sides of hills, and near lakes or the sea (a little difficult in Colorado). Avoid heavily built-up or heavily forested areas. Don't fly near overhead power cables or in a thunderstorm (unless you're emulating Ben Franklin—see later insert).

Make sure that the kite is airworthy, checking the balance, material, and connections. Make any necessary bridle adjustments, according to the weather.

When you arrive at your chosen site, resist the temptation to dash off frantically in hopes that the kite will rise up gloriously behind you, because it won't. If you find that you have to run to launch a kite, you're flying the wrong kite for the weather. Different kites are designed to be flown under different weather conditions.

Let out a little line and throw the kite lightly up into the air. Let the line run slack until the kite flutters almost to the ground. Then reel it in quickly so that the kite soars up into the air. It will reach an apex and then drop near the ground again. As it drops near the ground, reel it in again quickly. Do this repeatedly until the kite reaches the height at which you wish it to fly. As the wind velocity changes, make small corrective pulls on the line to keep the kite flying well.

Landing a kite can be one of the most difficult parts of kite flying. Walking towards the kite and at the same time reeling it in will relieve the tension on the line. The safest way of landing your kite will be to reel in slowly and steadily until the kite is within a few yards of you and then let the line go entirely slack so that the kite drops lightly to the ground.

story by Ric Akima
photographs courtesy Into the Wind

Into The Wind
1729 Spruce St.
Boulder, CO 80302



Into The Wind



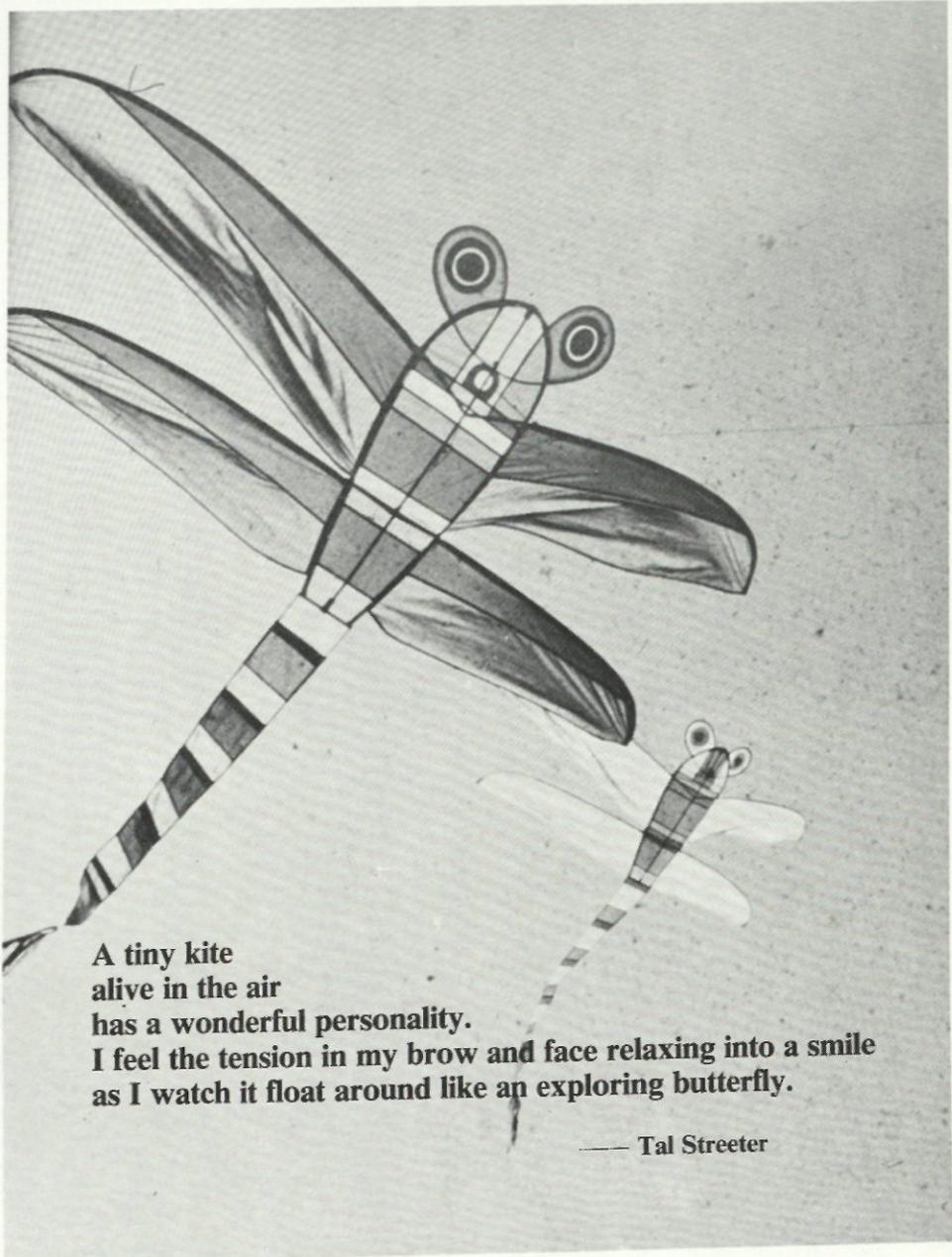
and bird-kites. The spectacular dragon or centipede kites, which may be 60 or more feet in length, are composed of a series of circular or elliptical discs, each acting independently as a kite, joined by two or more lines which keep them flying parallel, irregardless of the angle to the wind.

The lifting force of all kites is produced by deflecting the air downward, the resulting change in momentum producing an upward force. A kite requires an extremely low wind loading (weight/area) so that it can fly even on days when the wind velocity is not high. Efficient design requires that its lift-to-drag ratio be as high as possible; maximum efficiency is needed if a kite is to be used to fly to great heights. Low efficiency, or high drag, is sometimes desirable to have a kite which will fly stably, but will remain at a low angle to the horizon. This is the case when a kite is to be used to provide traction, e.g., of a boat or a life-line, or to carry lines across rivers and gorges, etc.

A kite must be designed according to its use and for the conditions under which it will be flown. Usually, a kite should be stable, that is, it should rapidly find a position of equilibrium and should resist changes of position due to sudden fluctuations in the weather conditions. Stability is obviously desirable for any purpose which requires the kite to act as a center of observation, such as in kite-photography or meteorological work. However, stability is a disadvantage in a kite which is to be used to move out of the line of the wind, as for kite-fighting.

Widespread throughout the Orient, kite-fighting involves trying to sever another man's line by crossing it with one's own and giving a rapid tug. The line near the kite is sharpened for this purpose by passing it several times through a mixture of glue and powdered glass or porcelain.

Experiments on the possible application of aircraft-type lifting surfaces, in which the low pressure created by the air flowing over the upper surface causes the lift, have shown most



**A tiny kite
alive in the air
has a wonderful personality.
I feel the tension in my brow and face relaxing into a smile
as I watch it float around like an exploring butterfly.**

— Tal Streeter

Collecting electric fire . . .

