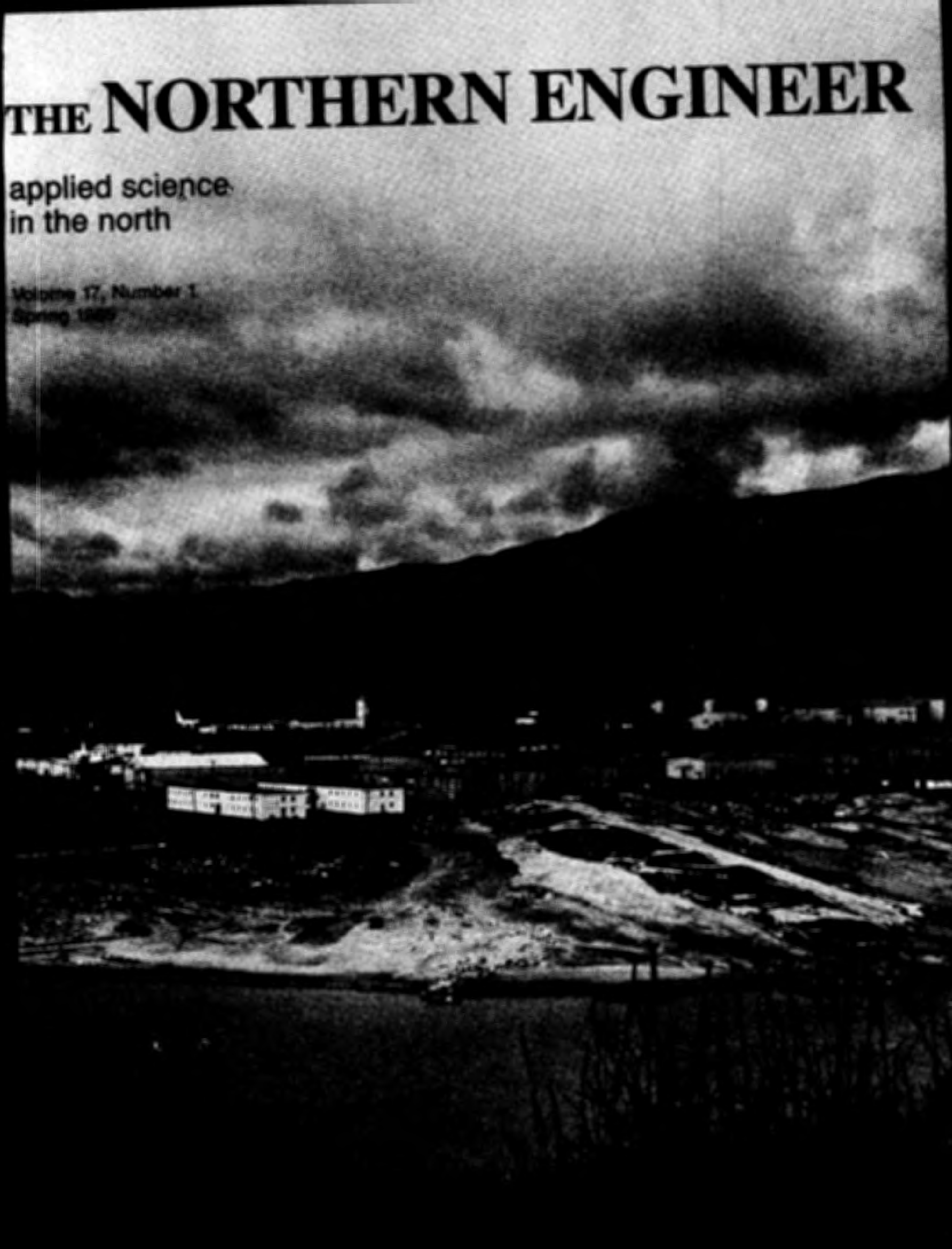
THE NORTHERN ENGINEER

applied science
in the north

Volume 17, Number 1
Spring [illegible]



Editorial: Counting Costs

This spring, Alaska's legislature and administration learned an aggravating lesson: as a source of revenue, oil is not only neither infinite nor eternal, it isn't even comfortably predictable. It is a simplification to say the state's leaders learned of this fact only recently, and an unfair simplification at that, but the truth is that this is the year in which the facts came home to roost. Oil revenues are going down, and therefore state expenditures must also shrink. That means all state-supported functions face belt-tightenings, hard decisions, and outright cuts.

When the Winter 1984 issue was so tardy in appearing, some of our readers thought *The Northern Engineer* might have been lost among the University's budget cuts. It was close, thank you, but *TNE* finally got off between the belt-tightening and the hard decisions. We are delayed and a bit depleted, but not dead.

The adjustments we've had to make are similar to those made everywhere in the University system—we're to do a bit more work with a bit less staff. This assuredly saves money, but it does have other kinds of costs. It will cost the "special" issue, for example, our annual attempt to examine a single subject with more breadth and depth than our format otherwise permits. We decided these "miniseminars in the mail," as one subscriber called them, demanded too much time. Given the nature of our reductions (and additions), we haven't the time to spend.

Incidentally, the presence of the index to Volume 16 in this first issue of Volume 17 was another attempt at saving time. This one didn't work, especially considering the time it takes to respond to irate librarians, so expect hereafter that the annual index will return to the fourth issue of the year to which it belongs.

More time- and money-saving attempts are likely to be needed; income projections for the next few years look no more rosy. We plan to survive, but in the process have no intention of letting quality slip—only deadlines. You who read these issues are the only ones whose judgment we accept on what constitutes a high enough quality for *TNE*, even if others hold the live-or-die decision, so we encourage you to speak out. If our tinkering displeases you, say so. Write. Phone. Complain so we know it. But please, be patient with our sloppy schedules. It's a choice of calendars against content, and we're going for the content.

—*Editor*

THE NORTHERN ENGINEER

The Geophysical Institute
University of Alaska-Fairbanks

Volume 17, Number 1
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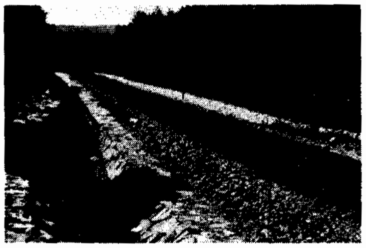

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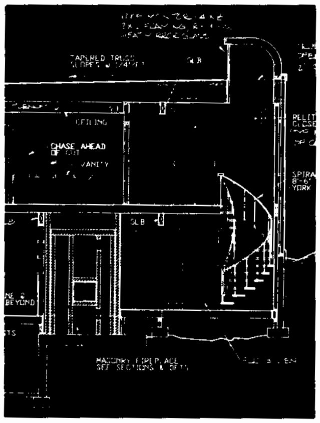

27

7

CONTENTS

COVER

Sondrestrom Air Force Base may look like an Aleutian outpost, but it lies near 67°N, 50°W, far up Søndre Strømfjord on Greenland's Davis Strait coastline. The problems that beset structures there are akin to those found elsewhere in the far north, as the Korhonen article beginning on page 7 indicates. (Photo by Don Rice.)

THE NORTHERN ENGINEER (ISSN 0029-3083) is a quarterly publication of the Geophysical Institute, University of Alaska-Fairbanks — Dr. Juan G. Roederer, Director. It focusses on engineering practice and technological developments in cold regions, but in the broadest sense. We will consider articles stemming from the physical, biological, and behavioral sciences, as well as views and comments having a social or political thrust, so long as the viewpoint relates to technical problems of northern habitation, commerce, development, or the environment. Contributions from other nations are welcome. We are pleased to include book reviews on appropriate subjects, and announcements of forthcoming meetings of interest to northern communities. "Letters to the Editor" will be published if of general interest; these should not exceed 300 words. (Opinions in the letters, reviews, and articles are those of the authors and not necessarily those of the University of Alaska, the Geophysical Institute, or *The Northern Engineer* staff and Board.) Subscription rates for *The Northern Engineer* are $12 for one year, $17 for two years, and $37 for five years. Some back issues are available for $3 each. Address all correspondence to THE EDITOR, THE NORTHERN ENGINEER, GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA, FAIRBANKS, ALASKA 99775-0800, U.S.A. The University of Alaska is an EO/AA employer and educational institution.

INSULATION SABOTAGE
Some Comments from Canada
by Jon Eakes

For years now people have been talking about proper procedures for installing insulation, more insulation, and superinsulation. Yet on more than one occasion the energy performance results of a building do not live up to the projections. The insulation simply doesn't save as much energy as it is supposed to. There are of course a lot of reasons for this disappointing situation—from lower than anticipated performance of heat recuperation devices, through errors in architectural conception, to the energy costs of drying out building materials during the first winter—but the most important causes are simple errors in workmanship. Digging through the record of the past few years of Canadian experience with such errors, I have collected some interesting but little-recognized facts that I call my "Insulation Sabotage List."

THERMAL BRIDGES

Some time ago we insulated walls partially, leaving an air space also. Arguments raged on whether the air space should be left on the warm or the cold side of the insulation. The National Research Council of Canada settled these arguments by detailing the effects of air spaces around wall insulation. Figure 1 shows the air space on the cold side, where the surface of the stud is exposed to cold temperatures. This leads to a much greater heat loss through the stud, and hence cold penetration. The consequences? The drywall nail gets cold, causing condensation and rust marks. Also, the wall is colder over the stud. It takes only a 2.5°C temperature difference between two adjacent parts of a wall for dust marking to occur—so these studs become clearly defined by dirt right over the interior paint. Figure 2 shows the same quantity of insulation pushed to the outside, leaving the air space on the inside. The surface area of the stud exposed to the cold is radically decreased, which decreases the heat loss. The front surface of the stud is warmer not only because there is less heat loss through the outside but also because there is a larger surface area exposed to the inside air temperature. The consequences? No rusting and no dust marking.

Ceiling joist nails have the same rusting problem when truss construction causes air spaces between fiberglass batts, letting cold air down to the ceiling joists. Careful placement of the batts, or better yet, the addition of loose fill over the joists between batts, will eliminate this problem.

Today's heating costs have made it economically necessary to fill the entire space with insulation—and even to increase the size of the stud space to allow for sufficient insulation. (In my part of the world, "sufficient" is assumed to be R-20.) With this has come the common use here of R-20 friction-fit batts. But these have created their own little problems. The very fact that they are made to fit tightly into the stud space causes them to bend back in the corner next to the stud, as shown in Figure 3. This creates a triangular air space right where it isn't wanted, so this "well-insulated" wall may start to condense water on nail heads and show dust markings just as the partially insulated walls of the old days did. Solution? Always push R-20 friction-fit batts all the way into the stud space and then pull the batt face back out so it is flush in front. This assures that the back

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surface reaches into and fills up the space where the stud meets the sheathing.

This same logic of keeping thermal bridges such as studs as warm as possible provides part of the explanation of why insulated sheathing is more effective if it is placed on the outside of the house rather than the inside. The stud is kept in a more moderate climate throughout the temperature swings of the day and has, on an average, less delta-T across it than if the insulation were on the inside. More complete coverage of obstructions and partition wall joints and more effective air sealing are other important plusses for exterior sheathing—but note that an overabundance of aluminum nails through the insulated sheathing, to hold on siding, reduces insulation effectiveness to a surprising extent.

COLD CONVECTION

Returning to the stud spaces: a little-recognized reason for filling them completely with insulation is the effect of convection loops around insulation. It is difficult to get batt or panel insulation to fit tightly against either the inside or the outside wall surface when the insulation is thinner than the cavity itself. This means that to some extent there will be an air space on both sides of the insulation. Then it requires only a tiny crack of 1 mm at the top and the bottom of the insulation to create a convection loop *around* the insulation, with the cold air on the outside falling and the warm air on the inside rising. Ric Quirouette of the National Research Council ventured a figure of 20 percent loss of insulation effectiveness because of this convection loop. So if it is next to impossible to avoid that top and bottom crack, then completely filling the stud cavity will block the front and rear air spaces and hence break the convection loop. Without the dynamic force of this loop, there is virtually no convection movement within fiberglass batts.

Then we discovered that the basement walls had this same looping problem with plastic foam glued to the foundation (Fig. 4). When the glue is applied in blobs, there is plenty of space for cold air to fall down between the foam and the wall. It is next to impossible to eliminate the air space between the foam and the gyprock, so we find our convection loop again—often loading the header area with rapidly migrating moisture. Hence foam should be applied tightly against the wall and the glue applied in a grid pattern, not in blobs. The glue serves less to attach the foam (fire codes require mechanical attachment of the drywall anyway) than to act as a convection loop break.

Exterior basement insulation is much more desirable than interior, and generally people are beginning to build this way with new construction. However, we have a great deal of difficulty getting renovators to insulate on the outside. When adding insulation to the outside of a foundation wall, it is a great temptation, if not a traditional habit, for builders to insulate just up to the last row of siding. Figure 5 shows the serious shortcomings of this. There is insulation in the stud cavity above and on the wall below, but none covering the header area. Yet this is the most difficult area to insulate from the inside; no technique does a perfect job because of all the obstructions caused by the floor joists. There are many good reasons for insulating from the outside, and the best of them is that it provides an opportunity to cover the header area with both an outside air barrier and the protection of insulation. If you are

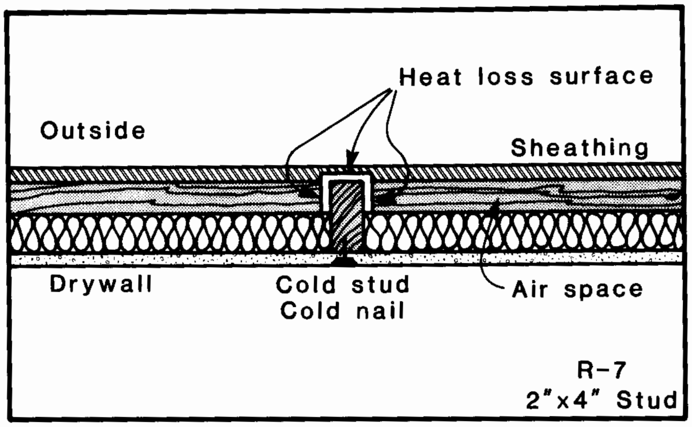

Figure 1. An air space beneath the sheathing exaggerates the thermal bridge effect of the studs.

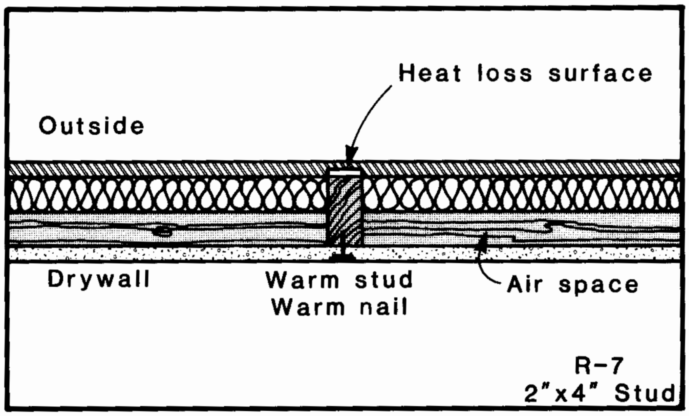

Figure 2. An air space between the insulation and room wall minimizes the thermal bridge.

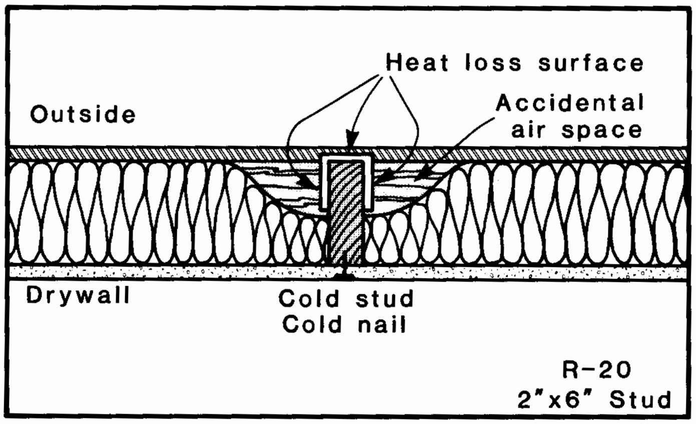

Figure 3. Sagging insulation can accidentally exaggerate a thermal bridge.

not insulating for the full height of the wall, remove some siding and go up at least six inches above the first story floor level, as shown in Figure 6.

We all know about the occasional settling of loose fill leaving insulation voids at the top of wall cavities as well as under windowsills. That has generated a debate that is as yet unresolved: the Canada Mortgage and Housing Corporation still does not allow loose-fill injection into vertical cavities while the Federal

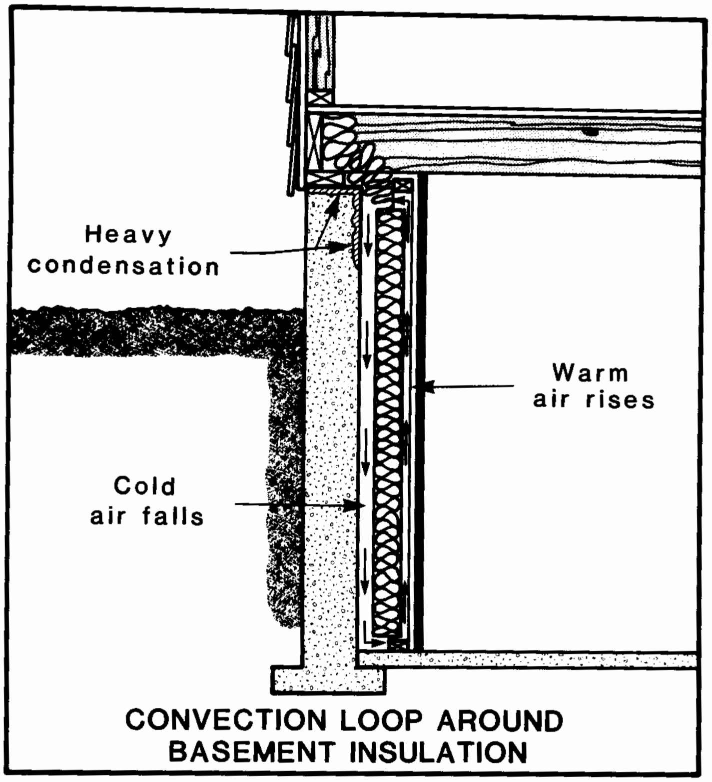

Figure 4. Subterranean sabotage: convection loops can affect the efficiency of interior basement insulation.

