Net Energy, Creativity, and a Cosmological Question

by Scott Ready

As oil companies drill deeper, push further out to sea, and penetrate into the arctic, it takes larger amounts of energy to obtain energy. To know whether an energy tapping endeavor is actually yielding net energy, one needs to be able to see all of the energy inputs involved in the process of extracting and refining the energy source. By seeing how our energy industries are wired into the main economy and how these two are wired into natural ecosystems, we can begin to calculate net energies and write environmental impact statements.

Diagram #1 is an energy network diagram in its most simple form. All of the diagrams in this article use the symbols and style of Howard T. Odum, an environmental engineer with the University of Florida who initiated this type of synthesis.

Diagram #1 could be a schematic of the symbiotic relationship between a simple farm and nearby village. At P1, energies E of the sun and weather systems, amplified by the work E2 of the farm, and the energies of the goods and services E6 from the village result in the growth of crops and maintenance of the structures S1 of the farm. S1 represents all of the assets of the farm—the soil, the plants, the buildings, the farmer, and all of his time schedules. The farmer sells part of his crop E3 to further stimulate the processing P1 of energies E and to organize his farm. The assets S2 of the town are used via E5 to generate new structures, and sustain, regulate, and restore those already existing. The sinks or ground symbols represent energy losses due to depreciation and energy conversion processes.

The flows of energy E0, E1, . . ., E10 interconnecting the parts of the system can be expressed in units of power, kilocalories per second, or in terms of total energy flow in kilocalories over a set period of time. For each processing unit and for each storage symbol, the amount of energy flowing in must exactly equal the energy flowing out. Any dispersed and unused energy is soaked up by the sink symbols.

Very interestingly, the shape of diagram #1 serves to describe a broad range of microcosms. Diagram #1 could represent the bonds between a farm and village, oceans and land, flowers and insects, herbs and deer, green plant parts and the darker more compacted plant parts, cell cytoplasm and cell nuclei, the extended parts of your body and your head. In each case the entity to the left is expanded and concentrates the dilute energies of the source E into an upgraded form to be processed by the compacted entity on the right. Thus over and beyond the rapid surface changes of the world we have discovered here a deeper constancy in designs.

Calculating net energies involves knowing both the magnitude of energy flows and their quality. As energies are concentrated their qualities are increased. In diagram #2, as one moves from left to right the energies of the sources are being concentrated and transformed into highly specialized, organized, and influential activities of high energy quality. The energy quality of information is the total amount of energy expended in its formation. This includes a tremendous amount of dispersed heat lost through the sink symbols. As Thomas Edison once said, genius is 1% inspiration and 99% perspiration.

To calculate the true energy requirements of the city, one must convert each of the inflowing energies into a common quality level, for example into the energy density of oil. Thus, although the magnitude of the innovative energy E5 being applied to the city is small, this energy is tremendously more valuable and costly on a per kilocalorie basis than say oil in a can, E2. To convert E5 into oil energy density units, called fossil fuel equivalents (FFE), one must multiply E5 by a large number, say between 5 and 50. The energy quality of food, that is, the amount of useful work food delivers per calorie, is less than that of oil. Therefore, to convert E1 into FFE one would multiply E1 by a number less than one, say 0.1.

CREATIVITY

Presently in the United States, in terms of FFE, we are consuming 2.5 times more energy through use of fossil fuels than what we are receiving from our own natural ecosystems, the sun, wind, waves, and rains. This tremendous surge of power has billowed out into the fantastic variety of services, machines, gadgets, and ideas that are so characteristic of twentieth century America. Our fossil fuels allowed us to break out of the circle of life and let our inventive craziness run wild.

Diagram #3 is an explanation of how creative processes operate at more benign energy levels. The basic pattern is to have a participator within a system generate more new units than the system has energy to support. The restrictive amount of energy forces the new units that are best able to contribute, reinforce, and enhance the power flows of the system to be chosen among the variety of units generated. The ability of a system to design, select, and reinforce improved parts is more an intelligent property of the entire system than that of individual units. It is by the creative evolutionary process described here that large scale systems are able to repair themselves.