Shortly after the celebrated experiment in June 1752, Franklin gave instructions as to how it may be repeated:

Make a small Cross of two light Strips of Cedar, the Arms so long as to reach to the four Corners of a large thin Silk Handkerchief when extended; tie the Corners of the Handkerchief to the Extremities of the Cross, so you have the Body of a Kite; which being properly accommodated with a Tail, Loop and String, will rise in the Air, like those made of Paper; but this being of Silk is fitter to bear the Wet and Wind of a Thunder Gust without tearing. To the Top of the upright Stick of the Cross is to be fixed a very sharp pointed Wire, rising a Foot or more above the Wood. To the End of the Twine, next to the Hand, is to be tied a silk Ribbon, and where the Twine and the silk join, a Key may be fastened. This Kite is to be raised when a Thunder Gust appears to be coming on, and the Person who holds the String must stand within a Door, or Window, or under some Cover, so that the Silk Ribbon may not be wet; and Care must be

taken that the Twine does not touch the Frame of the Door or Window. As soon as any of the Thunder Clouds come over the Kite, the pointed Wire will draw the Electric Fire from them, and the Kite, with all the Twine, will be electrified, and the loose Filaments of the Twine will stand out every Way, and be attracted by an approaching Finger. And when the Rain has wet the Kite and Twine, so that it can conduct the Electric Fire freely, you will find it streams out plentifully from the Key on the Approach of your Knuckle. At this Key the Phial may be charg'd; and from Electric Fire thus obtain'd, Spirits may be kindled, and all the other Electric Experiments be perform'd. which are usually done by the Help of a rubbed Glass Globe or Tube; and thereby the Sameness of the Electric Matter with that of Lightning completely demonstrated.

Franklin, B. *The Papers of Benjamin Franklin*, ed. L. W. Labaree, Vol. 4, New Haven, 1961, pp. 360-9.

kites to be too sensitive to changes in wind force and direction. Under normal atmospheric conditions the use of this type of lifting surface results in a kite that behaves in a violent and unpredictable manner. Thus, the higher drag associated with a surface from which the flow has separated is tolerated. Since stalled surfaces are much less sensitive to wind changes, most of the lifting force in kites is therefore obtained from pressure on the lower surface.

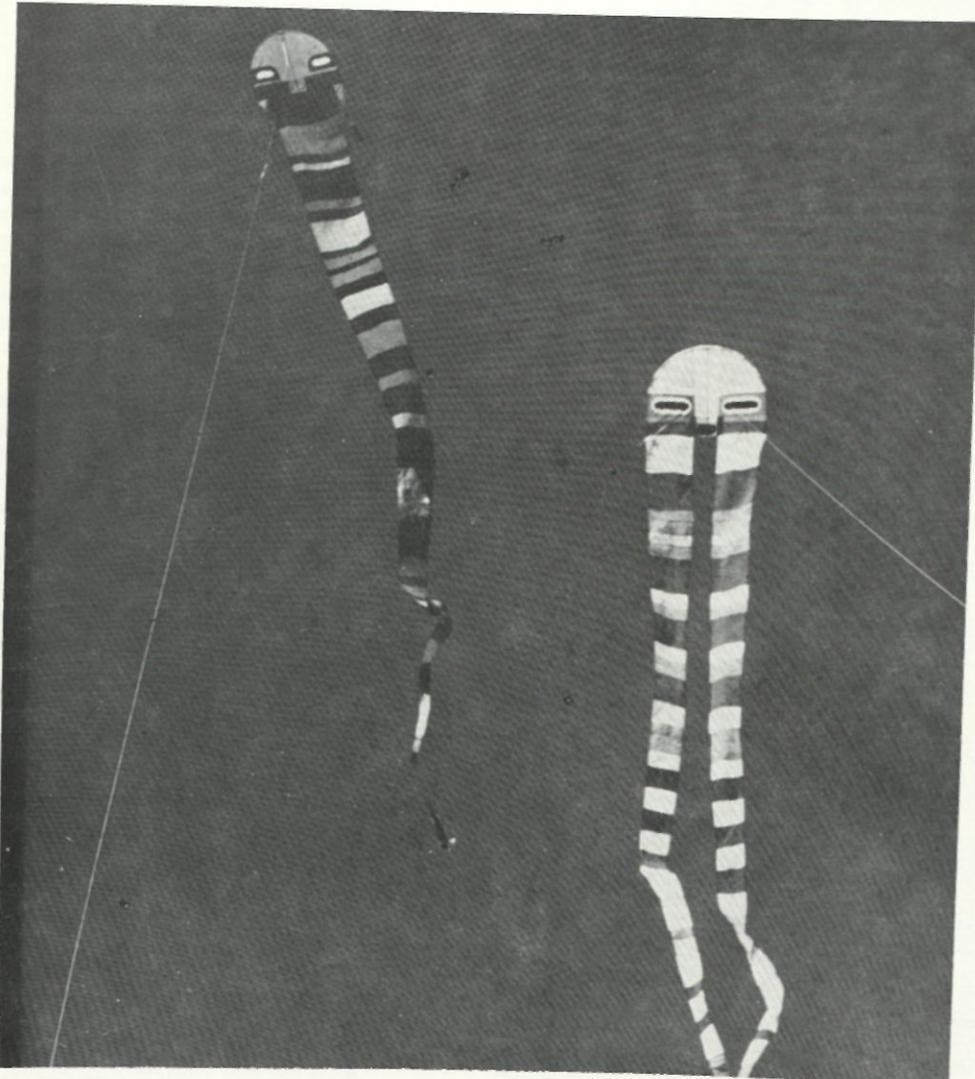
Both the lift-to-drag ratio and the stability of the kite are functions of the length of cable. The more cable release, the more drag created. The increased drag, combined with the increase in weight being supported, causes the kite to sag off downwind, reducing the flight angle. The flight angle is the angle formed between the horizontal and a line passing through the kite and the operator.