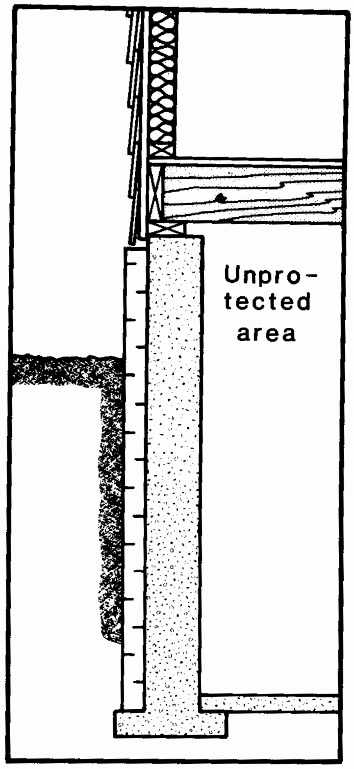

Figure 5. Exterior basement insulation usually stops too low.

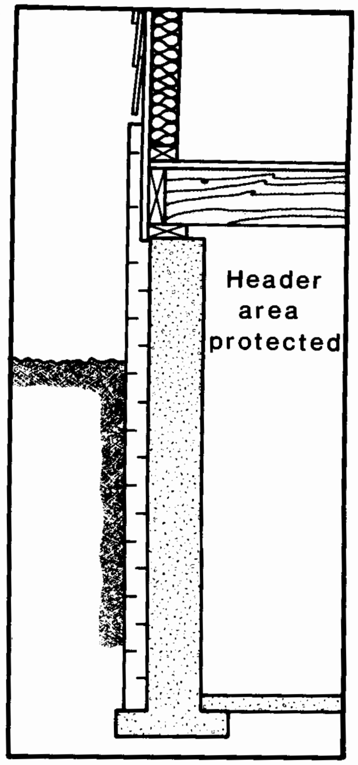

Figure 6. Exterior insulation should extend at least 6" above the floor.

Department of Energy, Mines and Resources does. Apparently, with excellent workmanship and proper application densities, settling is so slight that it creates no insulation voids. With anything less than superior workmanship, condensation problems will begin to show up at the top of walls and under windowsills.

Overfluffing the fiberglass in attics can cause air convection loops down into the insulation, radically cutting its effectiveness. With proper application this can be avoided. If such a problem is discovered, a common solution is to shoot some mineral wool or cellulose over the fiberglass to give it a dense barrier against air currents. That solution will work for the intended purpose, but at a cost: rarely is the loss of insulation effectiveness caused by compression of the fiberglass taken into account when builders calculate the cost effectiveness and the new overall resistance to heat loss of insulation in that attic—hence annual fuel savings are often overestimated.

The practice of installing insulated sheathing directly over existing siding can have serious problems. Occasionally you may find a case where the siding was ventilated on the house side by furring strips or other means of spacing it out from the wall (required in the Maritime provinces of Canada), and with this vent space the effective R-value of the insulated sheathing falls to zero. The convection loop behind the insulated sheathing completely sabotages the effort. Air paths to and from the warm side of that insulation must be blocked, although the permeability of the outer wall must be maintained so as not to have a vapor barrier on the cold side. A more common problem is the failure, in practice, to stop convection loops that are caused by corrugated "breathing" strips placed at the top of foil-faced sheathing. The reduction in R-value, while not as severe as that from complete ventilation behind the insulated sheathing, is still substantial. I strongly recommend stripping the old siding, repairing any wall or window frame damage, and then applying the insulation, a ventilation space, and new siding. That's not as simple or inexpensive as one would like, but it makes for a much better job without the potential sabotage of a convection loop.

A Noninsulation Note

Ineffective drainage around the house also costs energy dollars because wet soil around the foundation walls considerably increases heat losses through the bottom of the house. The common and serious error is to push the same debris back around the house that was taken out in excavating, including rocks that crack the drain tiles, boards and other organic material that will decompose and leave voids in the earth, and clay soil that refuses to drain and can even freeze to the wall. Proper backfill puts clean gravel over the drain tiles, a well-draining soil up most of the way, and then a clay topsoil on the last foot to act as an umbrella that sheds most water away from the house, leaving only a minor quantity to drain rapidly to the tiles. This means a dry soil in contact with the house and lower energy costs—with or without insulation.

CONCLUSION

Lack of attention to workmanship details can cause supposedly energy-efficient houses to consume two to three times as much energy as predicted. Yet thoughtful attention to detail can produce impressive results: I have seen Canadian houses built with proper planning and careful workmanship that are heated for as little as $50 per year. ♦

Deteriorated Building Panels at Sondrestrom, Greenland

by Charles Korhonen

INTRODUCTION

The exterior walls of reinforced concrete buildings at Sondrestrom Air Base (SAB) in Greenland have deteriorated to the point that they need repairs. At the request of the U.S. Air Force and with the assistance of Tony Husbands of the U.S. Army Waterways Experiment Station (WES), I examined the extent of this deterioration to determine its cause and to recommend appropriate concrete patching and repair procedures. I examined visually both the inside and outside of a dozen buildings, documented signs of distress, and took chips of concrete for laboratory analysis at WES.

The buildings were constructed in 1954 using a frame of reinforced concrete columns, bents, and beams, to which reinforced concrete roof and wall panels were attached. These elements were prefabricated in Zeist, The Netherlands, shipped to Greenland, and erected on insulated floor slabs that were either poured directly on grade or were elevated slightly above grade (Sondrestrom is in an area of discontinuous permafrost).

The exterior walls are of cavity construction. The outer leaf is made of concrete panels one story high supported by and keyed into precast grade beams; it is separated from the inner leaf by a 2-inch air space. As originally built, the inner leaf consisted of either prefinished, unreinforced, lightweight concrete panels or 2 x 4 wood framing sheathed with gypsum board and insulated with blocks of foamed glass. Many of these walls have been remodeled to make them more thermally efficient.

LABORATORY ANALYSIS

Several chips of concrete from various building walls and from unused wall panels stored since 1954 near the SAB runway (Fig. 1) were sent to WES for analysis. A microscopic examination showed that this concrete is highly susceptible to freeze-thaw deterioration in the presence of water because it was not air entrained. Air entraining is generally acknowledged to increase greatly concrete's resistance to this type of deterioration.

A chemical analysis of the concrete revealed a very low chloride content of 0.02%. This amount should not induce the embedded reinforcing steel to corrode, since chloride usually does not create corrosion problems until its quantity has reached at least 0.1% by weight of the cement in the concrete.[1]

A careful visual examination of the concrete chips showed a good bond between the aggregate and the cement paste. No signs of alkali-silica reaction were evident. In general, the laboratory results indicate that, other than not having been air entrained, this concrete has no serious problems built into it; it is structurally sound.

FIELD STUDY

Suspected culprits in the deterioration of the concrete wall panels included corrosion, foundation movements, thermal stresses, and frost action.

Corrosion

Usually when one thinks of corrosion in concrete, visions of rusted reinforcing steel come to mind. Figure 2 suggests that this was the case in Sondrestrom, since rust streaks like the one shown are evident on the exterior surfaces of these buildings. However, a closer look shows that the rust is emanating from a point source, not from cracks corresponding to reinforcement locations. I chipped out several of

Figure 1. Unused wall panels stored near the runway, Sondrestrom Air Base, Greenland.

Figure 2. Typical rust streak on exterior of building. Note the dark, iron-rich stone at its center.

Figure 3. Grade beam cracked and separated from floor, leaving a 1/4-inch crack.

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these areas and in each case found a rusted, iron-rich stone. Chipping deeper revealed even more of this material, except that it was not rusted at depths greater than about 3/8 inch. Unless it begins to expose more and more aggregate, this near-surface rusting is not a structural problem.

Structural Movement

My measurements and observations suggest that most of these buildings have settled differentially. Cracks and separations in the structural framework at several locations were evidence of this. For example, in the corner of one building a section of grade beam (Fig. 3) had cracked and separated from the floor slab by as much as 1/4 inch but had remained in contact with the floor along the rest of its length. In another case, an equipment support rod that was securely bolted to the ceiling and floor had bowed (Fig. 4). A comparison of the height of the bowed rod with an unbowed rod showed that the ceiling-to-floor distance had decreased by 1/16 inch.

Figure 4. Bowed equipment support rod, representing a 1/16-inch movement.

These and similar movements are considered responsible for developing shear forces within many of the concrete panels, causing them to develop diagonal cracks across their widths. Figure 5 shows a typical panel-wide crack.

However, on the basis of only one site visit, it is difficult to predict if the foundations are still moving. (Monitoring devices should be installed on several cracks to determine this.) But because these cracks are reported to have developed shortly after the buildings were constructed and because they have remained tight (see Fig. 5), I do not expect them to worsen significantly in the near future.

Thermal Stress

As the temperature changes, the concrete panels that clad these buildings are constantly expanding and contracting. To accommodate this movement, each wall panel has been separated from adjoining ones by a 3/8-inch joint and weather sealed with a flexible metal waterstop. Some joints have also been filled with a rigid cement mortar. Wherever this mortar has been used, the panels have not been free to expand. As a result, stresses have built up to the point where the panel edges have developed two types of cracks along these joints: short hairline cracks perpendicular to the panel edge (Fig. 6) and diagonal cracks at the panel corners (Fig. 7).

The stress σ developed in such a restrained member due to a change in temperature can be estimated by multiplying the member's modulus of elasticity E by its coefficient of thermal expansion α and the change in temperature ΔT to which it is subjected ($\sigma = E\alpha\Delta T$). If we assume that (1) the concrete panels were installed at 55°F and attain a summer temperature of 85°F, (2) their coefficient of thermal expansion is 6.5×10^{-6} inch/inch-°F, and (3) their modulus of elasticity is 4×10^{6} psi, then the stress would be 780 psi; this is too small to crack structurally sound concrete. But this assumes, of course, that the 780 psi is uniformly distributed, which obviously it is not. Both kinds of stress cracks do not occur together on the same panel but are part of an active process that can easily be solved by removing the cement mortar between panels.

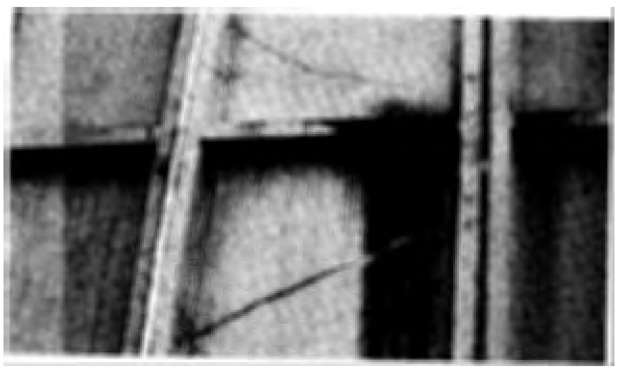

Figure 5. Typical panel-wide crack.

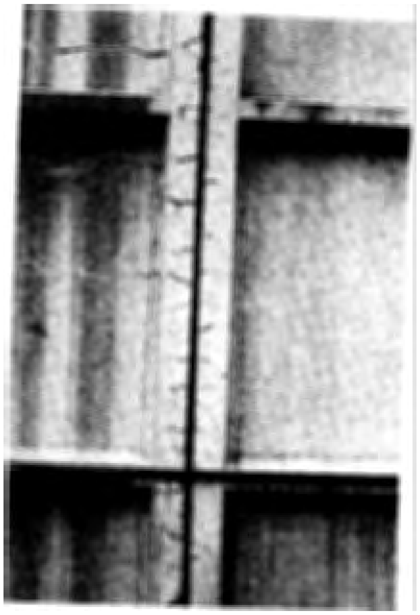

Figure 6. Hairline cracks along panel edge.

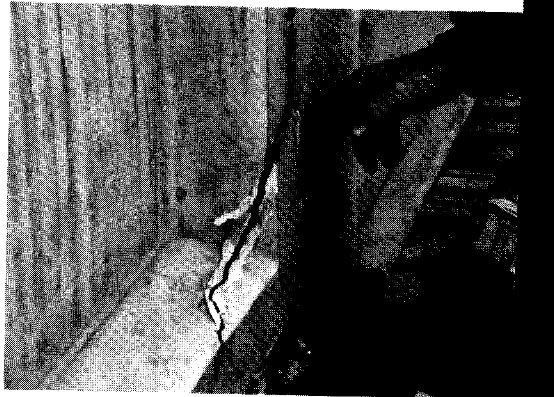

Figure 7. Diagonal cracks that have spalled off panel corners.

Frost Action

Frost damage is rare on these buildings. About the only place it is noticeable is on the grade beams (Fig. 8). This is somewhat surprising because the laboratory results showed that this concrete is susceptible to freeze-thaw deterioration. The main reason this concrete has survived the low temperatures so well is that the climate at Sondrestrom is very dry; the Air Force Weather Service reports a mean annual precipitation of 6 inches at the Base. Dry concrete, whether it is entrained with air or not, does not deteriorate by freezing.

The interior surfaces of the exterior wall panels, on the other hand, appear to be significantly more affected by frost action. I first became aware of this when building occupants described seeing water streaming out of the walls onto the floors during warm spring days. If ice had formed

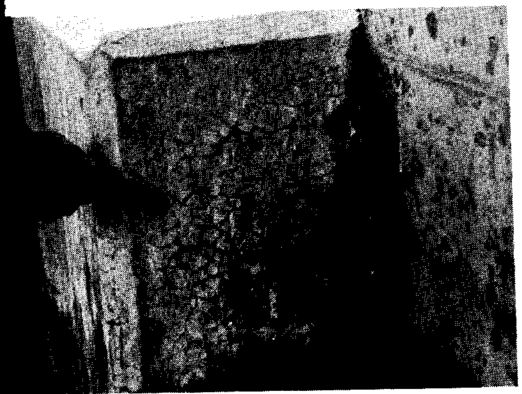

Figure 8. Minor freeze-thaw deterioration. The lime deposits indicate wetting.

Figure 9. The chips of concrete in the foreground came out of this weephole, indicating frost damage in the wall cavity.

within the wall cavities during the winter, as this suggests, did it also damage the concrete there?

To determine if it did, I probed into several weepholes and peered into other larger holes previously cut into the walls. In many cases the weepholes were filled with chips of concrete (Fig. 9), and the back sides of those panels that could be reached through the larger holes (Fig. 10) were much rougher than the back sides of the panels stored near the runway. This convinced me that the wall cavities were being eroded by frost action fed by interior building moisture.

Not all of the buildings were equally eroded. When I probed the weepholes of several barracks buildings, I found that more debris sloughed from some buildings than from others. The as-built drawings showed that there are four different wall cross sections for this type of building. Two of them, built in 1954, were described earlier in this report. A third wall type consists of some of the original walls retrofitted in 1976 with inside insulation and a vapor retarder. In 1981 the wall cavities of a few of the 1976 walls were filled with insulation, creating the fourth wall type.

Figure 11 compares the vapor pressure profile through each of these walls as outlined in ASHRAE.[2] It was assumed that the walls were exposed to indoor conditions of 70°F and 30% relative humidity and outdoor conditions of −10°F and 70% relative humidity. As can be seen, condensation is more likely to occur in the two walls without a warm-side vapor retarder (Fig. 11a and b). It was in these walls that I found the most debris. Also, it was on these buildings that the wall panels seemed to be a bit more cracked. Thus, it appears that much of the deterioration of these buildings can be alleviated by adding a vapor retarder on the warm side of the walls.

A vapor retarder does not completely stop moisture migration, particularly in retrofit situations where it is often extremely difficult to make vapor-retarding materials continuous. Air leakage through cracks around doors and windows and through splits and joints in the vapor retarder can be a particularly important means of vapor transport from the inside of the buildings into the walls. This method of vapor transfer can be, and in older buildings often is, more dominant than the flow produced by vapor pressure alone. The addition of cavity insulation (Fig. 11d) could help to reduce air leakage by tightening the walls to air flow, which in turn may reduce erosion. Tightening the walls could also increase erosion by reducing the amount of water that could escape by ventilation. Which effect cavity insulation will have is difficult to predict, but it will be interesting to compare the performance of these buildings over the next several years.

Currently none of the exterior concrete panels appears to be severely eroded on its warmer side, but because this process goes unnoticed, there is reason for concern.

RECOMMENDATIONS

Although no defect identified on these buildings is considered to be an immediate threat, remedial measures are needed to slow panel deterioration. The visible defects (rust, cracks, and spalls) can be repaired with commercially available patching materials and conventional repair procedures. To be effective, the patches must be sufficiently permeable to vapor to allow building moisture to escape. The frost damage in the wall cavities can be controlled by making the inside of the wall more vapor resistant.

Patching

Since rust is limited to near-surface pieces of aggregate, further rusting can be

Figure 10. Reaching inside holes such as this one revealed that the back sides of some panels were very rough, another bit of evidence of wall-cavity frost damage.

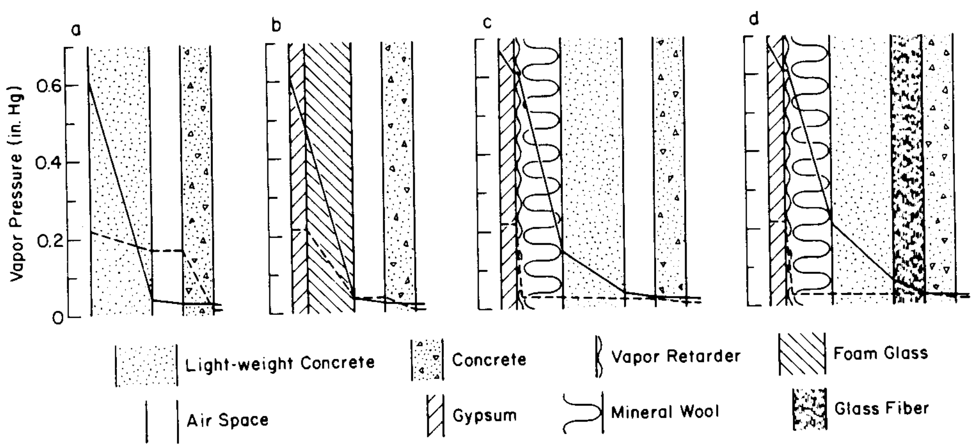

Figure 11. Vapor pressure profiles through four wall cross sections. Moisture condenses when the actual vapor pressure (dotted line) exceeds the vapor pressure of saturated air (solid line). The warm side of each wall is on the left.

eliminated by chipping out all rusted material and patching the resulting holes with an acrylic-latex-modified concrete (Fig. 12). A solution of oxalic acid and water can be used to wash off the remaining rust stains. It is best when working with acids to experiment with light applications to determine the success of various strengths of solution. Also, the surrounding concrete should be wetted to minimize etching.