In diagram #3, unit S2P2 has generated eight new varieties. Units 1 and 2 are individually healthy and are looping back high quality energy to their own life support module S1P1. Energies E1, E2 help recycle materials, help P1 overcome limiting factors, and help regulate system activities. As a result of the compatibility of the designs of units 1 and 2 with the needs of the system, units 1 and 2 will be able to attract like growing antennae increasing amounts of the energies leaving S1P1. This pirating of energies leads much to the demise of units 3 through 8 and hence we say that units 1 and 2 have been constructively loop reinforced or chosen by the system.

If S2P2 has been properly chosen, then good system designing would require the ingredients of short lived units 3 through 8 to be utilized by some other participator in the system, say S3P3.

Diagram #3 could represent a pond scene where S1P1 are photosynthesizing units, S2P2 is an insect that lays many eggs, and S3P3 are reptiles that enjoy eating these eggs.

An important variation of diagram #3 is when S3P3 is actually units #1 or 2. S1P1 could then represent the waters of the oceans, which when uplifted and rained upon the highlands S2P2, generate many tributaries, units 1 through 8. Those streams E1, E2 which offer the path of least resistance carve the land and divert the waters from units 3 through 6. Thus units 1 and 2 become chosen among the choices generated. Similarly S1P1 could represent a primitive heart and S2P2 could represent tissues giving rise to the embryological development of many blood vessels.

S1P1 could represent cool down-drafts of air and S2P2 could represent warm moist air rising and developing into many competing cumulus clouds. Since units 1 and 2 are in line with the overall circular plan of the system, they are able to draw units 3 through 8 into themselves and thus evolve into thunderstorms which contribute to the overall kinetic energy of the system.

S1P1 could represent a natural ecosystem and S2P2 could represent a small society which generates a variety of cultures, units 1 through 8. The chosen cultures are those that are in partnership with nature.

Thus the requirements for creative evolutionary action are the generation of many choices and an appropriate network design to select and reinforce the chosen. The presence of these two ingredients precedes the origin of species on Earth. The ability of a system of units to generate many variations ultimately depends on the fact that all energy network diagrams are built out of a quantum bubbling substrate.

As power flows are continually being redistributed, the wiring interconnecting key system parts may vanish and rematerialize into newly discovered arrangements. Diagram #4 is a lively network involving an insect-eating bird wired into his ecosystem. The creative processes described above result in the competition between the bird and predator insect at insect #2 being resolved by the predator insect withdrawing his connections with insect #2 and interposing new wiring between himself and insect #3.

To understand why the chosen are who they are an observer must multiply expand his vision to encompass increasingly larger systems in which the chosen are imbedded. For example, by utilizing the winds, the rhythm of tides, and falling waters, seeds are widely distributed, birds soar, estuaries are productive, and mankind generates electricity. The chosen are those who enter into the stream of already existing large scale circular loops.

An even larger flow diagram is #5. If the surging energy levels of our main economy and energy industries are increased much more, we may overwhelm, poison, or displace our natural ecosystems. However, an examination of diminishing net energy returns indicates that world energy developments have reached an upper crest. The net energy that we receive from the oil industry equals E2 minus E1 minus the oil industry's contribution to environmental stress. The net energy we receive from the nuclear industry equals E4 minus E3 minus the nuclear industry's contribution to environmental stress.

E1 includes the energy cost in FFE of all of the following: steel for oil rigs, pipelines, refineries, oil tanks, and tanker construction; enormous quantities of building materials of all kinds such as steel, concrete, electrical wiring, aluminum, glass, and wood for structuring office buildings, equipment, warehouses, research facilities, processing plants, facilities for laborers, service stations, and roads; the cost of company aircraft, cars, trucks, railway cars, tug boats, barges, yachts, and helicopters; landscaping costs, advertising, lobbyists, insurance to cover accidents and mistakes, prospecting, and utility bills. As costly as everything described above is the expenditure of very high quality energies to organize, monitor, and improve the incredibly complex megastructure which the oil industry represents. Another major energy input is the defense work of our government to protect and secure the industry's oil deposits. In the 1970's the oil industry is also beset with the high energy costs of drilling deeper, pushing further out to sea, and penetrating into the arctic.

