*The object of this column is to enhance our readers' collection of interesting and novel problems in Chemical Engineering. Problems of the type that can be used to motivate the student by presenting a particular principle in class or in a new light or that can be assigned as a novel home problem are requested as well as those that are more traditional in nature that elucidate difficult concepts. Please submit them to Professor H. Scott Fogler, ChE Department, University of Michigan, Ann Arbor, MI 48109.*

**Our student readers, both graduate and undergraduate, are encouraged to submit their solution to the following problem to Prof. Robert L. Kabel, ChE Dept., Pennsylvania State University, University Park, PA 16802, before June 15, 1980 (please designate your student status on your entry). A complimentary subscription to CEE will be awarded in each category, to begin immediately or, if preferred, after graduation, for the best solutions submitted. (Penn State students are not eligible.) We will publish Prof. Kabel's solution in a subsequent issue.**

# PRAIRIE DOG PROBLEM

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Prairie dogs live in underground burrows which are interconnected with tunnels as shown in Fig. 1. An important question immediately arises as to how the prairie dog architects provide ventilation for underground living during seasons of high activity and hibernation. You are requested to propose an explanation supported by calculations of how their tunnel ventilation system works.

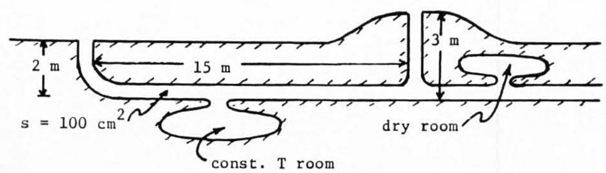
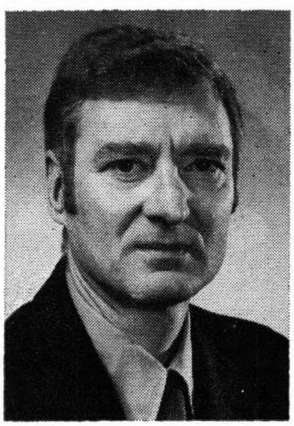



**FIGURE 1**

This problem illustrates a truism: The most difficult part of solving a problem is defining it. In formulating a ventilation mechanism you should consider the following discussion on prairie dog habits and habitats.

1. What is a prairie dog? (small rodent about 1/3 meter long)
2. Where do they live? (arid country, rather barren, sandy soil, some grasses in the region for food, etc.)
3. What do they need to live? (food—grasses, roots in burrows; water—not much; air)
4. How do they get their air? (molecular diffusion through soil and passage ways, going up to the top and breathing occasionally; replenishment in passage by some mechanism)
5. How much air do they need? (a single dog in a typical burrow has a 5-10 hour oxygen reserve)
6. What is the nature of burrow? (multiple holes, one in mound leading to a tunnel; spacing between mounds as shown in Fig. 1)
7. By what mechanisms could air be supplied?
   a. A "pig in a pipeline" theory might be



**Robert L. Kabel** received his B.S. degree from The University of Illinois in 1955 and his Ph.D. from The University of Washington in 1961. From 1961-1963 he served n the U.S. Air Force Space Systems Division receiving the Commendation Medal for Meritorious Achievement. Since 1963 he has been at The Pennsylvania State University where he is Professor of ChE. He was at The Technical University of Norway (1971-72) and Pahlavi University in Iran (1978) as visiting professor and lecturer, respectively. He has served recently as Chairman of the AIChE's Chemical Engineering Education Projects Committee (1976-77) and the Central Pennsylvania section of the American Chemical Society (1970). His research centers around catalytic kinetics and air pollution meteorology. He is active in industrial consulting, flying, and squash.

mentioned whereby prairie dogs moving through the tunnel drive the air out ahead of them and draw it in behind them. Everyone is familiar with the "whoosh" effect observed when subway trains come in. (My thought is that a tight fitting, fast moving, animal could well do this. But I expect that the animal fills only about 1/2 of the tube cross section. The tube radius is 5.64 cm versus an animal diameter of about 8-9 cm. Thus his sweeping efficiency may not be too good and a fairly continuous circulation might be required. Note also that this mechanism would not work during hibernation.)

b. The Bernoulli effect (high velocity, low pressure, and vice versa) is mentioned with no particular indication of the mechanism of getting high and low velocities. Perhaps there is a "mound" effect. There may be a variety of misconceptions about static air pressure; e.g., can the different elevations of openings induce flow simply because of $\Delta p$? In fact, $\Delta p$ is balanced by gravity and it is impossible to vent pollutants to the vacuum of space.

c. A variety of chimney effects are possible; e.g. sucking at all openings due to wind across them and natural convection due to animal warmth below. The day-night cycle could give an effect similar to the breathing cave phenomenon.

d. Finally, if a tube is held vertically just above the ground, would there be flow through it? There will be a flow upward

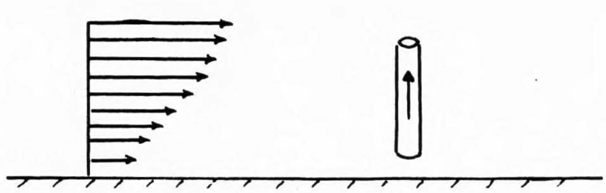


**FIGURE 2. Boundary layer velocity distribution effect.**

due to the boundary layer velocity distribution effect because of the low velocity and high pressure at the bottom and the high velocity and low pressure at the top. This $\Delta p$ is greater than that inferred from hydrostatics.

You are now encouraged to use any of the above points in your explanation of the tunnel ventilation mechanism. □

## POSITIONS AVAILABLE



## ChE books received

**"How to Find Chemical Information,"** R. E. Maizell, John Wiley & Sons, New York, 1979, 261 pages, \$17.95.

Chemical information tools are in a constant state of change. This book will show you how to efficiently locate, use, and in some cases evaluate, chemical data.

**"Fluid Catalytic Cracking with Zeolite Catalysts,"** P. B. Venuto and E. T. Habib, Jr., Marcel Dekker, Inc., New York, 1979 156 pages, \$19.50

This book attempts to cover the broad scope of fluid catalytic cracking (using zeolite catalysts), with emphasis on the highly-coupled interactions of the process between the feedstock, the catalyst, the process hardware, and the desired products. Workers in petroleum refining and petro-chemical activities, and those interested in catalysis in general, will use this book as a resource and necessary research tool.