The cracks that run the width of many panels and those that occur at the vertical edge of other panels can be cosmetically repaired with a coating. Several paint-like cement-based products are available that will adhere very well if the concrete surface is first sandblasted.

Before any cosmetic repairs are made, all cement mortar between panels must be removed to avoid further stress cracking. If a sealant must still be used in those joints, an elastomeric material would be best. Polysulfides, polyurethanes and silicones are excellent choices for working joints because they will return to their original shape even in very cold weather. To be effective, the sealant should not fill the joint completely. There is a definite correlation between sealant depth and joint width in a successful application (Fig. 13). As an elastic material is stretched, it begins to thin, producing the greatest strain at the top and bottom surfaces. For the elastomeric sealants mentioned above, the allowable working strain is ±25%.[4] As shown in Figure 13, a 3/8-inch joint subjected to a 0.05-inch movement produces a 25% strain in a 1-inch-thick bead of sealant. However, to avoid even approaching this strain, the sealant should not be placed any deeper than 3/4 inch. A polyethylene-foam backer rod should first be inserted to the proper depth in the joint, both to create the desired sealant cross section and to prevent the sealant from sticking on its bottom side.

Any spalling can be patched with an acrylic-latex-modified concrete using the following procedure:

a) Remove all unsound concrete with a lightweight chipping hammer.

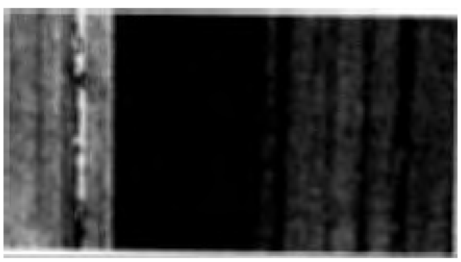

Figure 12. Hole remaining after an iron-rich stone has been chipped out.

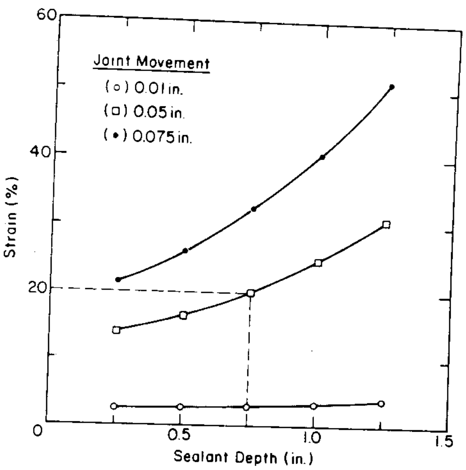

Figure 13. Relationship between movement, sealant strain, and sealant depth for a 3/8-inch-wide joint.[3]

b) Clean chipped surface with high-pressure water or sandblasting to remove oils, grease, dirt, sealants, and anything that would prevent good adhesion. If sandblasting, use compressed air to blow off any fines left behind.

c) Dampen the surface lightly with water, without creating puddles.

d) Mix and place the patch material, closely following the manufacturer's instructions.

Moisture Control

It is obvious from the erosion taking place in the wall cavities that water vapor generated within the buildings enters the walls faster than it can escape and condenses on the inside surface of the outer leaf. The erosion this causes can be minimized by adding a vapor-resistant material to the inside wall surfaces. On some buildings this has already been done, so no further work is needed on them. Those that have a vapor retarder and cavity insulation may deteriorate somewhat faster than those with a vapor retarder but without cavity insulation. Insulating the outside wall surfaces may provide some relief by moving the dew point outside the concrete panels.

Coatings must be applied carefully to the outside surface of these buildings to avoid creating a vapor trap. To minimize this possibility, the materials needed for repairing the concrete panels must breathe as much as the concrete does. A cement-based material should work.

SUMMARY AND CONCLUSIONS

The investigation revealed that the reinforced concrete wall panels are gradually deteriorating. Since these buildings are nearly 30 years old, some of this deterioration is considered to be normal. The majority of the visible deterioration is attributed to structural and thermal movements, minor freeze-thaw damage, and some rusting of near-surface, iron-rich aggregate. The most serious problem is that of frost damage hidden within the wall cavities. Currently no wall panel has deteriorated significantly, but remedial action is needed to slow this process.

The visible surface defects can be repaired using commercially available materials and conventional patching procedures. The interior erosion of the wall cavities can be alleviated by adding a warm-side vapor retarder to minimize vapor migration through the walls. Although it is difficult to achieve vapor retarder continuity in a retrofit application, the value of adding a vapor retarder is demonstrated by the smaller amount of debris recovered in those buildings that were retrofitted in this way.

The wall cavities of some of the buildings have been insulated, which reduces any ventilation that may have normally occurred there. This may become a factor in increasing wall deterioration. If deterioration increases, then consideration should be given to adding exterior insulation in an attempt to minimize cavity condensation.

Caution must be exercised in using coating materials on the outside of these buildings. If the coatings are not sufficiently permeable to vapor, moisture could become trapped within the wall panels. This could lead to additional frost damage, creating an even bigger problem than the one the coatings were intended to fix. Although information on the vapor permeability of concrete repair materials is limited, it is recommended that cement-based repair products be used, as these are likely to breathe to the same extent as the concrete being repaired.

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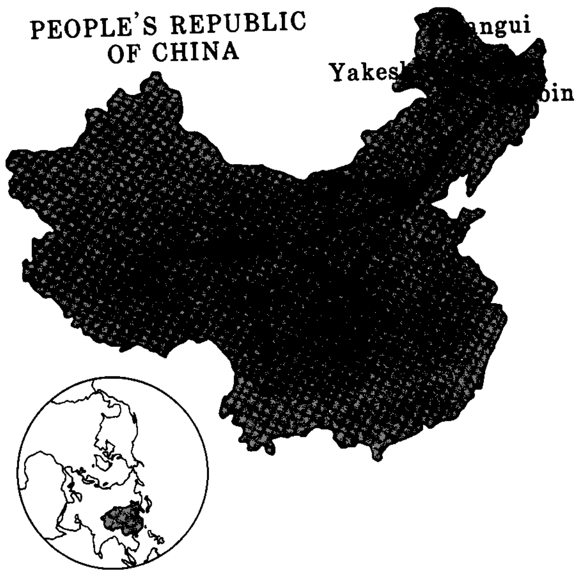
[1]American Concrete Institute. 1983. ACI Manual of Concrete Practice. Part 1, Materials and General Properties of Concrete. American Concrete Institute, Detroit, MI.

[2]ASHRAE. 1981. Handbook of Fundamentals. American Society of Heating, Refrigerating and Air-Conditioning Engineers, New York, NY.

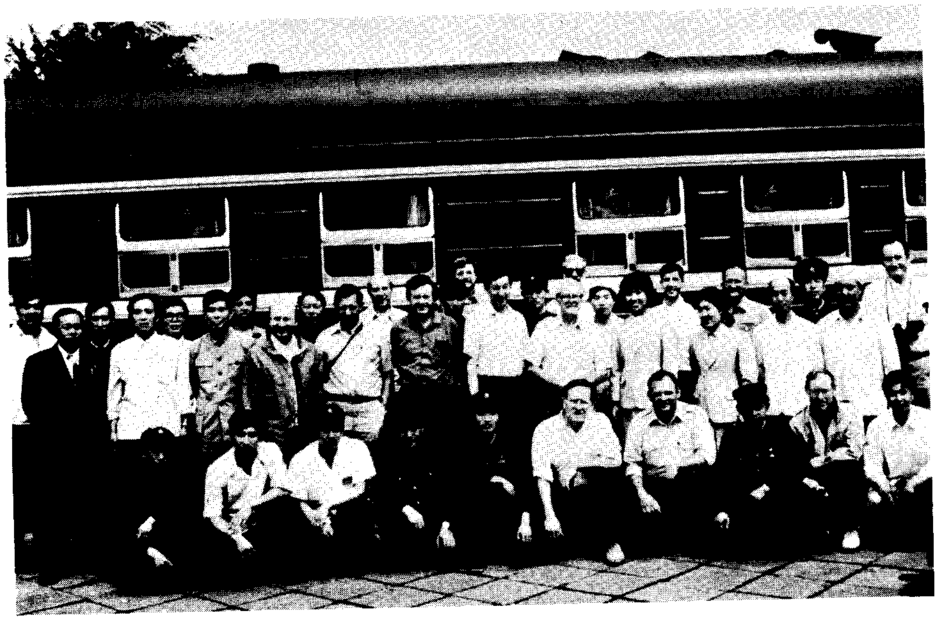
[3]American Concrete Institute. 1983. ACI Manual of Concrete Practice. Part 5, Masonry, Precast Concrete and Special Processes. American Concrete Institute, Detroit, MI.

[4]Maslow, P. 1974. Chemical Materials for Construction. Structures Publishing Company, Farmington, MI. ♦

U.S. PERMAFROST DELEGATION TO THE PEOPLE'S REPUBLIC OF CHINA



by Jerry Brown



The U.S. delegation poses with the Chinese railway engineers and crew of the special train.

A U.S. delegation of 15 scientists and engineers representing federal and state agencies, industry, and universities specializing in problems of seasonally and perennially frozen ground visited China during July 15-31, 1984. The objectives of this visit were to (1) view permafrost conditions and construction practices in a region comparable to interior Alaska; (2) meet with organizations responsible for frozen ground research, design, and construction; and (3) exchange detailed technical information with the two major frozen-ground institutes in Lanzhou.

The trip was cohosted by the Ministry of Railways and the Academia Sinica's Institute of Glaciology and Cryopedology in Lanzhou. Upon receipt of the official invitation from the Ministry of Railways in January 1984, the U.S. National Research Council Polar Research Board's Committee on Permafrost organized our participation. The 16-day visit was in return for a U.S.-hosted visit of a Chinese delegation to Alaska and the West Coast in July 1983 as part of the Fourth International Conference on Permafrost.

The visit consisted of two segments: a train trip through the western permafrost region of Northeast China, and technical sessions in Lanzhou. The train trip began at Harbin. The private, four-car train proceeded to Yakeshi, then went to the end of the Yalin Line at Mangui in northern Inner Mongolia and returned by the same route to Qiqihar, covering a total of 2000 km.

Since the 1950s **Dr. Jerry Brown**, *former Chief, Earth Sciences, Cold Regions Research and Engineering Laboratory (CRREL), has been studying soils and permafrost conditions in Alaska. A full account of this trip may be found in CRREL Special Report 85-9; an earlier trip was covered in CRREL Report 82-3. (His current address: National Science Foundation, Washington, DC 20550.)*

The Delegates to China, 1984

Delegate	Institution
Jerry Brown (Leader)	Chairman, Committee on Permafrost and Cold Regions Research and Engineering Laboratory
Troy L. Péwé (Deputy Leader)	Arizona State University
Richard L. Berg	Cold Regions Research and Engineering Laboratory
David C. Esch	Alaska Department of Transportation & Public Facilities
Oscar J. Ferrians, Jr.	U.S. Geological Survey
George Gryc	U.S. Geological Survey
Raymond A. Kreig	R.A. Kreig & Associates
Victor Manikian	ARCO Alaska, Inc.
Michael C. Metz	GeoTec Services, Inc.
Stuart E. Rawlinson	Alaska Division of Geological and Geophysical Surveys
Richard D. Reger	Alaska Division of Geological and Geophysical Surveys
Robert E. Smith	ARCO Oil and Gas Co.
Larry Sweet	Alaska Department of Transportation & Public Facilities
Ted Vinson	Oregon State University
Gunter Weller	Geophysical Institute, University of Alaska

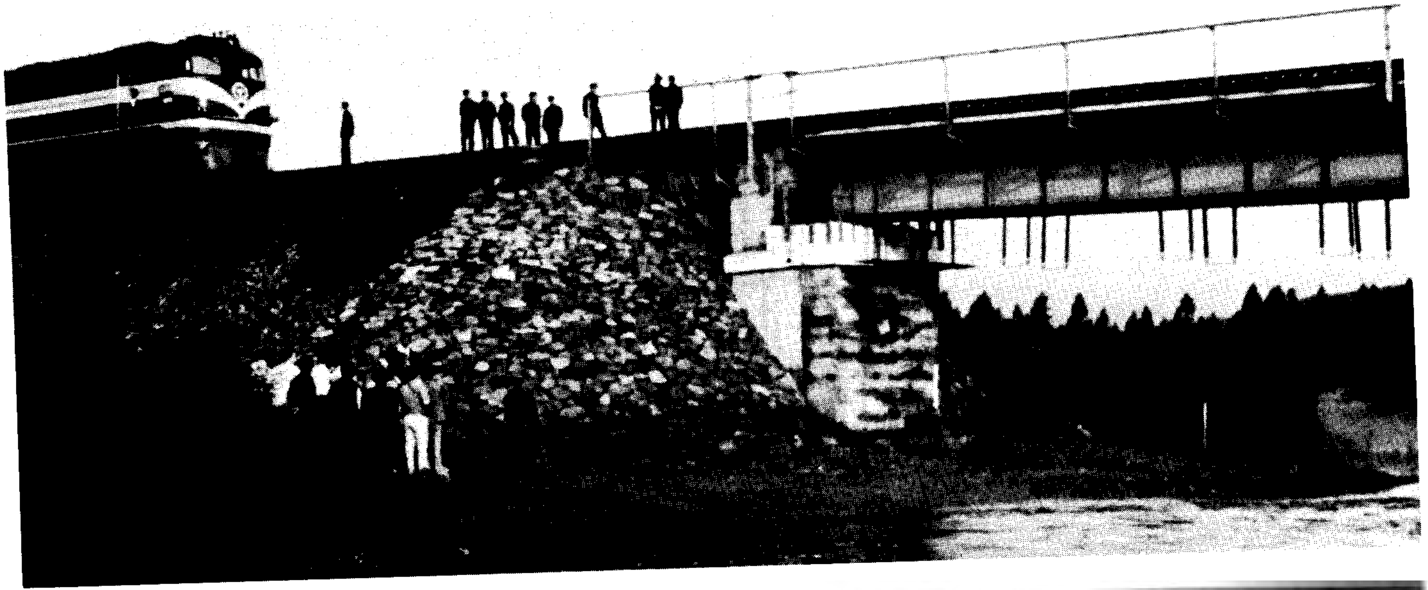
Chinese technician reading temperatures at the south abutment of the bridge at Jinlin. (Larry Sweet photo.)

The train stopped en route at six permafrost locations. Several photographs taken at stops along the way are included in this article.

The delegation's visit to the Wanjia Frozen Soil Field Test Station near Harbin illustrated field testing of piles and foundations subjected to deep seasonal frost penetration and heave. While in Harbin, the U.S. delegates presented several summary talks on frost heave, in situ measurements, and pile foundations at the Low Temperature Construction Science Research Institute. A one-day technical exchange took place at Yakeshi with Chinese and U.S. groups each presenting four talks. The Chinese covered permafrost distribution and mapping, and design, construction, and performance of railbeds, culverts, bridges, and building foundations. They also presented results of their field observations and successes and failures of structures affected by frost heave and permafrost degradation. A videotape illustrating permafrost research and frost heave problems in northeast China was shown. (For information about this 30-minute videotape, now with English sound track, contact Vic Manikian, ARCO Alaska, Inc., P.O. Box 100360, Anchorage, AK, 99510.)

Technical exchanges took place with the Qiqihar railway representatives of the Harbin Railway Administration at the Low Temperature Laboratory in Qiqihar. The U.S. delegation summarized ongoing and future frozen ground research in federal and Alaska agencies and industry. They then toured the Low Temperature Laboratory's large cold room and material testing facility and saw a slide show recapping the train trip, including sites not visited due to time restrictions. Each delegate was given a photo album and a comprehensive report on past field investigations and design and construction practices. The report has been translated and is included as an appendix to a CRREL Special Report on the trip.[1]

The trip in Northeast China provided a number of new insights into recent Chinese frozen ground investigations. Clearly the design and construction of railways built on permafrost is well advanced. Problems related to railway winter drainage,

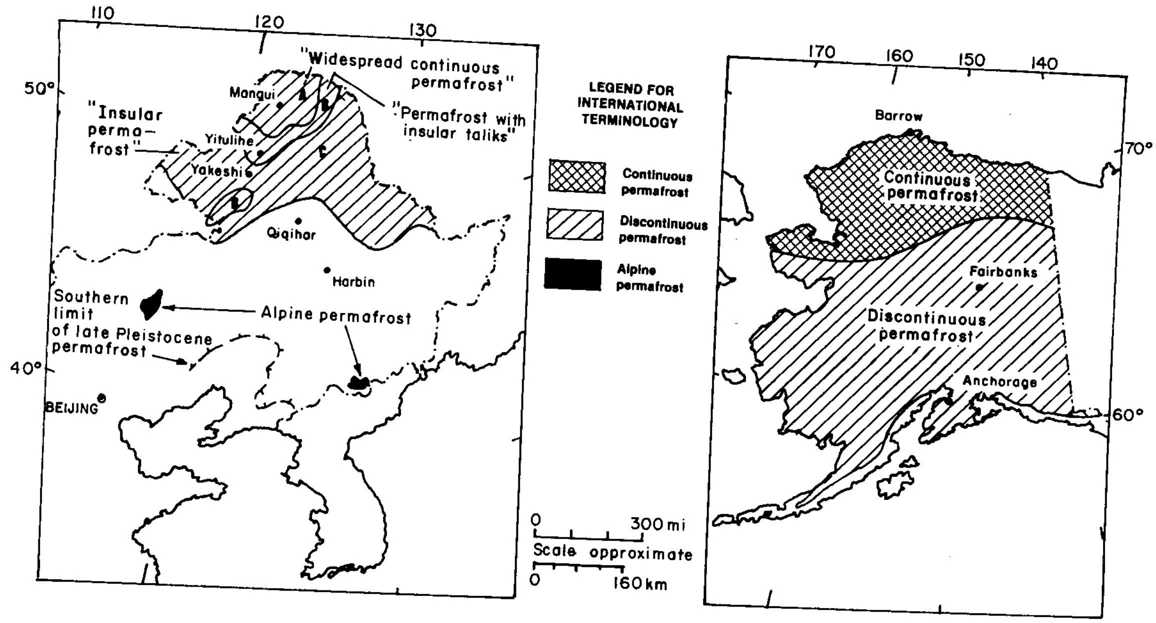


Steel plate girder bridge on the Yalin Line between Yakeshi and Mangui. Permafrost has been degrading under the riverbed, and there are access tubes in the river and the abutment that are used to measure temperatures.