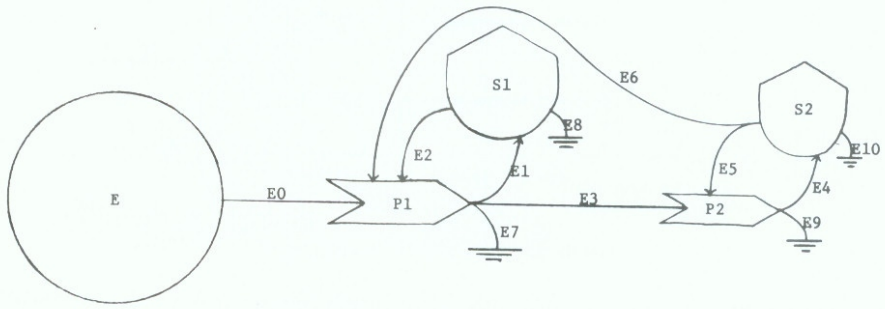

DIAGRAM #1.

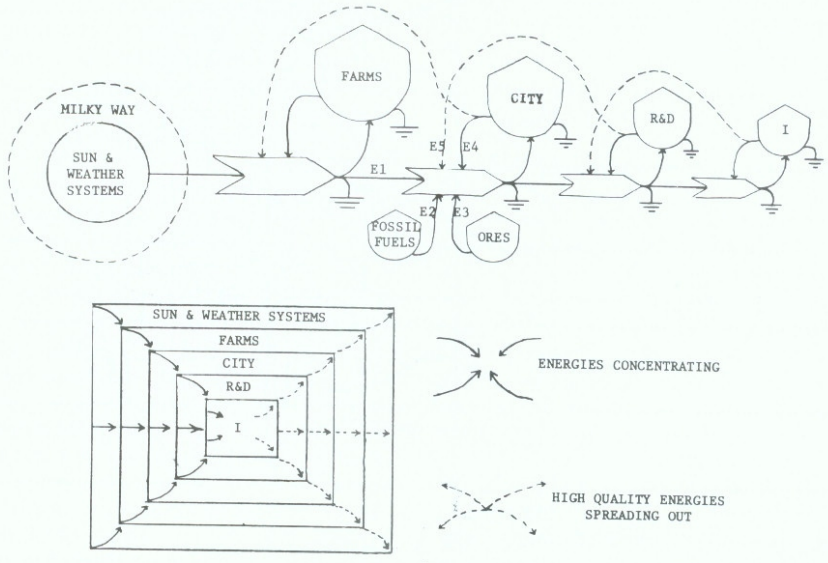

DIAGRAM #2. R&D equals research and development, I equals organized information and ideas.

Drilling deeper requires more steel and employs more pumps. Offshore drilling requires highly specialized platforms that demand special services and increased insurance rates. Arctic drilling requires special equipment, intensive heating for the laborers, and the high energy costs of transportation.

E3 includes the energy cost in FFE of all of the following: prospecting, mining, refining, and enriching the uranium ore; the total cost of constructing a plant site, the cost of handling its radioactive wastes, and after thirty to forty years the cost of disassembling and deactivating the plant site; the costs of insurance, advertising, landscaping, utility bills, and lobbyists. In general the energy inputs to the nuclear industry involving highly trained personnel, research and development, state of the art technologies, sophisticated apparatus, rare metals, monitoring work, safety, management, regulatory agency work, and defense department work require extremely high qualities of energy. Thus, when converting the bundle of energies comprising E3 into FFE, one must multiply many of the inputs by numbers much larger than the numbers used to convert oil industry inputs into FFE.