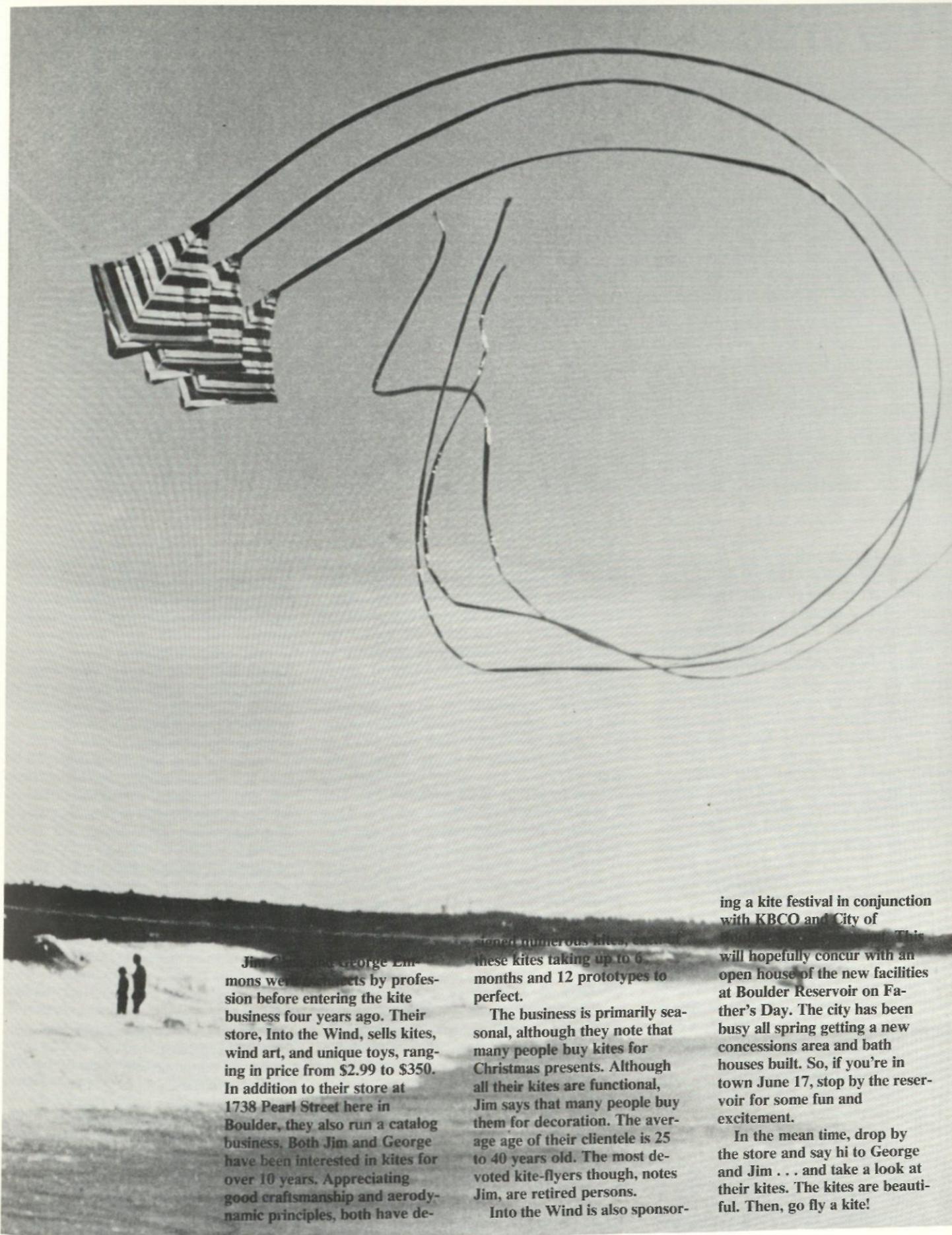
Kites take many forms; the bow and box kites are common in the U.S. In many countries, especially in Asia, kites are frequently used in rituals and festivals, and often take bizarre forms, some having been developed centuries ago. Chinese kites are also commonly equipped with simple musical instruments, a sort of Aeolian harp or whistles or pan-pipes.

Kites were, of course, important precursors of the aeroplane. From the earliest times they were associated with flying machines. The first documented account of a flight was first heard of in 1795, by George Pocock, a schoolteacher in Bristol, England. The next claim is a little-known one by a Frenchman. In 1859, an Irish priest, Fr. E. J. Corder, designed a system of multiple hexagon kites for lifting people to land in case of shipwreck. Attempts at manned kite flights grew in number and seriousness in the latter half of the 19th century. The first generally reliable system of man-lifters is credited to Captain B.F.S. Baden-Powell, of the Scots Guards; the first ascent took place on June 27, 1894, at Pirbright Camp. The 36-foot high kite used was approximately hexagonal in shape, and had a surface area of about 500 square feet. Since then, numerous experiments have led to various kite forms.

Alexander Graham Bell, known best as the inventor of the telephone, was instrumental in combining a number of kites to form a larger compound kite. Bell experimented with tetrahedron cells. As each side is triangular in a regular tetrahedron, it is inherently rigid and needs no bracing. Any two sides can be covered, increasing the surface-to-weight ratio from that of triangular cells. By 1905, Bell had made a kite capable of lifting a man; the kite consisted of 1,300 cells, each about 10 inches on a side. The 18-foot-long by 9-foot-wide kite only weighed 61 pounds.

During the last few decades the most common use of the kite has of course been for recreational purposes. Modern kites are continually being devised. The number of possible shapes is limitless, as are the methods of flying and controlling them. With the advent of hollow graphite and fiberglass and synthetic cover materials, modern kites are lightweight, responsive, and highly decorative. ◀





Jim Olson and George Emmons were professionals by profession before entering the kite business four years ago. Their store, Into the Wind, sells kites, wind art, and unique toys, ranging in price from \$2.99 to \$350. In addition to their store at 1738 Pearl Street here in Boulder, they also run a catalog business. Both Jim and George have been interested in kites for over 10 years. Appreciating good craftsmanship and aerodynamic principles, both have de-

signed numerous kites, each of these kites taking up to 6 months and 12 prototypes to perfect.

The business is primarily seasonal, although they note that many people buy kites for Christmas presents. Although all their kites are functional, Jim says that many people buy them for decoration. The average age of their clientele is 25 to 40 years old. The most devoted kite-flyers though, notes Jim, are retired persons.

Into the Wind is also sponsor-

ing a kite festival in conjunction with KBCO and City of Boulder.

This will hopefully concur with an open house of the new facilities at Boulder Reservoir on Father's Day. The city has been busy all spring getting a new concessions area and bath houses built. So, if you're in town June 17, stop by the reservoir for some fun and excitement.

In the mean time, drop by the store and say hi to George and Jim . . . and take a look at their kites. The kites are beautiful. Then, go fly a kite!

Hazardous Wastes

A look at industrial poisons

by Kathy Hands

On August 2, 1978, in an unprecedented move, New York state officials ordered the emergency evacuation of over 200 families living near the Love Canal, an old abandoned canal near Niagara Falls. Highly toxic and carcinogenic chemicals had been found oozing from the canal in extremely dangerous concentrations. These chemicals had been dumped into the canal between 1947 and 1952, when the Hooker Chemical and Plastics Corporation had used the canal to dispose of over 21 thousand tons of industrial chemical wastes. These wastes included over six thousand tons of lindane, a chlorinated hydrocarbon pesticide that is highly toxic and carcinogenic; over two thousand tons of chlorobenzenes, chlorinated derivatives of benzene, which is a highly toxic industrial solvent known to cause aplastic anemia and leukemia; and about 250 tons of trichlorophenol (TCP), used in the manufacture of herbicides and of cosmetic ingredients. This TCP was contaminated with several hundred pounds of the most toxic synthetic organic chemical known to man—tetrachlorodibenzo-para-dioxin (TCDD), more simply known as dioxin.