The south abutment of the bridge at Jinlin on the Yalin railroad in Inner Mongolia. The abutment was built on permafrost and has settled. The light-colored concrete near the center of the photo is a cap that has been inserted to level the bridge. (Dave Esch photo.)

thaw settlement, damage to culverts, and frost heave have been experienced and in many cases resolved. Large labor resources allow excellent maintenance of the railbed. Much of northeast China's railway system serves forestry needs, and specialized institutes and field stations have been established to obtain design data. In the past decade, new approaches have been made in foundation design. Ventilated slab and pile foundations are being used for residential dwellings and other structures. However, experience in these areas seems limited.

The distribution of permafrost in China was clarified by the visit. Much of northern Inner Mongolia is underlain by permafrost and is within the southern part of the dis-



A comparison of the distribution of permafrost in northeast China and in Alaska. Note the differences in terminology for the permafrost zones in China and Alaska (the Chinese terms are in quotes); all permafrost areas in China are in the discontinuous zone as defined internationally.

Xie Yingi, director of the Wanjia Frozen Soil Field Test Station located east of Harbin, holds a thermometer used to measure ground temperatures at various depths.

A section of the Yalin railroad south of Mangui, Inner Mongolia, is constructed over permafrost. To prevent continued subsidence of the railroad bed from melting of the permafrost, the embankment has been insulated with 1 to 3 meters of peat for a distance of 10 to 15 meters on each side of the center alignment. Ballast is placed on each side of the tracks to allow for continued leveling of the rails. (Larry Sweet photo.)

continuous permafrost zone. A comparison of permafrost conditions between Alaska and northeast China is shown above. The delegates observed ground temperature monitoring wells and were provided ground temperature maps. Members of the U.S. delegation had with them several enhanced Landsat images for portions of the routes. These proved useful in the discussions and for field observations from the train. The Chinese were most interested in these images.

After flying to Xi'an, the delegation took a train to Lanzhou, where members were hosted by the Academia Sinica's Institute of Glaciology and Cryopedology and the Chinese Academy of Railway Science's Northwest Institute. A half day was spent in each institute in briefings and visits to the facilities. Several of the delegates had previously visited the institutes and were able to note recent changes in research projects and organization. The second and final day was devoted to two concurrent sessions on general geocryology and engineering geocryology. All of the U.S. delegates presented talks and there were five Chinese presentations. Approxi-

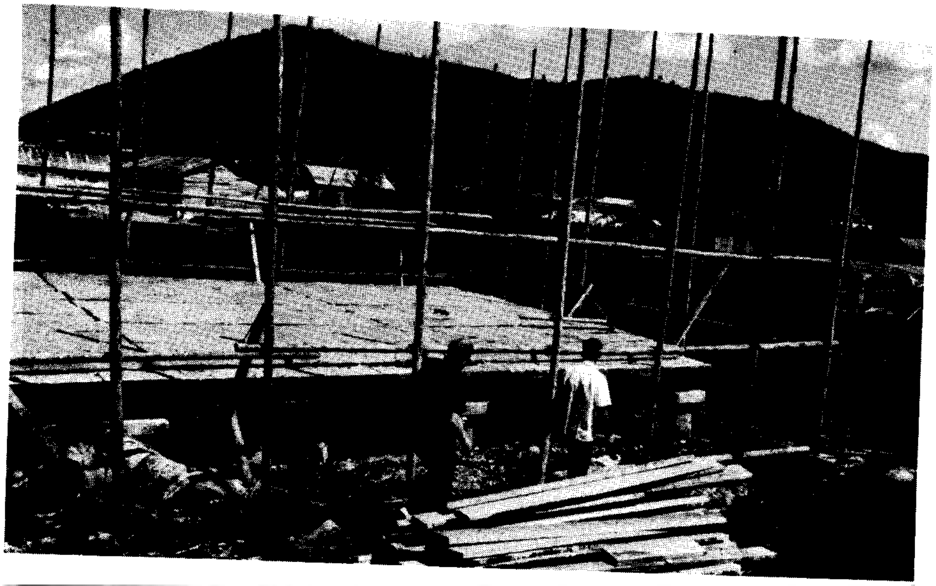
Right, slope stabilization along the Yalin railroad line south of Mangui. Underdrains are used to remove excess water that had previously caused serious icings on the track. Continuing slope movement is shown by the partially closed rock-lined drainage ditch.

Left, edge of the railroad along the Yalin Line between Qiqihar and Yakeshi shows the source of the embankment. Material was hand dug in carefully laid out plots to determine the amount that had been excavated by each crew of workers. (Larry Sweet photo.)

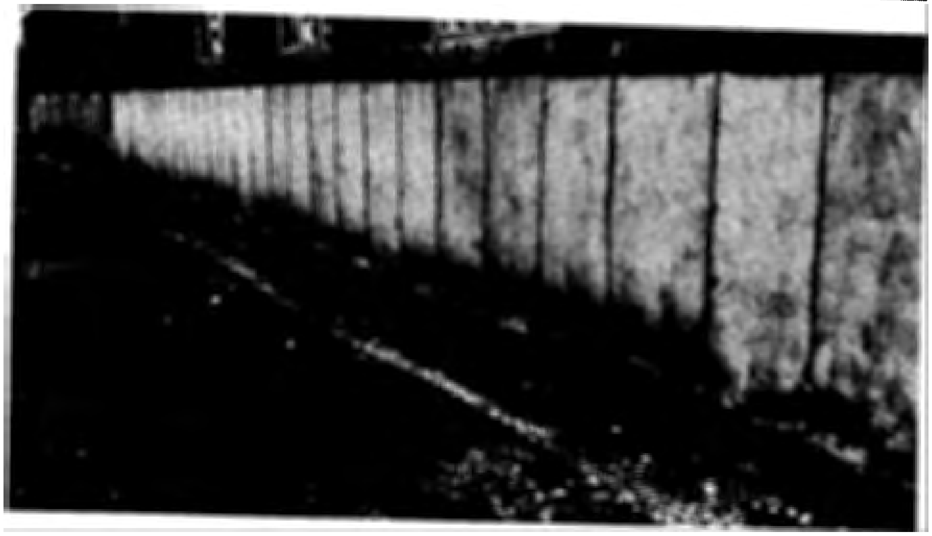
Right, Chinese engineers describe the instrumentation used to measure frost heave forces on vertical walls at a test site at the Wanjia Frozen Soil Field Test Station near Harbin. (Larry Sweet photo.)

mately a hundred Chinese attended. A number of discussions took place on the topics of frost heave, remote sensing, and piles and foundations. These intensive discussions resolved questions regarding Chinese engineering geocryology, particularly on foundation design and frost heave research.

In Beijing, several delegates made a courtesy visit to the Academia Sinica's Foreign Affairs Bureau, and several delegates visited the Institute of Remote Sensing Applications. One delegate lectured at the Geologic Institute of Academia Sinica.



Left, concrete panel floor assembly placed on concrete piles for building foundations in Mangui, the northern end of the Yalin railroad in Inner Mongolia. The permafrost conditions in this area are similar to those in interior Alaska and cause the same sorts of construction problems. (Larry Sweet photo.)



The foundation for a large apartment building to house railroad workers in Mangui. The structure, built on permafrost, was elevated approximately 1 meter above the ground surface. The holes near ground level provide ventilation to the space under the building. (Larry Sweet photo.)

Ray Kreig, Richard Reger, and Troy Péwé explain the details on a satellite photo that shows the surrounding area of Inner Mongolia to Chinese engineers at the Yakeshi Forestry Survey and Design Institute. (Larry Sweet photo.)

Another delegate with particular interest in terrain and route analysis remained for several days to lecture and visit the Ministry of Railways Special Design Institute.

Prior to leaving, U.S. delegates compiled an informal list of topics for future exchanges, including:

General Geocryology

- Establish several U.S. and Chinese ground temperature sites using comparative instrumentation. (A site in the Poker and Caribou creeks watershed in the Fairbanks area is being developed as a U.S. location.)
- Correlate landscape analysis and surveying techniques for permafrost terrain.
- Conduct joint studies on ground ice and seasonal icing formations.
- Conduct joint studies on age, history, and climatic sensitivity of permafrost.
- Evaluate and apply methods of environmental protection for permafrost terrain.
- Conduct joint studies on origin and classification of alpine permafrost.

Engineering Geocryology

- Utilize Chinese frost heave field test facilities and U.S. laboratory and analytical capabilities to improve engineering practices.
- Evaluate U.S. mitigative techniques to reduce permafrost degradation (such as thermopiles, insulation) at Chinese field test facilities for foundations, piles, bridges, and roadbeds.
- Prepare comparative evaluation of U.S. and Chinese cold regions engineering design practices based on available and revised building codes.

REFERENCE

[1] Brown, J. 1985. Permafrost Delegation Visit to People's Republic of China, 15-31 July 1984. Cold Regions Research & Engineering Laboratory, Hanover, NH. Special Report 85-9. 137 pp.

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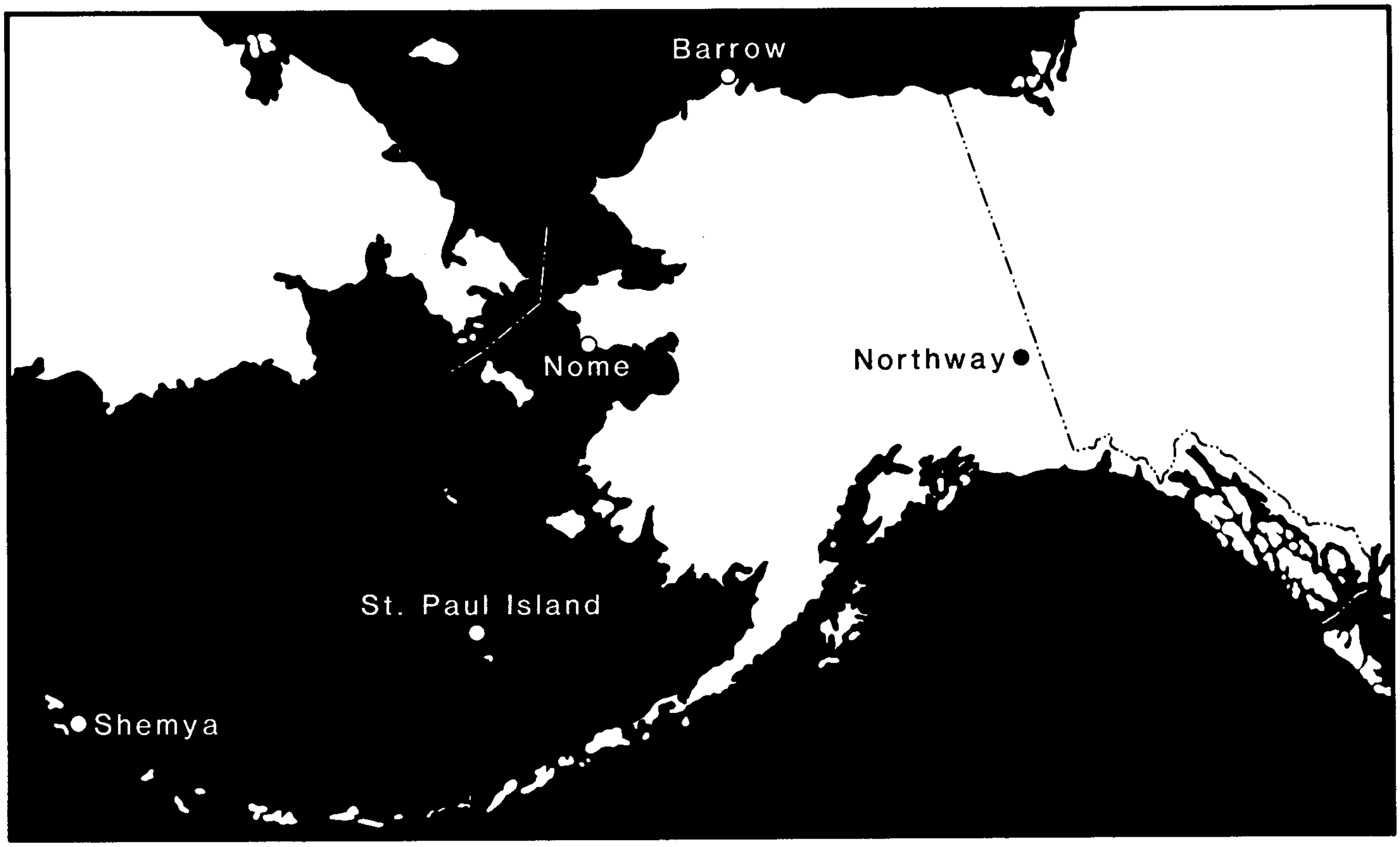
Water, Ice, Land, and the Alaska Climate

by Sue Ann Bowling

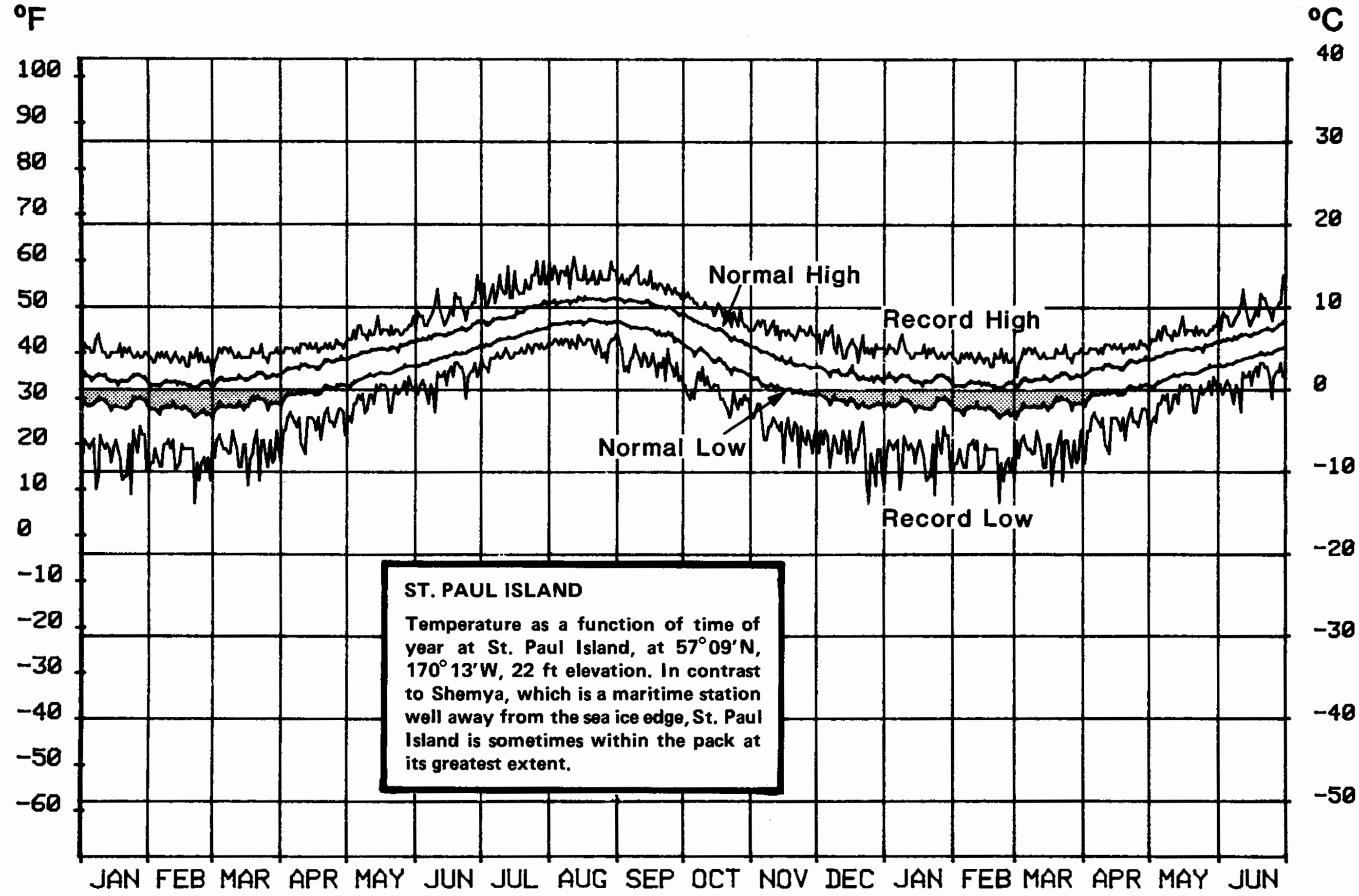
Alaska is a big land mass, with a corresponding variety of climates. Some of the variability in climate is due to size: Alaska's 20° spread in latitude alone exceeds that from the northern Great Lakes to southern Arizona. The presence of water and sea ice, however, has even more dramatic effects on the climate of Alaska. The five locations to be considered here (see map) have been selected from National Weather Service stations in Alaska to illustrate the significance of those effects.

Water is a fascinating substance. Its heat capacity is among the highest known, as is its latent heat of freezing. (It takes as much energy to melt a block of ice as it does to warm the resulting water to 80°C.) A cold air mass sitting over warm water could be warmed by 10°C to a height of 300 meters, while the top meter of the water would cool by only 1°C. And since water is fluid, that cooled water would normally be spread over a depth of more than a meter and the amount of cooling would be correspondingly reduced in magnitude. The practical result of this is that an ocean has a tremendous stabilizing effect on the air temperature.