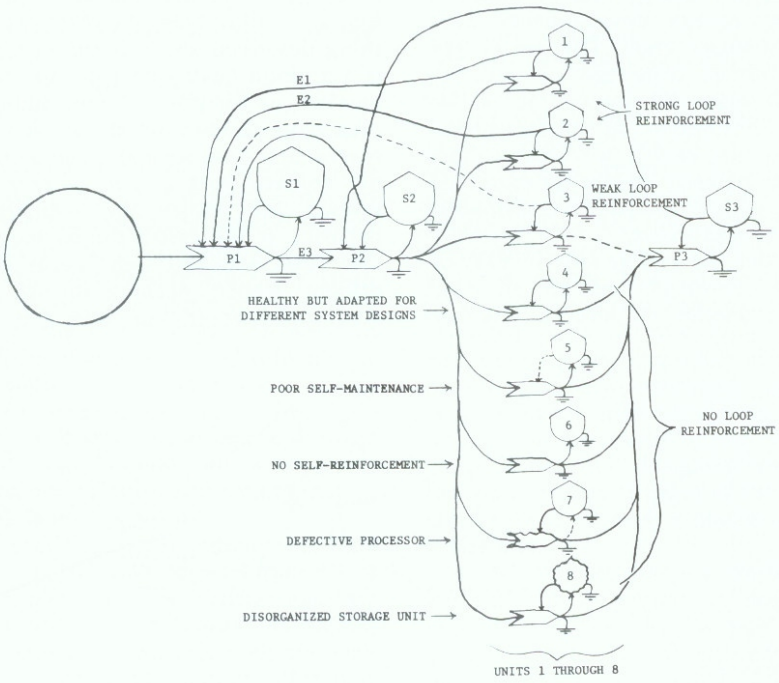

DIAGRAM #3.

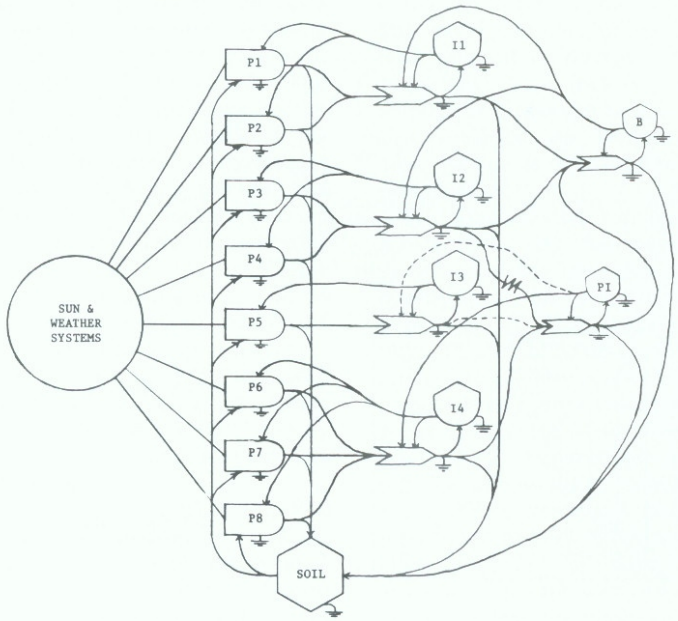

DIAGRAM #4. Pi equals plant type #i, Ii equals insect type #i, PI equals predator insect, B equals bird.

Considering the long descriptions of E1 and E3 it is clear that net energy returns from the oil industry are decreasing, and it is doubtful whether the nuclear industry can deliver any net energy at all. Table #1 gives the sobering results of several net energy calculations that have been made.

During times of diminishing net energy returns, the amount of new energy pumped into the economy per circulating dollar decreases. Overall the amount of energy flowing behind each dollar becomes less. The ability of each dollar to deliver useful work diminishes. Our present inflation, which is world wide, is a symptom of diminishing net energy returns. World energy development is climaxing.