Any manufacturing process will produce, in addition to the desired product, waste products which are not necessarily useful. Often these wastes still have economic value, but waste generators are either unaware of the usefulness of their wastes, or, which is more likely the case, they deem it economically unfeasible to recycle the wastes, and they are disposed of, often as cheaply as possible. Unfortunately, a small percentage of these useless by-products are toxic materials. These hazardous wastes, although requiring careful disposal, are too often viewed as poisons that must be disposed of as cheaply as possible also, which usually means dumping them somewhere convenient.

Hazardous wastes are conventionally classified in the following major categories: radioactive wastes, flammable wastes, heavy metals, asbestos, acids and bases, and synthetic organic chemicals.

Radioactive Wastes

Radioactive materials are unstable and give off energy or charged particles as they decay into other stable, nonradioactive forms. Since the energy or particles which are given off by these materials have the potential to damage living tissue, radioactives are extremely hazardous. Small quantities of radioactive materials have the potential to lead to cancer, birth defects, and other chronic diseases upon exposure, whereas exposure to larger quantities can cause burns, injury, or immediate death.

Certain radioactive minerals, such as uranium, thorium, and radium, occur in large quantities in nature. In the 1930s, new radioactive elements and isotopes came into being via the fission process, whereby neutrons emitted from uranium were used to split other atoms.

A variety of uses for these new materials were found, including medicinal tracers within the body, as well as fuels for nuclear power plants. Radioactive materials are now being used in a wide variety of industries, but by far the largest producers of radioactive materials are the nuclear weapons industry and nuclear power plants.

The main characteristic of radioactive wastes that makes them so dangerous is their persistence in the environment. The amount of time it takes for radioactives to decay into nonradioactive forms, although it varies with the element or isotope, is an extremely long time in human years. For plutonium 239, a principal component of nuclear weapons, the fuel used in "breeder" nuclear reactors, and a by-product of other nuclear reactors, the amount of time it takes for one-half of its total radiation to be released is 24,000 years. Thus, plutonium 239, being the most lethal radioactive material as it will lodge in the body, in the lungs, if it breaks down into particles, poses a real long-term threat.

Flammable Wastes

Flammable wastes consist of chemicals which react strongly with other materials, in this case, oxygen. For example, petroleum or natural gas by-products, upon coming into contact with the atmosphere, react violently, giving off large quantities of heat in the process. Their reactivity makes them relatively short-lived as hazards to the environment.

Heavy Metals

Heavy metals, including lead, arsenic, cadmium, mercury, copper, and selenium, were some of the first materials used for technological purposes. They are relatively easy to separate

from their natural ores via smelting, and are easy to shape and mold, either alone or with other metals. Thus, the advancement of technology brought greater varieties of uses for these metals.

Lead is used in pigment manufacture, lead acid batteries, and is a by-product of metal smelting. Lead is a powerful neurotoxin, causing learning disabilities in children; exposure to low levels of lead over long time periods can cause brain and bone damage.

Arsenic is used in the production of boric acid and pharmaceuticals. Exposure to arsenic can lead to brain and nervous system damage, as well as possibility of carcinogenic action in skin and lungs, birth defects, and genetic damage.

Cadmium, used in electroplating, pigment manufacture, and as a plasticizer in polyvinylchloride manufacture, has been implicated in heart disease and high blood pressure. It is carcinogenic, causing lung cancer, and can cause kidney function damage at prolonged low-level intakes.

Mercury is used in metallurgical processes, and in the production of chlorine, caustic soda, and a variety of chemicals. An even more powerful neurotoxin than lead, mercury causes brain and central nervous system damage, and has been implicated in cases of mental illness. It is also mutagenic and teratogenic, resulting in genetic damage and birth defects, respectively.

Copper is a gastrointestinal tract irritant and can be highly toxic.

Selenium, used in steel, pigment, glass, and ceramics manufacture, can cause eye, lung, and heart damage with acute exposure.

The toxicity of heavy metals is a function of their atomic structure. Therefore, as elements they are toxic, whereas many other materials obtain their toxicity only in particular molecular or chemical forms. These materials can be changed to less harmful forms; metals will always be metals. Neither heat nor biological processes can change a metal to another form. Heavy metals can only be temporarily assimilated into a form that cannot be readily ingested by living organisms; they will always retain their toxic potential.

Asbestos

Asbestos is the name for a group of minerals consisting of calcium or magnesium silicates formed into long, threadlike fibers. These fibers can be woven or spun into cloth, or mixed with cement or other substances to form various materials. They have a high resistance to heat and electricity, making them extremely useful for a variety of things, including firemen's suits and insulation for electrical wiring.

The danger of asbestos does not lie in its chemical reactivity; but rather is due to its fibrous nature and resistance to chemical change and biological degradation. The fibers of asbestos can easily penetrate lung surfaces, resulting in a lung disease known as asbestosis or various lung cancers.

Acids and Bases

Materials that are very acidic or basic tend to be extremely reactive and corrosive. Acids or bases that are released into the environment tend to be short-lived hazards, as they encounter other bases or acids which neutralize them, giving neutral salts and water. The release of large concentrations of acids and bases into the environment can cause considerable damage before they are neutralized, however. In small streams, they are capable of fish, and other aquatic, kills. Acids also leach heavy metals out of the soil, which remain even after the acid itself becomes neutralized.

Synthetic Organic Chemicals

This relatively new category of industrial products, first proliferated with the use of petroleum as a basic feedstock. The petroleum age has enabled the synthesis of organic chemicals in unlimited quantities, and revolutionized the entire chemical industry.

Hydrocarbons, the basic unit of synthetic organic chemicals, are formed through chemical reactions under heat and pressure from plant and animal remains and preserved as fossil fuels—coal, natural gas, and petroleum. Coal and petroleum are large, complex molecules composed of long chains of carbon and hydrogen. Natural gas consists of a simple molecule, methane, but can be combined easily into larger, more complex chains.

Synthetic organic chemicals from naturally occurring hydrocarbons, such as wood and grain, have been produced for thousands of years. Alcohol, from fruit and grain fermentation, charcoal from wood, turpentine from pine resins, are all examples of very ancient chemicals obtained from wood and grain bases. These chemicals were simpler versions of natural organic materials and thus could be assim-

ilated easily by natural systems.

However, when fossil fuels are subjected to heat and pressure, myriads of new complex compounds that don't exist in nature can be produced. Nature finds it difficult to assimilate these substances, either due to their complexity, or their specific chemical structure.