As an example, consider Shemya, Alaska, a tiny island about two-thirds of the



Sue Ann Bowling *is an assistant professor of physics at the Geophysical Institute, University of Alaska-Fairbanks. Dr. Bowling's special research interests are high-latitude air pollution, climatic change, and the day-to-day vagaries of weather that go to make up climates past, present, and future.*



ST. PAUL ISLAND

Temperature as a function of time of year at St. Paul Island, at 57°09′N, 170°13′W, 22 ft elevation. In contrast to Shemya, which is a maritime station well away from the sea ice edge, St. Paul Island is sometimes within the pack at its greatest extent.

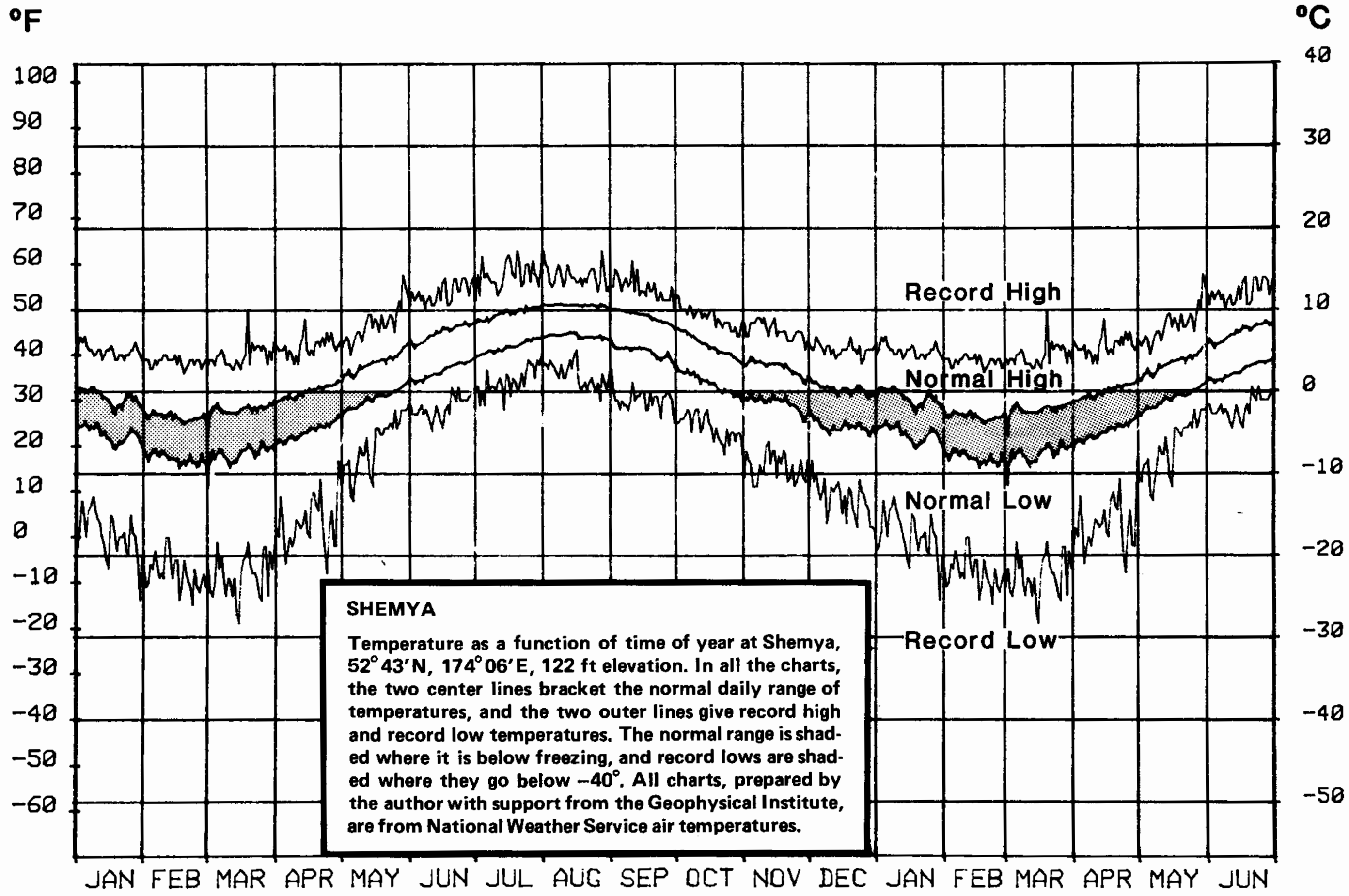
way along the Aleutians. The average sea surface temperature at Shemya is about 3°C after a winter's cooling (in February and March), rising to an average of 9°C after a summer's "heating." Sometimes warmer currents shift into the area, bringing water temperatures as high as 14°C in August.

Air temperatures at Shemya follow the sea surface temperatures in a number of ways. The normal minimum temperature in summer and the normal maximum temperature in winter are quite close to the average sea surface temperatures for these seasons. The radiation that very slowly changes the ocean temperature heats the land much faster, so the radiative cooling brings night air temperatures below water termperatures in winter and day air temperatures above water temperatures in summer—but not by much. The very small range of normal daily temperature, like the very small range of seasonal temperature, is typical of a *maritime* climate such as Shemya's. The record temperatures are also affected—the difference between the record high and record low temperatures for a given date at Shemya is sometimes less than the difference between the normal high and normal low temperatures at a *continental* station such as Northway.

Finally, notice when the highest and lowest temperatures occur at Shemya. The lowest temperatures are in late February, long after the solar radiation has passed its minimum and begun to heat things up, and the highest temperatures are in late August, almost two months after the sun has begun its journey back to the south. Thus the annual cyclic progression of temperature is controlled almost entirely by the slow response of the oceans.

Sea ice behaves thermally more like land than like water, at least while it is stable. Some heat "leaks" through from the water beneath, both by conduction through the ice and overlying snow and by direct contact between air and water at leads. During the thaw, the very large latent heat of melting makes the ice behave almost more like water than water itself, though the conduction of warmer temperatures upward by mixing is still inhibited. Overall the temperatures above sea ice, especially if it is covered with snow, are controlled more by radiative balance than by conduction and convection of heat from below. Thus, because of the presence of sea ice, the records from island weather stations near or in the ice show thermal behavior to be more continental than maritime for part of the year.

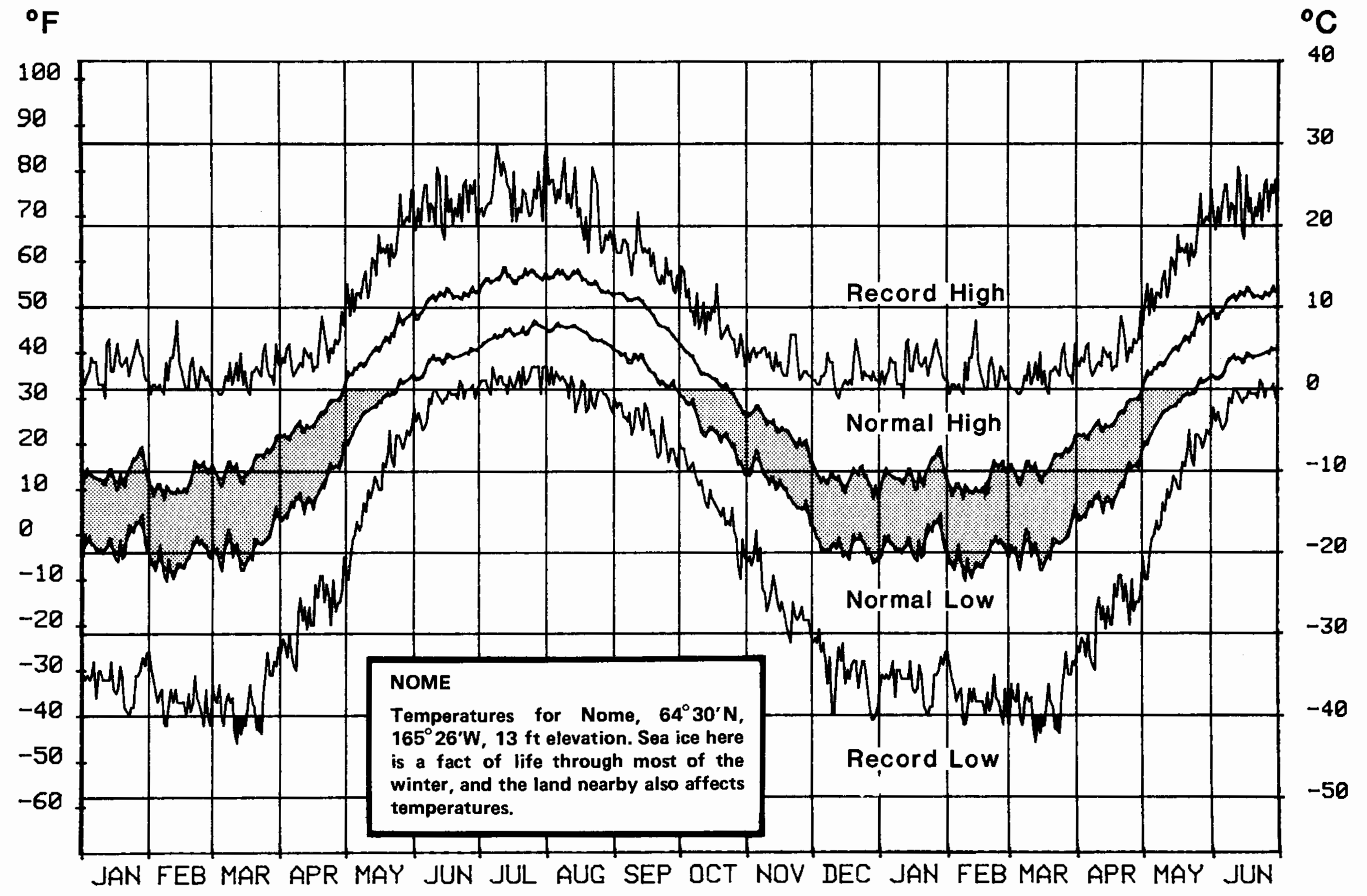
Sea ice even at its greatest extent does not reach Shemya, though winds from the ice edge are probably responsible for its lowest temperatures. St. Paul Island in the Pribilofs, however, is located just about on the edge of the sea ice during its average maximum extent, in March. St. Paul is also larger than Shemya, which in itself has an effect on temperatures. The range of water temperatures at St. Paul is slightly differ-



ent from that at Shemya. The water temperature can go down to the freezing point in the years when ice reaches the island, and of course the ice temperature can be far below freezing. The sea surface temperature is normally about the same as at Shemya in summer, though the highest sea surface temperatures in summer do not exceed 13°C.

The increased daily air temperature range at St. Paul is more likely due to the size of the island and its proximity to the mainland (compared with Shemya) than to direct effects of sea ice. However, several effects of the ice may be seen in winter. One of the most striking is the behavior of the record minimum temperatures. Most stations have either a sinusoidal variation of record low temperatures with time of year (e.g., Northway) or a flat plateau of minimums in the winter (e.g., Shemya). St. Paul minimums show a steady, almost linear drop from the time the ice begins to form in the Arctic Ocean in late September until it reaches its maximum extent in March. While the first part of this decline may be due to normal seasonal cooling, the continued cooling from January on is probably due to the approach of the sea ice front. Ice and wind work together to affect temperatures at St. Paul: the northern winds not only carry low temperatures from the ice edge, they also push the ice itself farther south and accelerate its growth. Note that the normal winter temperatures at St. Paul are not located symmetrically between the record high and record low temperatures, but are closer to the highs. This indicates that the record lows were set during rare events—probably in years when the ice edge moved well south of St. Paul.

Nome temperatures are influenced by its coastal location, the relative shallowness of Norton Sound, and the presence of sea ice from November through March. The coastal location means that winds can reach the station from inland as well as from the ocean. The shallow waters of Norton Sound can warm much more in the summer than can the deeper waters near the Aleutians, while sea ice in the winter acts as an extension of the land. August sea surface temperatures are normally around 10°C and can be as high as 16°C. The effect of all these things on the temperature chart is striking. Certain tendencies seen at St. Paul are still present: the warmest air temperatures are normally in late July or early August, when the water is warmest, and the coldest record temperatures occur in March. Normal daily minimum air temperatures in summer are still rather close to the water temperatures. But occasionally Nome's coastal location allows winds from warm summer land to produce much higher record temperatures in summer than at the two island stations, even though Nome is more than 10° latitude north of Shemya. The normal daily temperature range and the seasonal range are both greater than at Shemya and St. Paul, the former due to the influence of the mainland and the latter



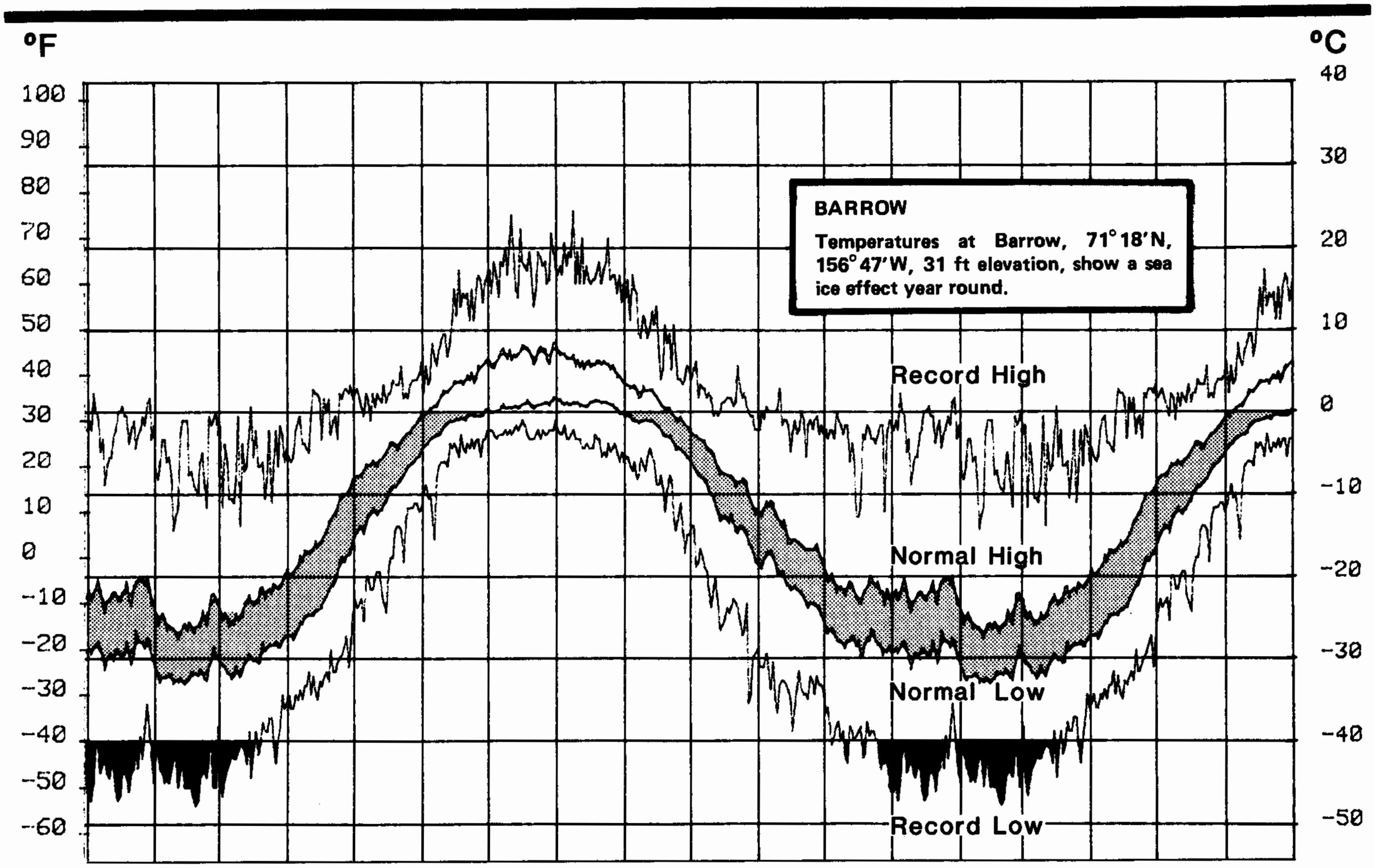
due to sea ice. Neither of these ranges, however, reaches the values seen at Northway, a more fully continental station 1.5° farther south, so it is probably safe to say that even in winter the sea ice is not behaving quite like land. It is difficult, however, to separate the effect of winter sea ice (as opposed to land) from the much higher winds and exposed situations of coastal stations such as Nome or Barrow.

Barrow is the premier example of a climate affected year-round by sea ice. Sea ice cover is effectively continuous except for transient leads during the winter and spring, and has an average cover of over 50 percent for most of the rest of the year. In practice, this means that in about half of the years the sea ice is within a few miles of the coast for most of the summer; in the other half it may be as much as 150 miles away. As the latter years are those with prevailing southerly winds, Barrow can have reasonably warm record summer temperatures compared with fully maritime stations. However, normal summer temperatures are clearly controlled by the sea ice, with normal minimums just above freezing. At the same time, record minimum temperatures fall very slightly below freezing, probably due to the tremendous thermal mass of the soggy ice and sea water offshore.

Normal winter temperatures at Barrow are certainly low, and the presence of almost continual winds creates a more severe climate than in the Interior. But the actual temperatures are higher than at Northway, 8° farther south. The daily range of temperatures is also much smaller at Barrow than it is farther inland. Barrow, like the island stations, has its lowest normal temperatures rather late in the season, but for a different reason. At Barrow the sun is below the horizon continuously from late November to late January, and does not rise high enough in the sky to cause perceptible heating until about the middle of February. So the temperature "lag" at Barrow is a direct response to the local solar radiation, not a lag due to the large specific heat of water.

After this discussion, it is easier to predict the pattern found at weather stations far from the sea and sea ice. Northway, located well inland, is a good example of a continental station. Both daily and seasonal temperature variations are extreme, and the seasonal cyclic progression of temperatures lags the cyclic progression of solar radiation by only a couple of weeks. Both normal and record temperatures are the highest in summer and the lowest in winter of any station examined here. This is due to the relatively low heat capacity and effective conductivity of soil—and even more, of snow—compared to water and to some extent to sea ice. (Fairbanks, at a lower elevation, has slightly higher summer temperatures, but its winter temperatures are not as low.)