In the twentieth century, because of our intensive channeling of fossil fuel energies, we have been able to invent and sustain far more activities than a system operating at more benign energy levels would have permitted. In effect, the burning of fossil fuels has suspended us from the creative error correcting processes described earlier. When will our use of fossil fuels be sufficiently limited to allow the ancient evolutionary processes to reengage themselves in our lives?

At this point I send many thanks to Howard T. Odum for showing me most of the ideas presented so far. In the next issue of the *Colorado Engineer* the diagrams presented here will be used to see into the future.

A COSMOLOGICAL QUESTION

All together from diagrams 1 through 5, the reader has encountered 59 heat sink symbols. To where does this dispersed heat flow? The temperature of the space through which the earth orbits is 2.7 degrees kelvin. This ambient heat is extremely isotropic to within 0.2%, indicating that it is of extragalactic origin. If the earth does not occupy a special position in the universe, or if this ambient heat is dilute energy from the initial expansion of the universe, then the temperature of outer space everywhere is about 2.7 degrees kelvin.

Now the temperature of a black hole of stellar origin is at most on the order of 5×10^{-8} degrees kelvin. Therefore, if heat pours from hot regions into cold regions,

then black holes are powerful vortexes inhaling the last of our world's dispersed heat. That black holes are cosmic ingredients of the universe is reinforced by the fact that there are enough stars in the Milky Way to develop one million black holes and there are more galaxies than there are stars in the Milky Way.

Diagram #6 shows the gravitational collapse process of a black hole reconcentrating the radiant energy of a star. The event horizon represents a cosmic drape surrounding the black hole behind which we can see no events. As energies slip behind the horizon they appear to ride off into our infinite future, that is, it takes an infinite amount of time to see them slip through. However, from the perspective of an infalling participator it takes only a short amount of time to slip through the event horizon which is hardly noticed. But once inside, the participator cannot get back out. Instead he must spiral inward colliding with intense energies as he experiences the gravitational collapse of space, time, and energy. With the collapse of space and time, the framework of every dynamic principle of physics collapses and hence physics collapses. The descriptions of physics stop, but the hidden action of gravitational collapse goes on. The cosmological question is: What happens next?

The *Colorado Engineer* invites its readers to send in their own inspired and imaginative guesses as to what happens next. To help initiate some responses I will give my own guess. The matter-energy collapsing within the event horizon is transfigured and used to generate the expansion of new spacetimes within our universe. The contribution that a single black hole has given to initiate the expansion of new spacetimes is measured by us as its mass. □

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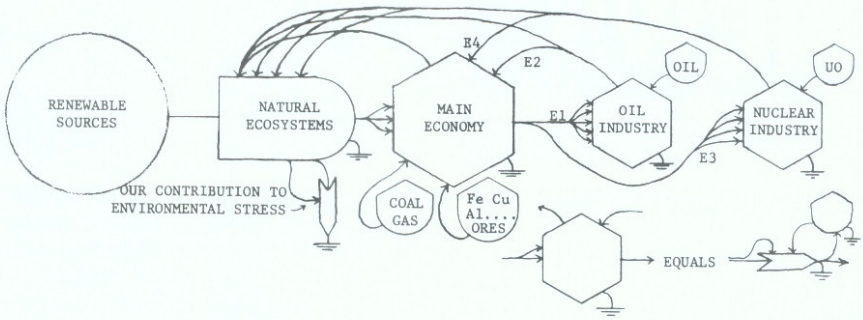