The majority of organic chemicals in use are manufactured or synthesized from a number of light weight, highly volatile hydrocarbons that are yielded from petroleum via fractional distillation. These synthetic organic chemicals have a wide range of uses. Products from these chemicals have replaced such natural materials as wood, leather, cotton, and natural rubber. Petrochemical technology has made possible the production of a variety of new products that could not be manufactured in large quantities from natural materials. There are substantial commercial advantages to both producers and consumers from these new substances. Often these advantages occur at the expense of natural product markets, which are supplanted. They have also occurred at the expense of the health of exposed workers and the general public, and at the expense of the generation and disposal of highly hazardous toxic wastes.

There are three major uses of hydrocarbons that need to be distinguished. Some are used as end products in themselves. These include ethylene, benzene, toluene, and styrene, all light-weight hydrocarbon fractions, which are often important industrial solvents. Secondly, some, such as ethylene and styrene, are used as intermediates. These can be linked together to form long-chain plastics, for example, polyethylene and polystyrene, which are used in insulation foam, furniture, and packaging materials. Finally, some are used in the synthesis of novel molecules by chemical splicing or molecular engineering.

These novel chemicals, having entirely new properties, have never before existed. Thus, natural systems have never before been exposed to them. A good example of these new molecules are the halogenated hydrocarbons, in which atoms of chlorine, bromine, or iodine are added to basic hydrocarbon chains. This splicing produces such new chemicals as trichloroethylene (TCE) and perchloroethylene (PCE), which are used as solvents or degreasing agents, or more complex chemicals such as the pesticide DDT, which was widely used against agricultural pests and insect-borne disease after World War II.

The most common characteristic of the halogenated hydrocarbons is an ability to alter or suppress various chemical reactions that involve naturally occurring organic processes. For example, the pesticide DDT lethally alters the metabolic processes of insects. But many of the complex halogenated organics have an additional characteristic—resistance to biological degradation. Thus, chlorinated pesticides, i.e., DDT, were used due to their natural persistence; repeated application was not necessary. However, the toxicity of these chemicals results from these same characteristics.

Halogens, chlorine and bromine in particular,

are very toxic. When attached to the unreactive hydrocarbon chains, they are unable to enter forms, such as sodium chloride, which are less toxic. As such, they are able to enter the metabolic systems of a wide range of organisms, whether they are pesticide target organisms like mosquitos, or non-target organisms such as fish or humans. The possibility of ingestion by non-target organisms is greatly increased by the fact that halogenated hydrocarbons, while being almost insoluble in water, are actually fat-soluble. Thus they tend to accumulate in the fat cells of fish, and are therefore passed through the food chain. This property of halogenated hydrocarbons is known as "bioaccumulation"; these chemicals tend to accumulate in living organisms in much higher concentrations than in the environment into which they were released.

Useful as they may be, synthetic organic chemicals are hazardous. Benzene induces aplastic anemia and leukemia; chlorinated hydrocarbon pesticides such as DDT produce adverse reproductive effects in birds and have been shown to be carcinogenic; polychlorinated biphenyls (PCBs), used as insulating fluids in electrical machinery, are carcinogenic and impair fertility; and dioxin (TCDD), a contaminant in herbicides such as 2, 4, 5-T, is the most toxic known chemical, inducing cancer and birth defects in test animals at extremely low levels of exposure.

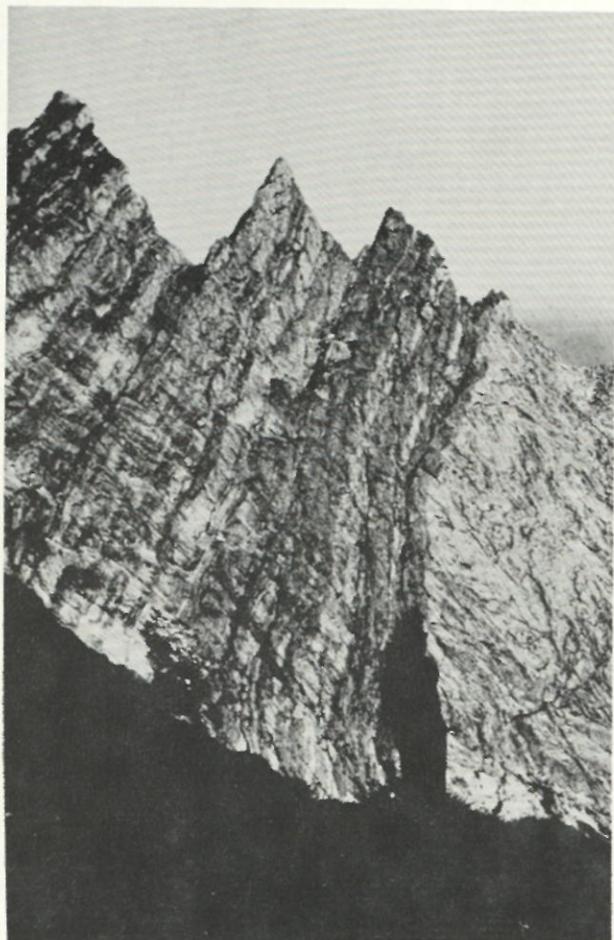
A major problem facing society is how to ensure that these hazardous wastes are not simply dumped, but handled in a way that prevents them from creating health or environmental problems. Some of the dangers that improper disposal can create, and has created in the past, include the contamination of underground aquifers and water supplies, destruction of natural habitats such as rivers, lakes, or fields; death and disease due to exposure to toxic chemicals; soil contamination; fish kills in lakes or rivers; and contamination of sewer systems or water treatment plants due to discharge of toxic materials into these systems. The dangers and costs of improper disposal of these hazardous wastes can be overwhelming; the episode at Love Canal has incurred costs in legal claims of over 2 billion dollars. And this figure was the result of a time in which the production of materials that ended up as hazardous wastes was a fraction of what it is today.

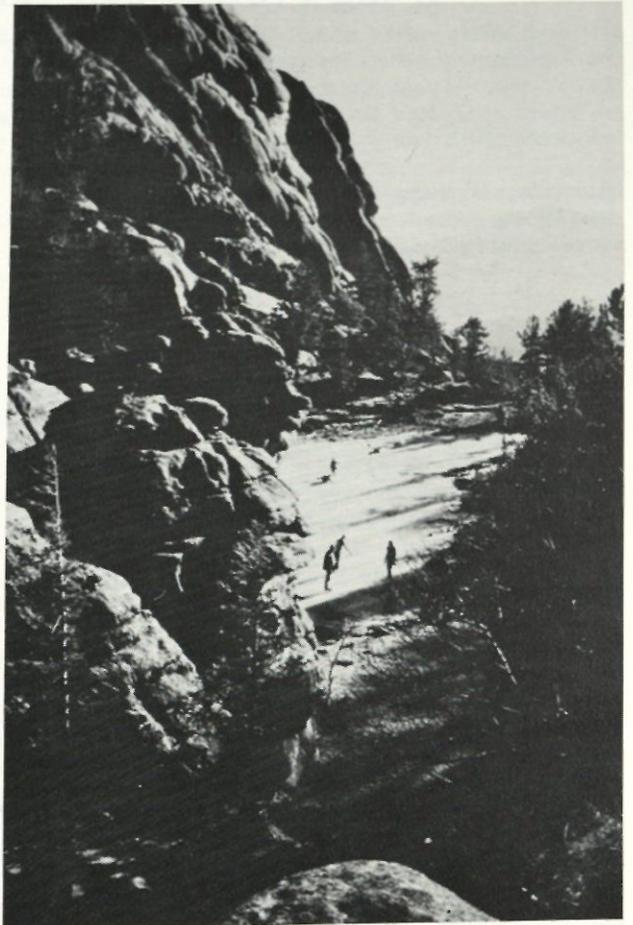
It cannot be assumed that safe disposal techniques will be easily found or implemented. Years of research and debate has failed to determine whether it is even possible to safely dispose of nuclear wastes—the one substance in the hazardous waste scene that has been most widely recognized. New approaches to the hazardous waste problem must be found. Since America alone produces over 88 billion pounds of hazardous wastes a year, it becomes obvious that in order to preserve our environment and our health, this is a goal that we must pursue now. ◀