We have not looked at how precipitation varies among these stations, or at how temperatures vary in the southern and southeastern parts of Alaska. These will be the subjects of future articles. ♦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BARROW
Temperatures at Barrow, 71°18'N, 156°47'W, 31 ft elevation, show a sea ice effect year round.
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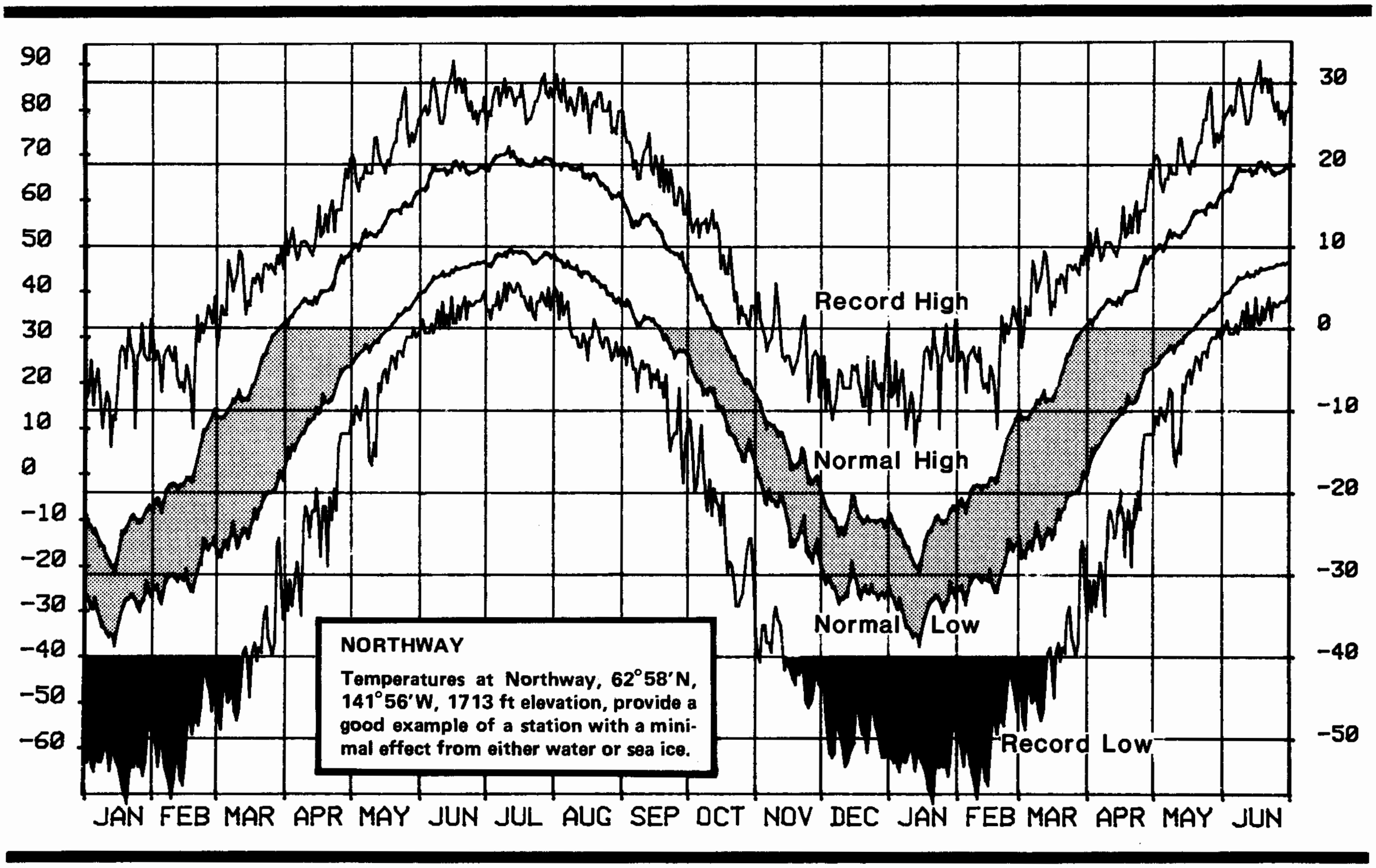
Record Low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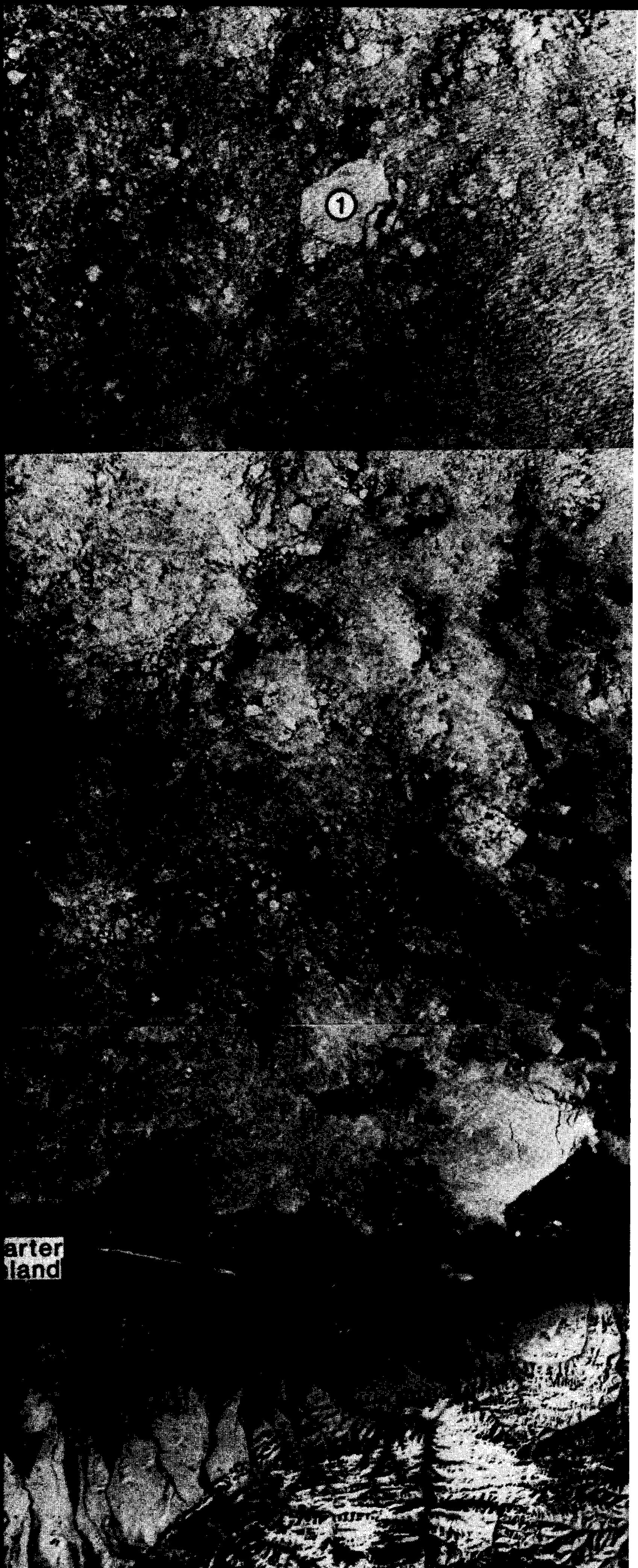
Normal High
Normal Low
Record Low
NORTHWAY
Temperatures at Northway, 62°58'N, 141°56'W, 1713 ft elevation, provide a good example of a station with a minimal effect from either water or sea ice.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN



SEEKING THE PERFECT FLOE

by Kristina Ahlnäs

Part of the vision would ring true for nearly anyone, anywhere: to find an ideal place to work, a secluded getaway where no one could distract you, a place of limitless horizon and boundless opportunity but without phone calls, junk mail, air pollution, traffic congestion, complaining neighbors. . . . To this idyllic picture must be added uncommon details: this place had to be on an ice floe in the Arctic Ocean—a big floe, steady as a rock yet drifting slowly with the winds and currents toward the west, following the general ocean circulation of the Beaufort Gyre.

So much for the dream. The reality was that a group of scientists from the Applied Physics Laboratory (APL) of the University of Washington needed a floating research station as a home base for work that could not be accomplished in the rain and civilization of Seattle.

To make the enterprise a success, the APL group needed an ice floe of suitable size and strength to carry a scientific research camp. The floe would have to be strong enough to take the abuse of the curious scientists for two months without cracking up; a multiyear floe would have the required strength. Preferably, its size would be larger than 3 by 5 km. The floe also would have to be accessible. The scientists wanted to get to it after the middle of September by icebreaker, and could use the U.S. Coast Guard's *Polar Sea* for transport; they also wanted it to be far enough away from the coast to be secluded but still within helicopter range of Barter Island. The floe also had to be in position for a rendezvous with the icebreaker when the time came to break camp.

The best way to find a suitable ice floe is to use remote sensing. National Oceanic and Atmospheric Administration (NOAA) satellite imagery with daily coverage of the Arctic

Figure 1. Landsat photograph, August 13, 1984. The "perfect ice floe" designated by the number "1" measures 15 by 25 km. It is located 300 km northeast of Barter Island.

Kristina Ahlnäs *earned her Master of Science degree in oceanography and geophysics from the University of Helsinki, Finland. She is a remote sensing specialist with the Northern Remote Sensing Laboratory at the Geophysical Institute, University of Alaska-Fairbanks, where she uses satellite imagery and weather data to study sea ice advance in the Bering Sea.*

Ocean, a synoptic view, and scale of 1:7 million, is suitable for general surveillance. For greater detail, to "zoom in" on a specific area, Landsat imagery at a scale of 1:1 million is desirable, but this satellite cannot provide daily coverage. A remote-sensing specialist at the Northern Remote Sensing Laboratory of the Geophysical Institute, University of Alaska-Fairbanks, was to select the floe, using both NOAA and Quick-Look Landsat imagery, and tell the icebreaker how to get there.

THE SEARCH

The first Quick-Look imagery was received on August 13, 1984, with a large floe in a seemingly perfect location within helicopter range—about 300 km to the northeast—of Barter Island (Fig. 1). Was it really this easy to find the perfect floe at the first attempt?

The following two weeks were cloudy, which is normal for the Arctic Ocean in summer. The next time the ocean could be seen, the "perfect floe" was nowhere to be found. The other large floes that had been located northeast of Barter Island had drifted about 100 km to the southeast, toward the mouth of the Mackenzie River where the ice edge was farthest from shore. Those floes were beyond helicopter range to start with, and they were in danger of melting once they reached the open water along the coast. The images from the September 1 Landsat orbit showed a strange cluster of floes (Fig. 2), and after some comparison with NOAA imagery, the mystery of the disappearing "perfect floe" was solved. Some floes build up internal stress to the point that they can suddenly disintegrate, and that is what had happened to the first-choice floe.

The searchers began to contemplate the virtues of a smaller floe. A floe that had been around a while without changing its size might last longer, a matter of considerable interest to people intending to camp aboard it. The promising floes were labelled so they could be documented and discussed. From September 6 to 11, floe "G" drifted toward the southwest (Fig. 3). It looked promising, but just before it came within helicopter range its direction of drift changed. The importance of selecting the right floe became

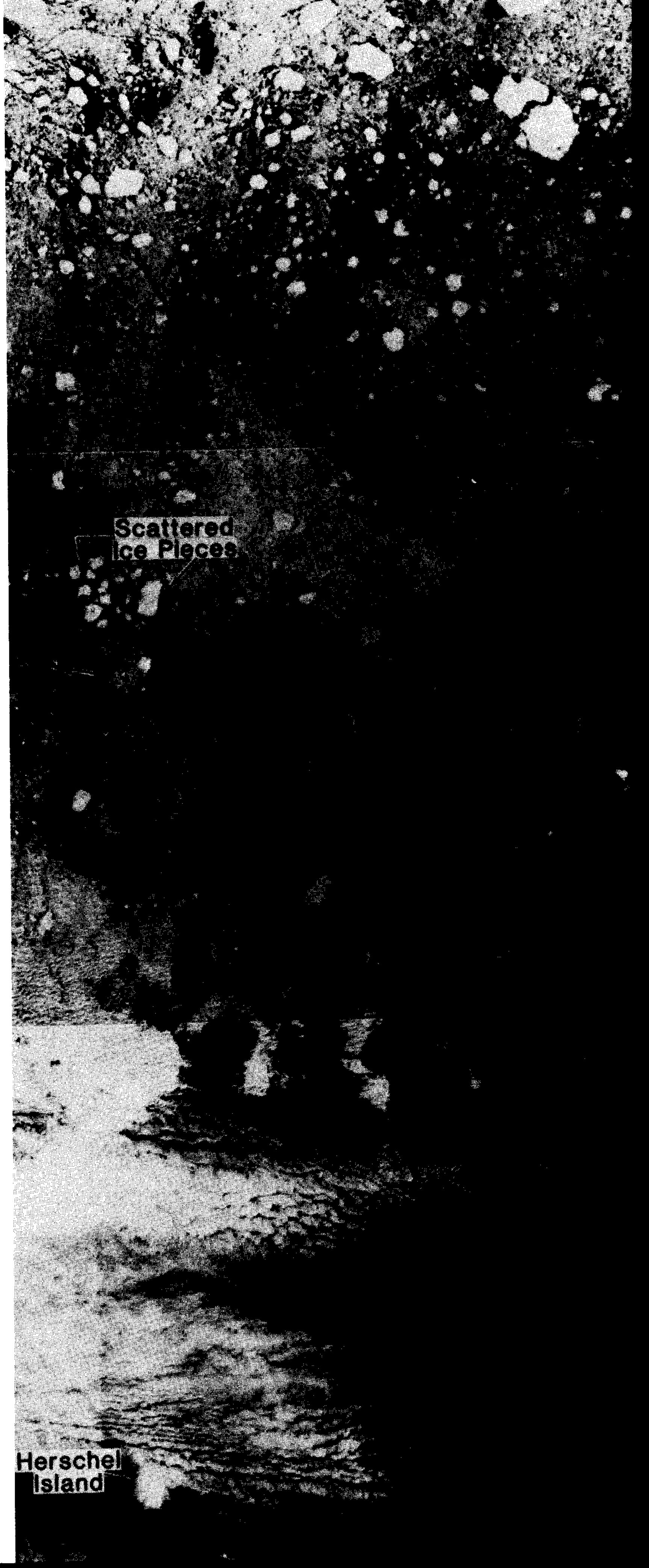
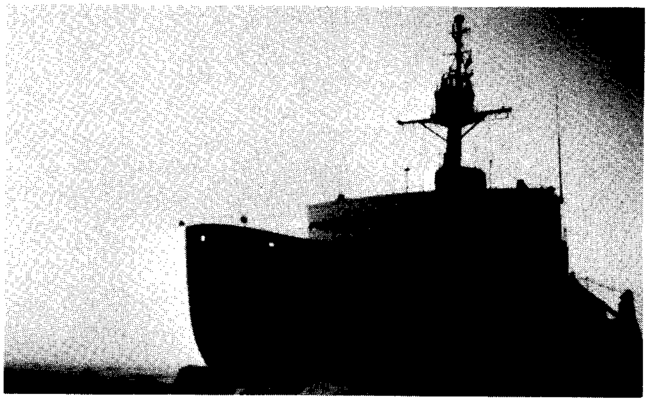


Figure 2. Landsat photograph, September 1, 1984. The "perfect ice floe" shown intact in Figure 1 appears here as scattered pieces of ice. Large floes, which are out of helicopter range, can be seen at the top of the photograph. A jet contrail is visible across the left side of the ice-floe cluster (single arrow).

A lead in the vicinity of the selected floe north of Barter Island as it appeared from the icebreaker *Polar Sea.* (Photo by Pat Hardisty.)



Personnel from the icebreaker *Polar Sea* survey a floe. (Photo by Pat Hardisty.)

more serious as the deadline approached. Floe "F" was a bit small but seemed to be in the proper place. On August 30 it had been at the location where the "perfect floe" was first spotted. While "F" was being watched, it drifted about 70 km toward the northwest in nine days, coming to the edge of the access range. This was not expected; according to all rules, the floes should drift toward the west. None of the floes considered so far had done so.

To avoid the influence of the Mackenzie River outflow, the chosen floe should be as far inside the pack ice as possible —yet not so far that there was a danger of its drifting outside the access range. NOAA imagery no longer showed any large old floes within that range. (The old floes can be identified on the satellite images because they appear to be brighter, since they consist of denser ice with a higher reflectance.)

The project leader flew to Prudhoe Bay to do air reconnaissance. Satellite imagery flew from Fairbanks—via air mail—to Seattle and at the same time by overnight courier express to Prudhoe. For orientation purposes a small bright floe in the middle of the access range was flagged on the images as "3" and used as a reference position for future planning.

Figure 3. Landsat photograph, September 11, 1984. Floes "3" and "F" are within helicopter range. Several large ice floes, including floe "G" to the north, are out of range.

Crew unpacks equipment in order to set up camp on the floe. The *Polar Sea* can be seen in the background. (Photo by Pat Hardisty.)

Established research station on the selected ice floe. (Photo by Pat Hardisty.)

THE SELECTION

Time seemed to be winning over technology. On September 17 members of the main crew passed through Fairbanks on their way to Barter Island, where they would board the icebreaker. A suitable destination floe had not yet been found. The assistant project leader, Dr. Gerry Garrison, visited the Northern Remote Sensing Laboratory where he and the imagery specialist scrutinized satellite data until past midnight, trying to find a suitable floe. For the previous six days all of the floes had drifted toward the north-northwest, and they continued to do so. Garrison himself travelled on toward the north-northeast and joined the icebreaker. The Landsat Quick-Look program tried to sense through clouds to find a suitable floe. The Air Force took over communications between the icebreaker and the Northern Remote Sensing Laboratory, and radioed the size and drift of some floes to Dr. Garrison on the icebreaker.