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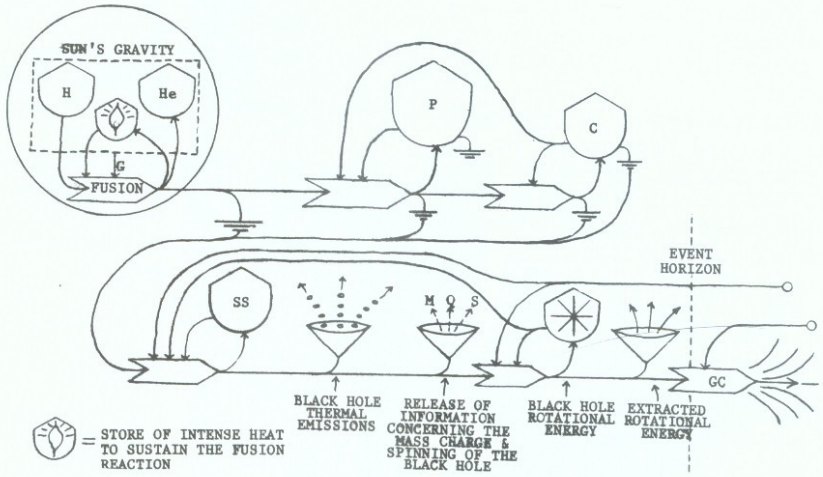

DIAGRAM #6. G equals sun's gravitational containment and control of the fusion reaction, P equals producers, C equals consumers including us, SS equals surrounding space of black hole, GC equals gravitational collapse.

TABLE #1

Activity	FFE of Energy Received	For Every	FFE of Energy Invested
Hand made solar cells generating electricity	1		456
Anvil Rocks oil shale pilot plant 1947-1975	1		82
Modern windmills generating electricity in a 16 kph wind	1		3.6
Fossil fuel subsidized agriculture in Florida	1.014		1
Strip mining coal and transforming it into electricity	4.82		1
Buying Mideastern oil in 1974 at $10 per barrel	6.5		1
Hydroelectric plant with 30 m dam	193		1

Scott Ready plans to be a free man of ideas. While immersed simultaneously in the worlds of electrical engineering, physics, math, and astronomy he managed to graduate from the University of Florida in 1976. Presently, he is in the CU department of mathematics and hopes to use the energy network diagrams used here to enhance quantum geometrodynamics.

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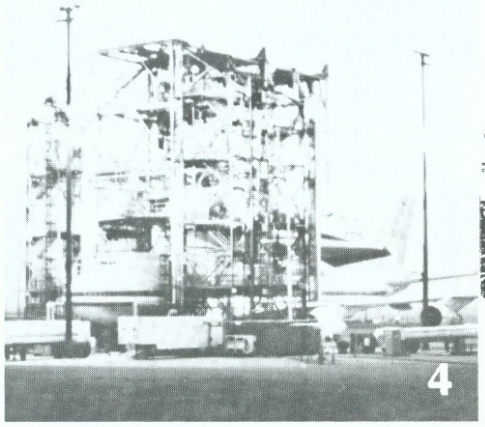

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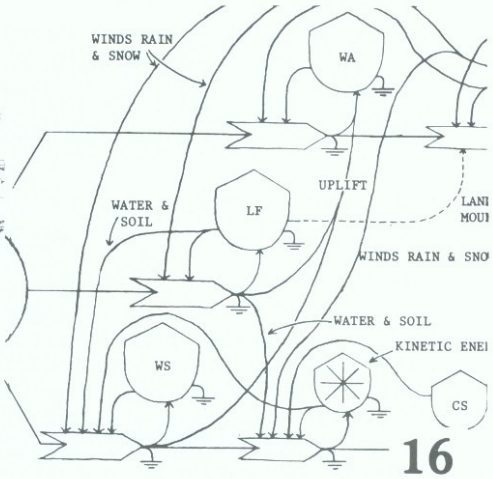

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FEATURES

DEPARTMENTS

COVER

This issue's cover is a reversed high contrast image of the space shuttle *Enterprise* mated with the NASA modified Boeing 747 carrier aircraft. A hybrid spacecraft and glider, the reusable shuttle opens a new era of the space age by making space more accessible to man. Over 500 flights are currently planned to help in the study of the earth and the universe, and to maintain the security of the nation. Original photo courtesy of NASA, graphic design by Tom Brooks.