A look at present waste disposal practices, and an overview of some alternate approaches to hazardous waste treatment, will appear in the next issue of The Colorado Engineer.

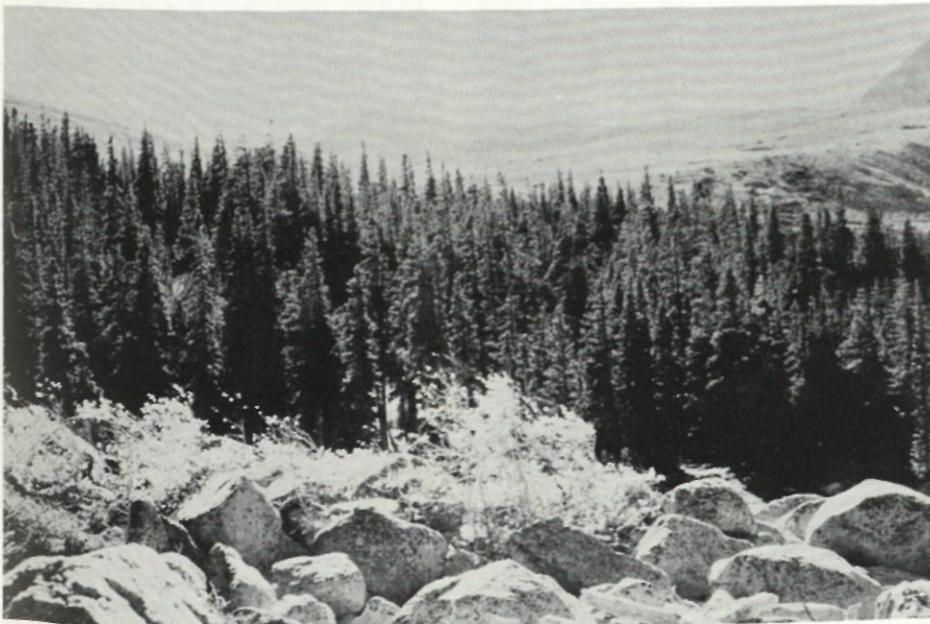


**a
rocky**





**mountain
high**



The Over-Byte

Wang Professional Computer

by William Patterson



Wang Laboratories, Incorporated, the king of complete office systems, has entered the personal computer market with a computer that is semicompatible with the IBM PC. The Wang Professional Computer is driven by an Intel 8086 16-bit microprocessor or a 8087 coprocessor which is not very different from IBM's 8088 16-bit microprocessor. It has 128 IC bytes of memory that is expandable to 640 bytes of memory. Both the Wang Professional and the IBM PC use Microsoft's MS-DOS operating system. This system allows for free-space allocation, and random and sequential file access. MS-DOS is emerging as the standard 16-bit microprocessor's operating system. Wang, however, added several features to the operating system to increase flexibility and usability. The key change is that the user can execute file operations using plain English menu prompts rather than using the MS-DOS command instructions.

Being able to operate the personal computer with simple, common English words rather than having to learn the MS-DOS command system was Wang's primary goal in developing this computer. The intention of the computer was to have a non-Engineering executive or minimally-educated secretary be able to fully

operate and be comfortable with the computer within an hour. Another modification of the operating system is the communication parameters of the RS-232C serial port and the utilization of the text-to-document and document-to-text conversion. This is where Wang becomes noncompatible with the IBM PC. Any program that uses the IBM PC's I/O (input/output) devices will not run on the Professional Computer. However, with just a little modification the program can be changed to run on Wang's personal computer.

One unique aspect of the Wang Computer is the separated monitor screen. The screen can be pivoted to vary the viewing angle or it can be moved forward, backward, right, left, up, or down. For office applications, the fact that the screen can be left in the air above the desk simply means more desk space and a better utilization of the office environment.

The keyboard has several advantages for the common user. The main advantage is the 16 programmable function keys. Wang and outside software companies take advantage of the functions in their programs. These function keys are encoded in plain English so that their operations are again, easily understood by the common operator.

Keeping with the theme of office applications, the word processing system is sophisticated yet easily operated. The screen, when using the word processor, indicate the page number, the line, and the location in the line. When typing in text, the screen will highlight the line that will be the last line for that particular page when the document is to be printed. This is very advantageous when reading through the document to visualize what it will be like when it is printed. The word processor also has a menu that is accessible at any time during the typing process. The menu has literature enhancing items such as boldface, underline, subscript, and superscript. The word processor also has a spelling checker which I wish I could have used in writing this article. The spelling checker requires 128 K bytes of memory so the user will have to take into account when purchasing a Wang personal computer.

The Wang Professional Computer is essentially an office adapted IBM PC. The Professional Computer is designed to fit together with Wang's overall office system. ◀

Some of the facts used in this article were obtained from Byte magazine.



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NEWS NEWS NEWS

HIGH-TECH FIRMS INCREASE SALES

Overall sales growth of high technology firms in Colorado is projected by those firms at nearly 60 percent over the next three years with an expected employment increase of 50 percent, according to a comprehensive study of the industry released today.

More than 400 Colorado firms participated in the study of history, financing, sales, employment, past growth and future potential growth, and support services of the industry. The study was sponsored by Central Bank of Denver and Arthur Anderson & Co.

Denver, Boulder, Colorado Springs and Fort Collins were targeted as the areas for future growth of "high tech" industry by the director of the study, Gerald L. Allen, chief economist at the Business Research Division of the Graduate School of Business Administration, University of Colorado, Boulder.

Allen said the existing educational and research facilities of those four areas will dictate what future high tech industry development will take place in those cities.

But he cautioned in a news conference today in Denver that "if the quality of life deteriorates, if we have too much of the Silicon Valley syndrome, we could see this industry gravitating to other areas of the country."