September 25 was a day of hectic action in Fairbanks. Phone calls came from both the Navy in Hawaii and the Air Force in Alaska—at the same time. Cloud-free imagery from the Gilmore Tracking Station showed the last identifiable piece of the "perfect floe" at the ice edge (Fig. 4). Navy pilots visited and were expected to return later;

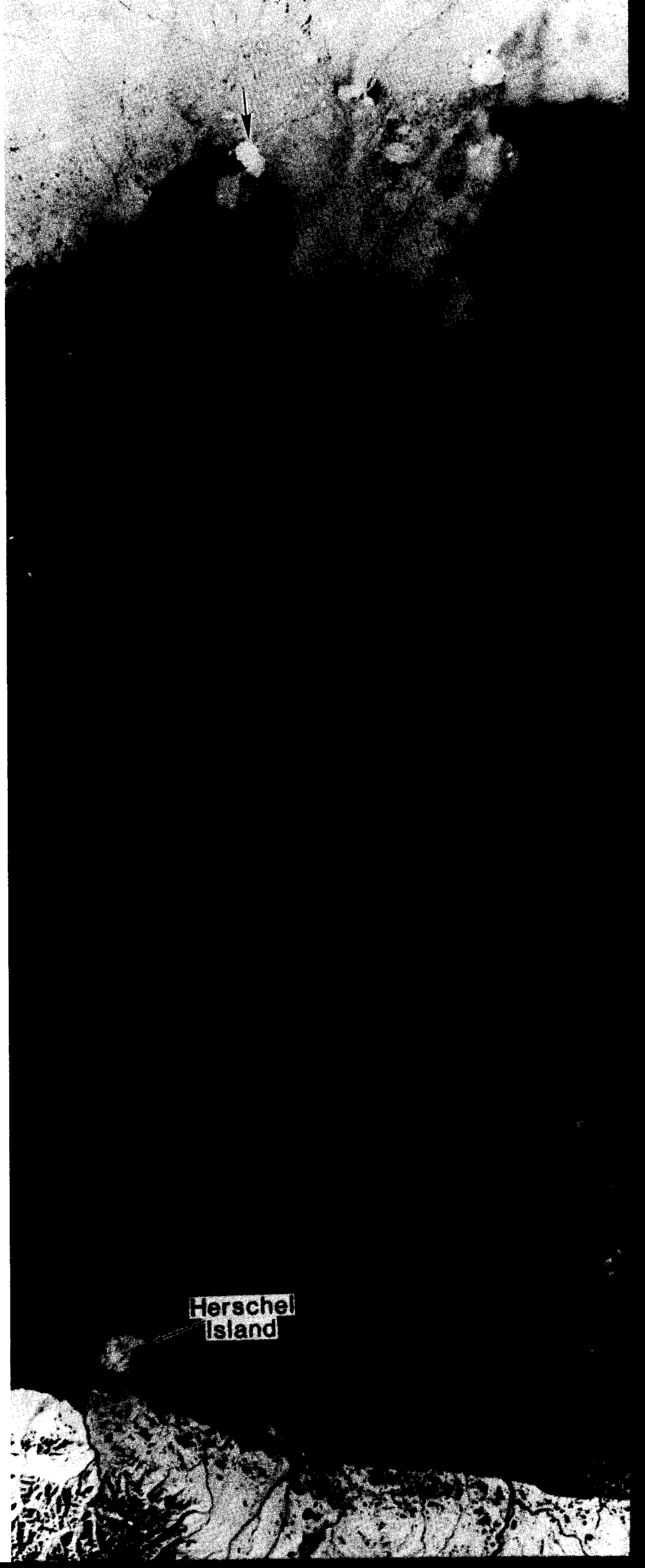


Figure 4. Landsat photograph, September 25, 1984. The largest remaining piece of the "perfect ice floe" is visible at the ice edge (single arrow).

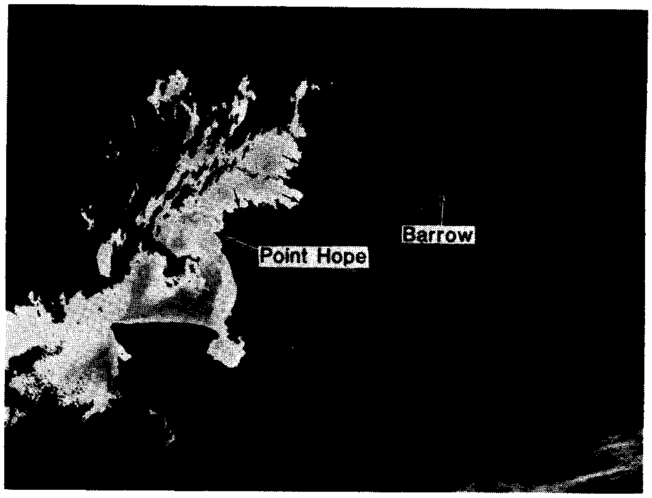


Figure 6. NOAA photograph, October 25, 1984. New shorefast ice (black) has formed between Barrow and Point Hope along the Chukchi Sea coast. Open water shows up as the lightest gray on the left side of the photograph. Old ice (darker gray) is visible to the upper right of Barrow.

instead, a delegation including men in dress suits and two official ice observers came looking for the remote sensing specialist. They took the latest satellite imagery in an envelope addressed "Coast Guard Icebreaker *Polar Sea,* Arctic Ocean." The next day, September 26, that imagery landed on deck aboard the icebreaker. A floe had been selected (Fig. 5).

DRIFT AND RETURN

The remotely sensed site was quickly occupied. The floe was 2.4 m thick and was embedded in ice 45 cm thick. On one side was open water with chunks of ice 6 to 12 meters in length floating around. While the floe was adrift, the sea ice closed in and started its slow expansion toward the south. On October 25 new ice reached Point Hope (Fig. 6); on October 28 the area was cloudless, and the manned ice floe was found on a 4X enlargement of NOAA imagery.

The scientists were busy collecting samples and taking measurements for the next 45 days, if in not quite the serene seclusion they had imagined. All the polar flights between Alaska and Europe passed above the vicinity of their personal ice floe. That is at least 50 flights per week, and each leaves a contrail behind. People came and went by helicopter, and day by day ticked off in busy routine—with occasional bits of excitement, as when a crack opened 100 meters from the camp, running right across the landing field. It soon reclosed. The floe stayed discreetly on a conservative westerly course, and drifted 120 km in 38 days.

On November 11 the icebreaker kept its rendezvous and picked up the scientists from their frozen isolation. They returned to the trees and traffic in Seattle, leaving the Arctic Ocean—and the *Polar Sea*—far behind. ♦

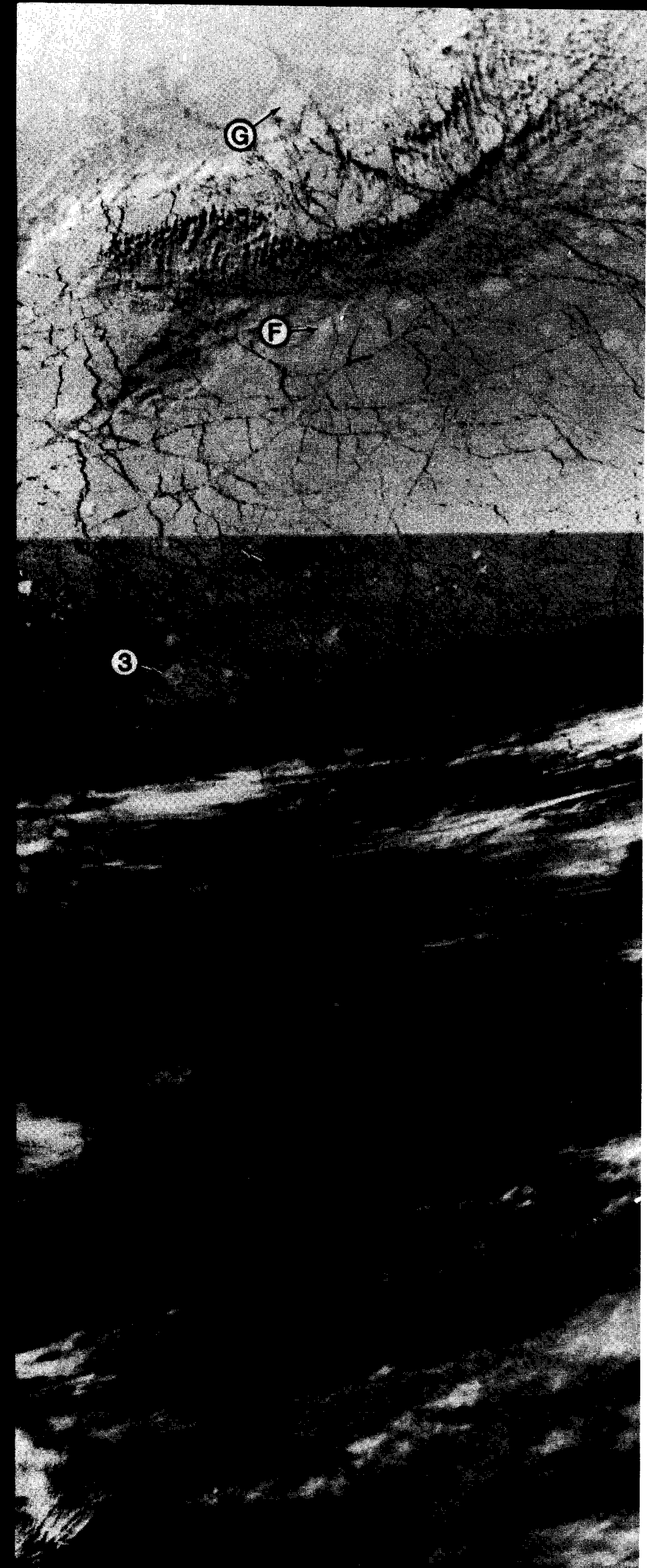
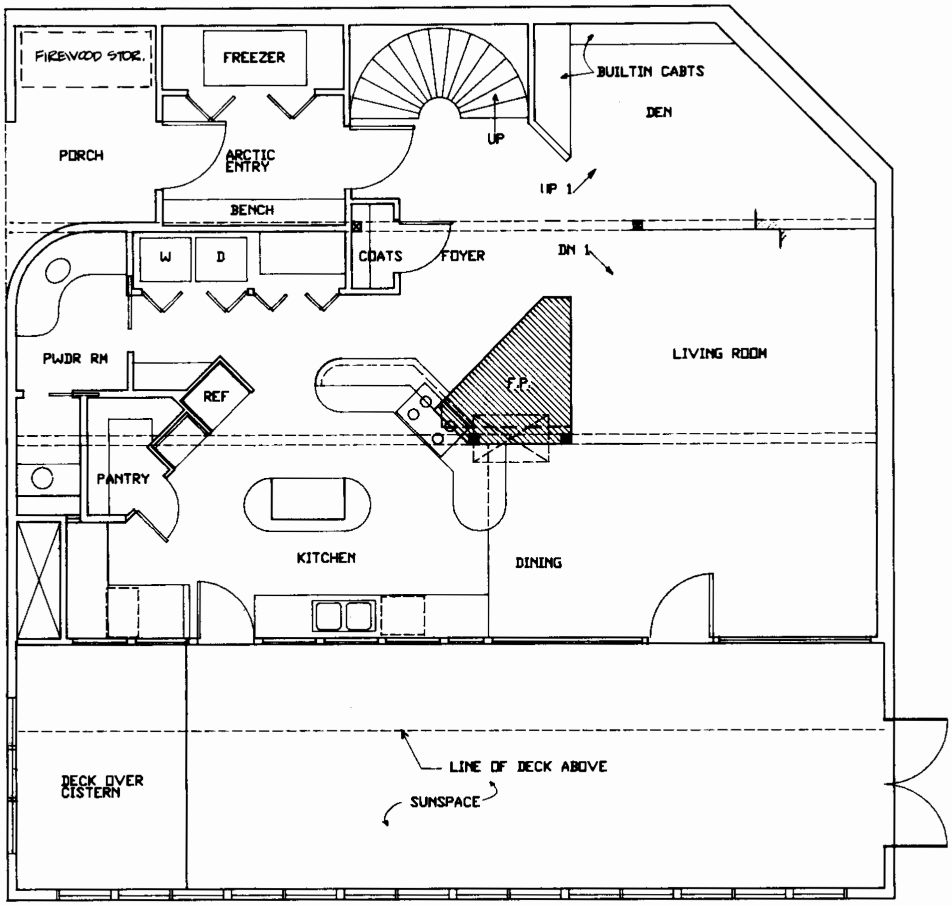


Figure 5. Landsat photograph, September 28, 1984. Floe "3" (the selected floe) is located 275 km north-northeast of Barter Island. A faint icebreaker trail leads from the vicinity of floe "F" to floe "3" (single arrow).

SHELTER AS ORGANISM

by Robert L. Crosby, Jr.



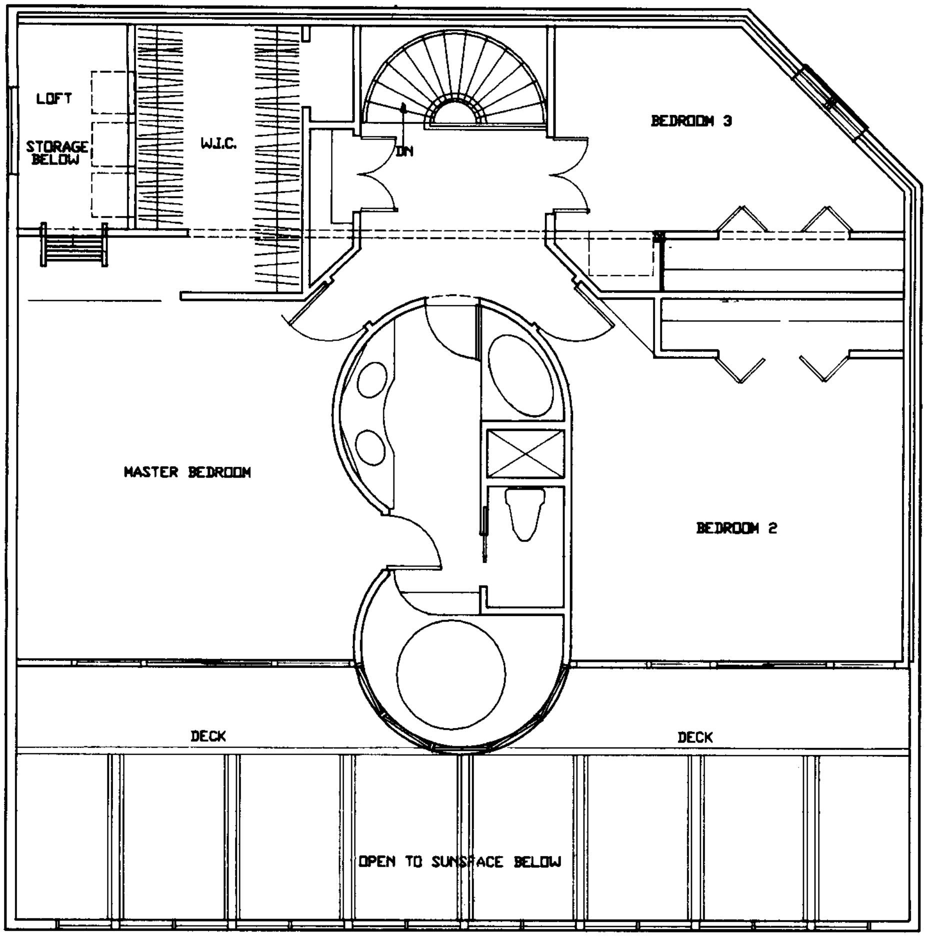
FIRST-FLOOR PLAN

INTRODUCTION

From recent expansion of solar-oriented architecture, design strategies are emerging that are similar to those found in natural living systems, where energy efficiency is synonymous with survival. Living systems are organized in such a way that their subsystems (i.e., cells within organs, organs within organisms, organisms within societies, etc.) interact with each other to create collectively a self-regulating whole larger than the sum of the individual parts. Typically, energy does not flow through such systems in a straight line from source to sink, but is first modified and stored in various forms within the system to offset fluctuations in the supply. Each subsystem often performs more than one function, and the end product of one process is typically the raw material for the next in a complex series of loops within loops.

Biological architecture, or "biotecture," is concerned with the intentional design of a community of symbiotic organisms in an attempt to create a self-regulating micro-ecosystem. In designing a bioshelter, we wish to create a system that emulates these features of living systems: a system that is biologically complex, but technologically simple.

Robert L. Crosby, Jr., *is an energy management consultant and mechanical systems designer in Anchorage. He submitted this house plan in the Alaska Energy Center/Division of Energy and Power Development residential design competition, source for our continuing series of articles on energy-efficient house designs. Questions and/or comments regarding this article should be addressed to the author at Biorealis Systems, Inc., 508 W. E Street, Suite 316, Anchorage, AK 99501.*

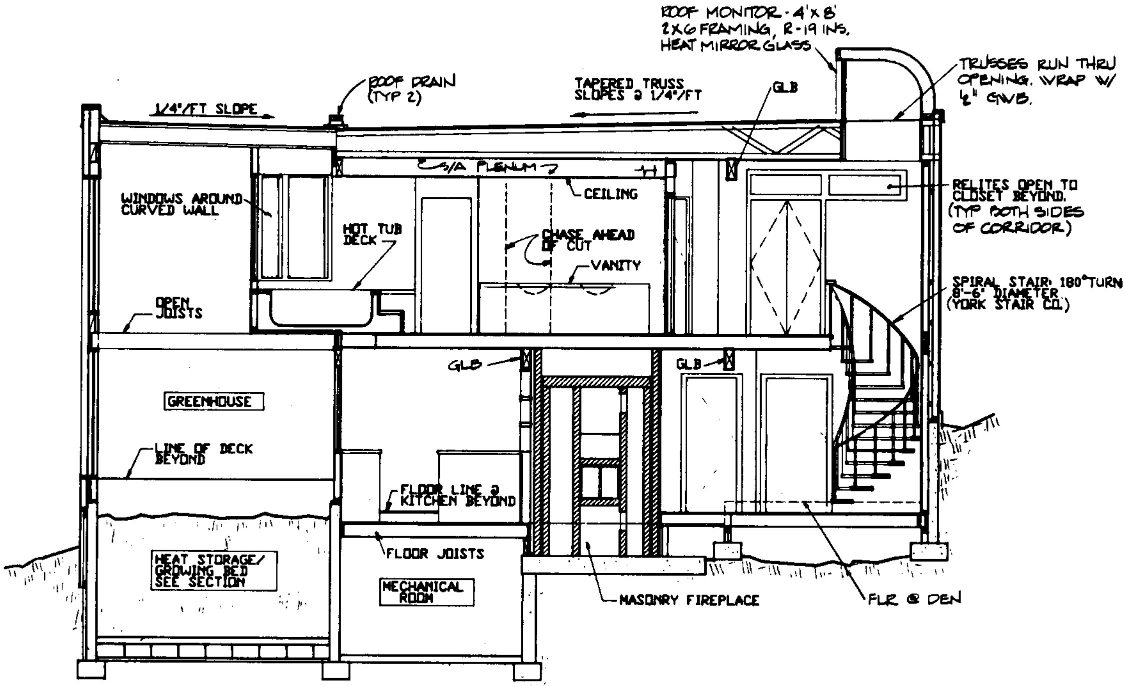


SECOND-FLOOR PLAN

THE BIOSHELTER

Imagine a house situated in an 11,000 degree-day climate, but whose windows all open out to a garden located in a 3000 degree-day climate where the temperature never drops below 40°F— a garden with a rich variety of plants and animals, fountains, and productive fish ponds—a small self-sustaining ecosystem. Further, imagine such a structure using one-tenth the amount of water and less than a quarter of the total energy used in a conventional house of the same size. And of course we would want it to be comfortable, affordable, well ventilated and odor-free, and one should not have to devote too much personal attention to maintaining it.