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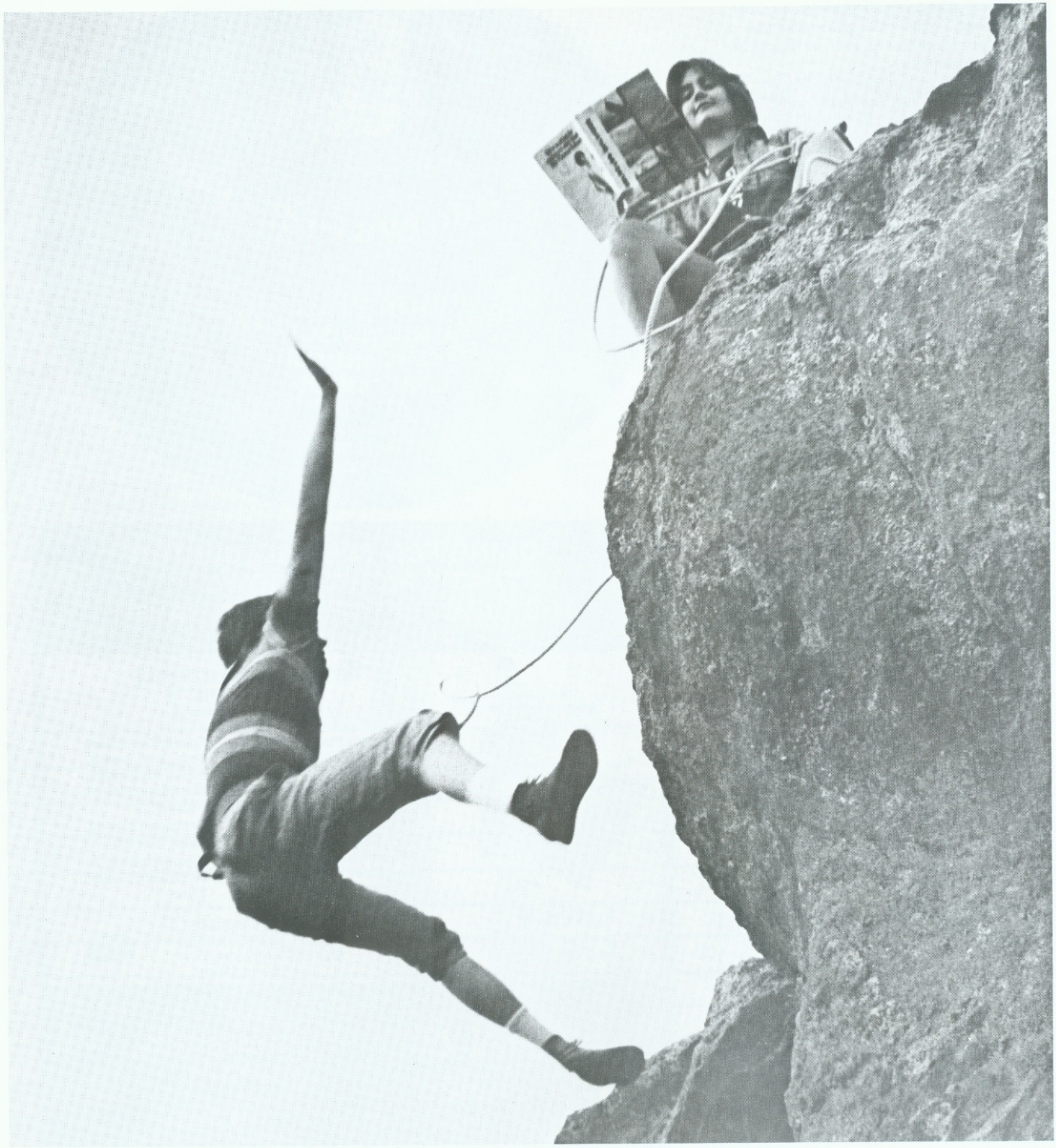
What Kind of Woman Reads *The* COLORADO *Engineer*?



. . . the Kind Men Fall For !