High tech firms must be "on the leading edge of research in their field" and are looking for such backup research capabilities as the National Bureau of Standards in Boulder, Allen said. The announced space research center in Colorado Springs also could prove to be a magnet, he added.

High tech "spawns" more high tech with former employees of existing firms such as Storage Technology Corp., IBM and Hewlett-Packard founding most of the new companies, Allen said.

Survey results show that 62 percent of the firms responding to the study were established since 1975 and 28 percent since 1980. Most of the firms—75 percent—are in the Denver-Boulder area. El Paso County accounts for about 12 percent and Larimer County for 8 percent.

The firms are generally small with 58 percent having less than 20 employees. Only 10 percent have 250 or more employees. Annual sales also reflect size with 77 percent having sales of less than \$5 million.

Median growth in sales for the last three years was 40 percent, employment 28 percent and office space growth was 27 percent. But more than a third reported a 100 percent increase

in sales and a half reported facilities expansion of 100 percent or more.

Projected sales growth in the next three years of 100 percent or more was reported by 43 percent of the firms and 35 percent of the firms expect to double the number of their employees in the same period.

"The recession shows up in that almost a fourth of the firms reported zero or negative growth in employment, more than a third didn't expand their facilities, and 29 percent expect zero or negative growth in the next three years," Allen said.

Although only 21 percent of the larger firms are headquartered in Colorado, nearly three-fourths of all firms are headquartered here, of which more than 85 percent are private corporations or are owned by entrepreneurs, with only 15 percent public companies.

Principal products include computer software, electronic computer equipment and electronic components. In all, 36 different products are reported by the firms.

Less than 10 percent of the high tech companies used venture capital for business start-ups.

"Private equity and retained earnings have been the principal financing methods for the firms," John Roeder, Arthur Anderson & Co. partner for high technology industry, said. "The most frequently mentioned secondary source of funds was long term debt.

"However, twice as many firms plan to go public as have gone public in the past," he added.

In the future, about 13 percent expect to use public issues, but 22 percent will use retained earnings, 15 percent long term debt, 13 percent private equity and 12 percent venture capital.

The greatest financial need is for working capital loans or lines of credit, with cash management services least needed. The companies are looking for leasing or plant/equipment loans, export lines of credit and real estate mortgages.

Jerry Helmke, Central Bank of Denver vice president, said there will be adequate funds for loans within Colorado to support the rapid growth in high tech industry which the survey indicates may take place.

"In fact, because we have just emerged from a two year economic slowdown, bankers here typically have a lower loan-to-deposit ratio than desired and are actually seeking qualified loan requests," Helmke said.

Future personnel needs include, in order, technicians, clerical workers, managers and professionals, engineers and production workers. Availability within Colorado was rated good to very good for all categories.

External support services needed most were subcontractors and marketing support, followed by material suppliers, computer support, audit and accounting, and legal. Least needed are engineering, research and development, and management consulting.

Research and development, and administration were cited as the strongest internal capabilities of the firms, while marketing was the weakest.

FIRST REINFORCED EARTH® SPILLWAY COMPLETED AT TAYLOR DRAW DAM

In a first-of-a-kind U.S. application, a Reinforced Earth® spillway has been incorporated into Taylor Draw Dam, a major earthfill dam on the White River near Rangely, Colorado.

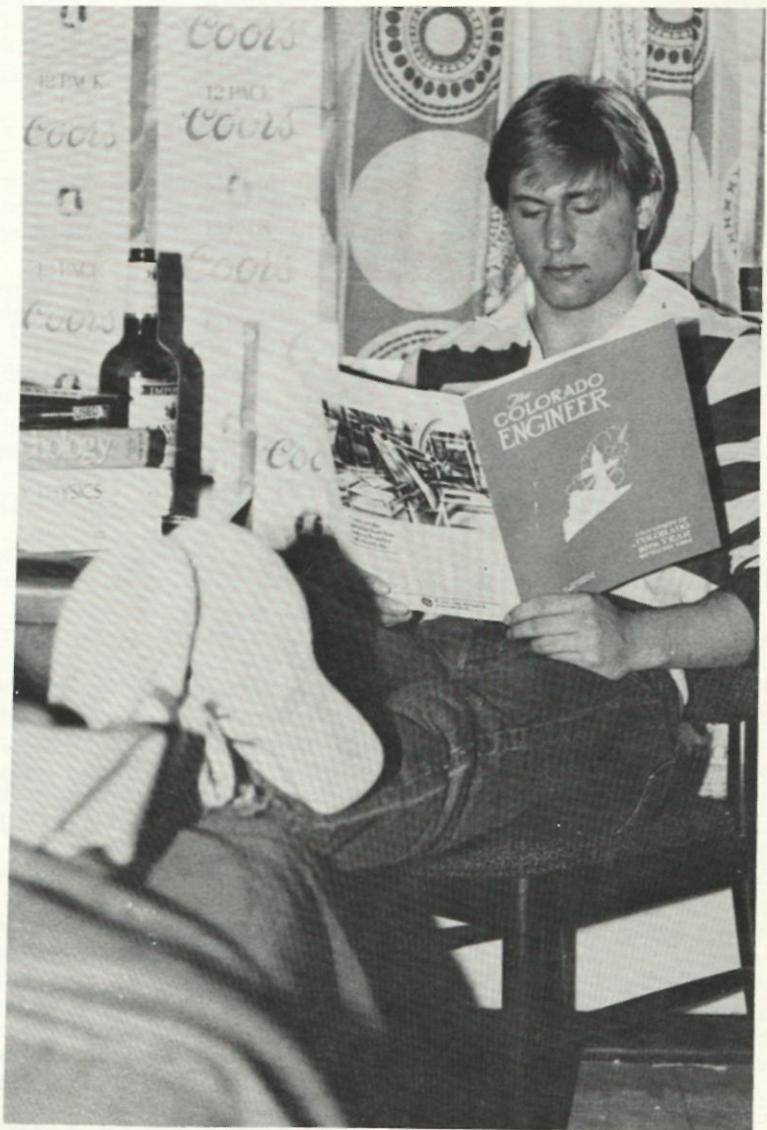
The Reinforced Earth structure supports a 65,000 cfs uncontrolled ogee spillway. Beginning near the right abutment, the spillway extends for 504 ft of the 1,250 ft long embankment. The ogee, its concrete apron and flip bucket are 15 ft below the dam's 79-ft-high crest.

Reinforced Earth structures are constructed with granular backfill and steel reinforcing strips, which attach to precast concrete facing panels. At Taylor Draw, these panels form the downstream face of the spillway. A concrete leveling pad, keyed into rock, supports the panels, which, in turn, protect the Reinforced Earth zone from scour.

The reservoir formed by the dam will lie in the broad, shallow floodplain just upstream of Taylor Draw. At normal high water in the reservoir will contain 13,800 acre-ft and extend 3.5 miles. It will provide a dependable water supply for the region, as well as flood control, recreation and a future source of hydroelectric power.

Reinforced Earth structures are used to meet a wide variety of transportation, commercial and industrial earth-retaining and load-supporting requirements. The Reinforced Earth Company provides specialized construction components and works closely with owners and contractors in the development of each project. The company's services include feasibility studies and cost estimates, structure-related design and engineering, specifications and expert construction advice.

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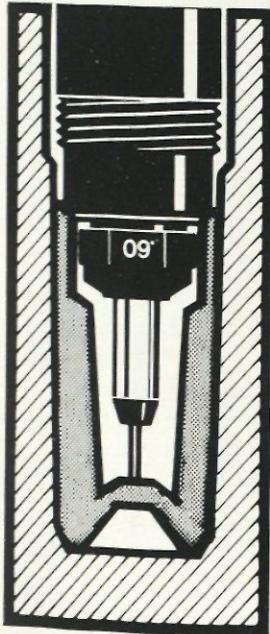
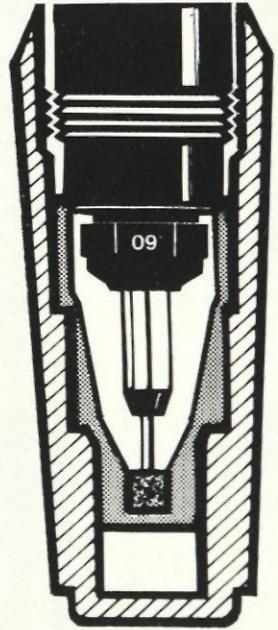
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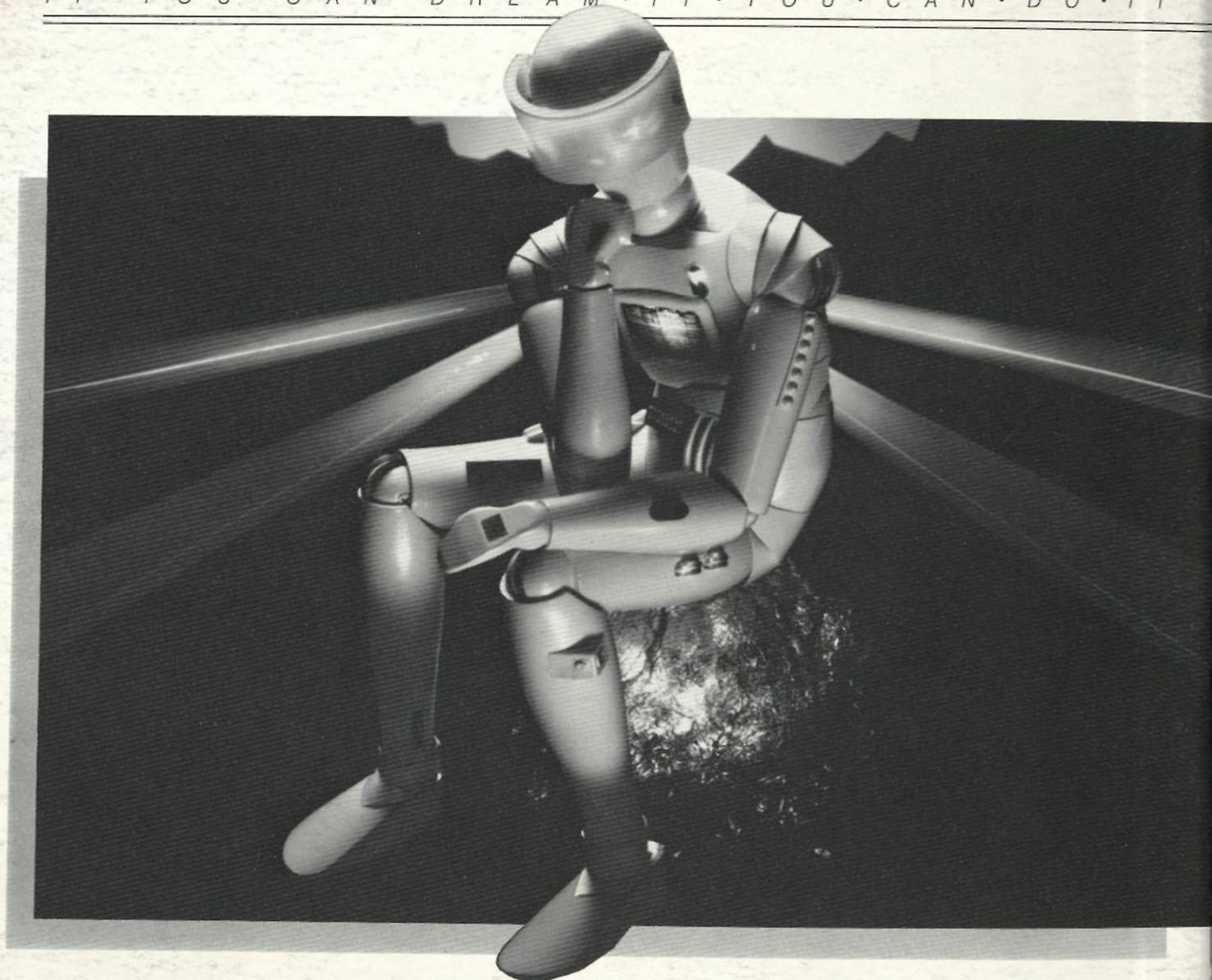
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Sat.: 10:00-5:00

Thurs.: 8:30-8:00



Create computers that capture the mysteries of common sense.

The brain does it naturally. It wonders. It thinks with spontaneity—advantages we haven't been able to give computers. We've made them "smart" able to make sophisticated calculations at very fast speeds. But we have yet to get them to act with insight, instinct, and intuition.

But what if we could devise ways to probe into the inner nature of human thought? So computers could follow the same rationale and reach the same conclusions a person would.

What if we could actually design computers to capture the mysteries of common sense?

At GE, we've already begun to implement advances in knowledge engineering. We are codifying the knowledge, intuition and experience of expert engineers and technicians into computer algorithms for diagnostic troubleshooting. At present, we are applying this breakthrough to diesel electric locomotive systems to reduce the number of engine teardowns for factory repair as well as adapting this technology to affect savings in other areas of manufacturing.

We are also looking at parallel processing, a method that divides problems into parts and attacks them simultaneously, rather than sequentially, the way

the human brain might.

While extending technology and application of computer systems is important, the real excitement and the challenge of knowledge engineering is its conception. At the heart of all expert systems are master engineers and technicians, preserving their knowledge and experience, questioning their logic and dissecting their dreams. As one young employee said, "At GE, we're not just shaping machines and technology. We're shaping opportunity."

Thinking about the possibilities is the first step to making things happen. And it all starts with an eagerness to dream, a willingness to dare and the determination to make visions, reality.

An equal opportunity employer



***If you can dream it,
you can do it.***