Biorealis Systems, Inc., an Alaskan energy research and development company, is currently constructing an experimental bioshelter designed to turn this idea into reality. The project is an outgrowth of a design which my wife and I had entered in —and which was selected as one of the winners of—the 1981 home design com-



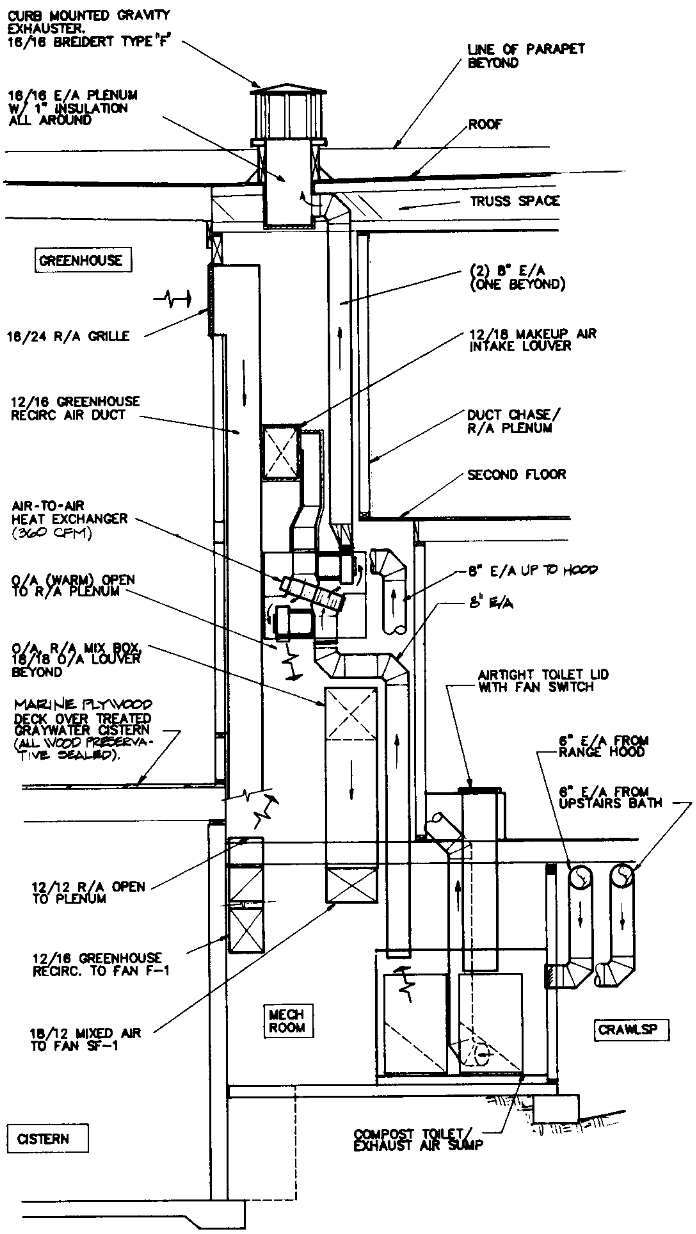
BUILDING SECTION

petition sponsored by the now-defunct Alaska Energy Center (AEC).

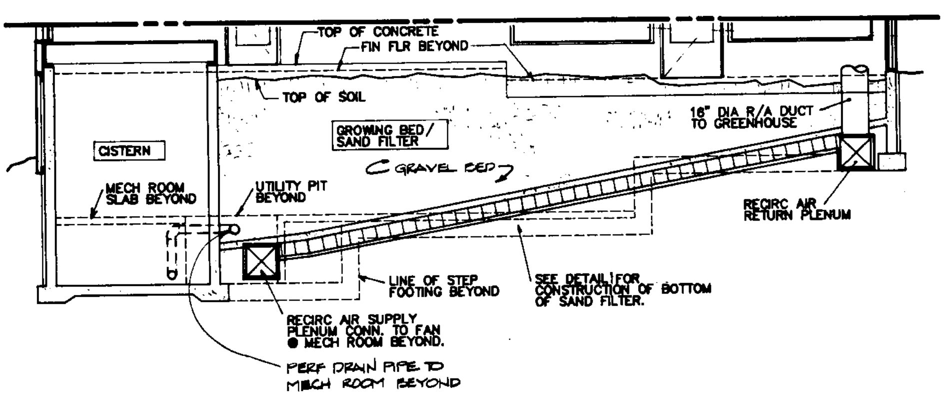
The original design submitted to AEC incorporated much of the "integrated systems" approach which is developed here, but it was somewhat more complicated architecturally and structurally. In contrast to the original design, which included many angles, cantilevers, clerestories, and roof planes that presented a very contemporary architectural appearance and a complex construction problem, the present design is a clean geometric solid. It encloses about 20 percent more useable floor area than the original scheme, but due to its simple shape, has considerably less exterior surface area through which to lose heat. Landscaping, plantings, and multilevel exterior decks are used to offset the starkness of the building.

The building itself is a simple 42- by 42-foot box set into a southwest-facing slope on the diagonal, so there is an uphill and a downhill corner. A full-height partition 12 feet back from the all-glass south face separates the enclosed volume into two spaces: a 12- by 42-foot greenhouse on the south, and a two-story 30- by 42-foot living space behind it. With the exception of one skylight near the back of the house, and one small bedroom window, no other windows open directly from the living space to the outside. Instead, the interior of the living space is laid out so that all the major rooms have large glass areas opening out into the enclosed garden. The skylight provides natural daylight to the rooms at the back of the house.

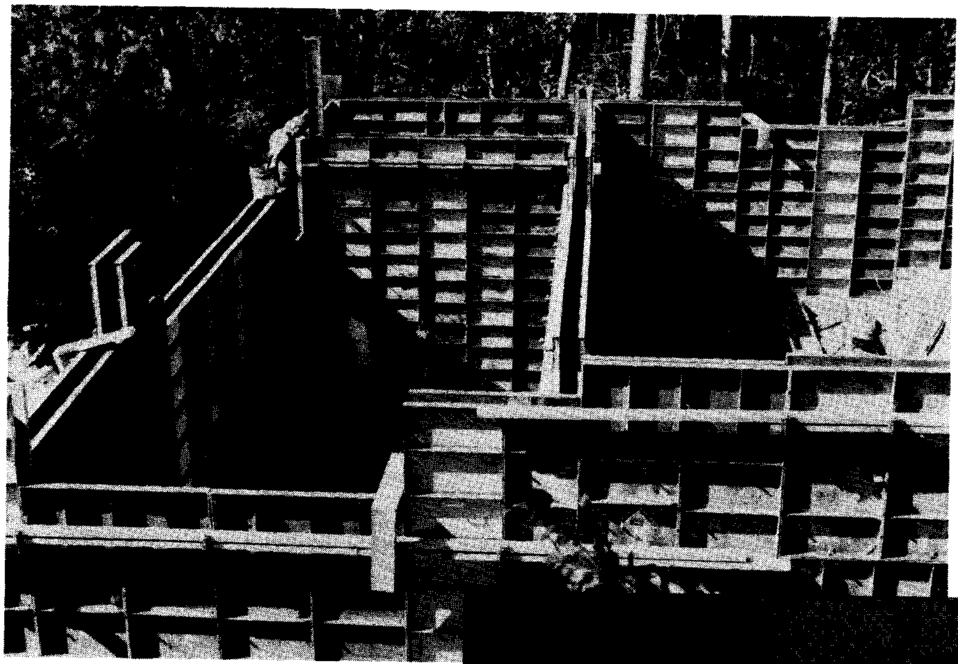
The entire growing bed area of the greenhouse was excavated down to the footings, waterproofed, and backfilled with 4 to 8 feet of clean sand and gravel, a filter fabric, and 2 feet of biologically active organic topsoil. It could be visualized as an insulated swimming pool with the bottom sloping to a collection sump and cistern at the deep end, and with a heat exchanger built into it. This area functions as (1) plant growth space, (2) graywater sand filter, and (3) thermal mass. (See photographs, next page.)



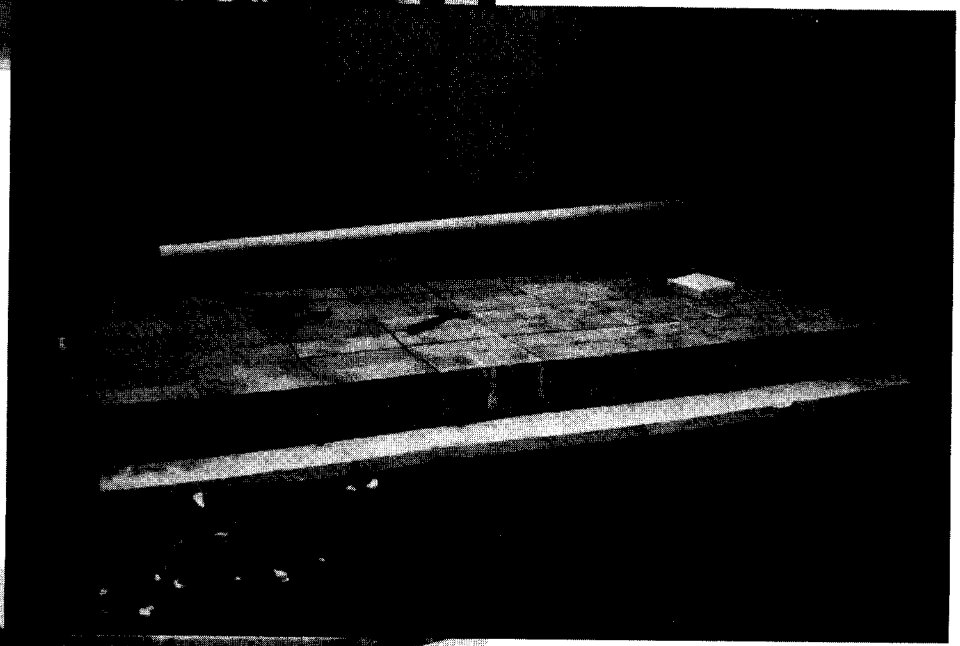
VENT SYSTEM — SECTION THROUGH CHASE



SECTION THROUGH GREENHOUSE



The concrete formwork in place. The greenhouse pit is to the left (with the man inside it) and the cistern beyond it (12 ft deep).



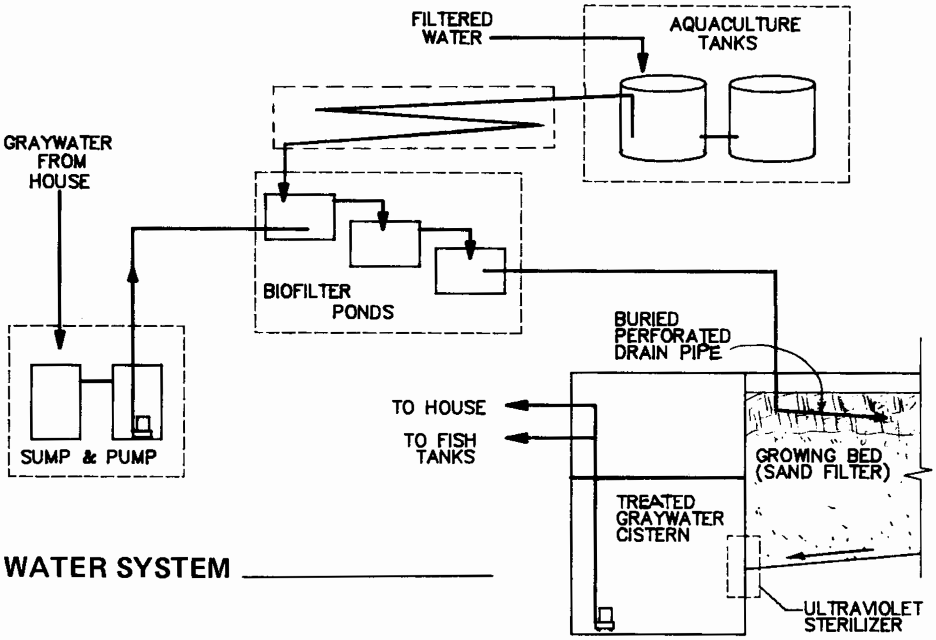
Construction of concrete block heat exchanger, showing 2" rigid insulation, 8" concrete blocks, and 4" perforated drain pipe. The pipe was wrapped in Mirafe™ filter fabric before being backfilled with gravel.

View of supply plenum and duct opening to the mechanical room beyond. Note 4" drain pipe penetration.

Greenhouse pit after the concrete slab has been poured and waterproofing begun.

Upper end of greenhouse pit before backfilling. The 16"-diameter duct is connected to the air return plenum below the slab.

The partially completed house, as of winter 1984.



WATER SYSTEM

THE CIRCULATORY SYSTEM

In a living organism, the circulatory system performs a variety of functions, including distribution of nutrients and oxygen, removal of metabolic waste products, and precise temperature control of the entire organism. By analogy, in the bioshelter about 5000 gallons of water are stored within the envelope and continuously circulated through the system to perform similar functions, while being slowly replenished with fresh water at a rate of about one-tenth the circulation rate. (The bioshelter "drinks" about 20 gallons per day, and will "get sick" if too much bleach goes down the sink drain.)

There are two sources of fresh water. A 5000-gallon concrete freshwater cistern stores rainwater collected from the roof and water collected from a seasonal subsurface spring. A conventional shallow well pump and pressure system is used to distribute this water to kitchen fixtures only, with recycled gray water being piped to all other fixtures in the house. As in a conventional house, water used for drinking and cooking purposes accounts for less than one-tenth of the total usage.

GRAYWATER TREATMENT

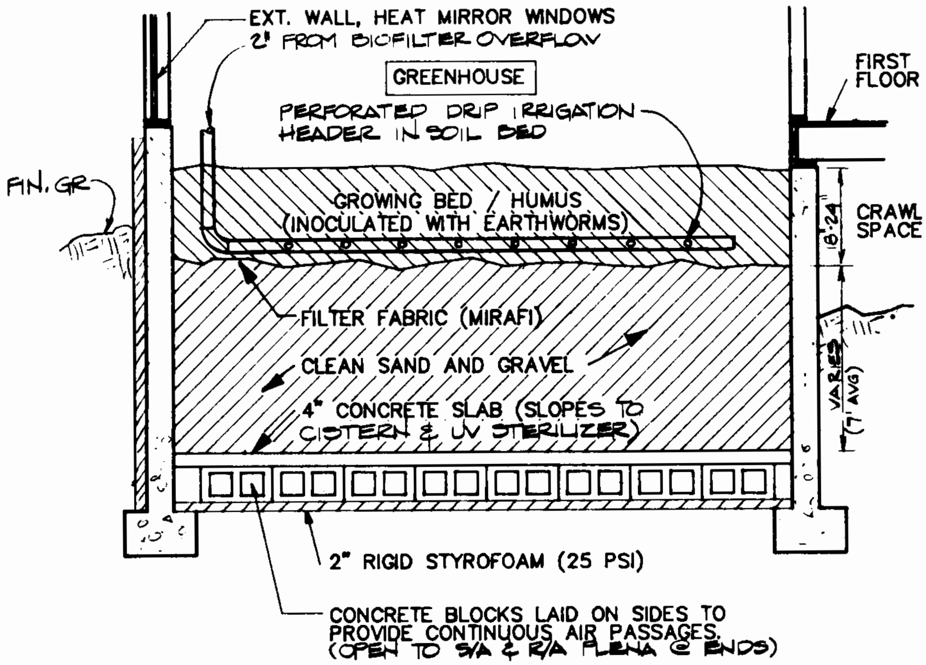
House wastewater (not including toilet wastes, which are composted aerobically) undergoes three levels of mechanical and/or biological filtration before being sterilized for reuse in the house. At each level, the nutrients in the water support a microecology of organisms which in turn purify the water.

Wastewater first drains by gravity to a primary filter located in a utility room below the house. This simple mechanical filter consists of two 55-gallon drums, some 5-gallon plastic buckets, 2-inch PVC piping and fittings, and functions as a graywater sump, grease trap, and settling basin.[1]

From the primary filter, water is pumped up through the first of three biofilter ponds located in the greenhouse above, which remove dissolved nutrients from the water, dealing with biochemical oxygen demand (BOD), and dissolved and particulate organic carbon (DOC, POC). The biofilter consists of cascaded plastic tubs filled two-thirds full with broken clam shells topped with a 3- to 4-inch layer of pea gravel. The clamshells provide a substrate for attached microorganisms, and the gravel is a rooting medium for aquatic plants used to concentrate and remove nutrients. The plant root structures also provide a habitat for a polyculture of bacteria, invertebrates, and detritivores which also feed on nutrients in the water. The biofilter ponds are incorporated into the design architecturally, to create the appearance of a multilevel fountain with trickling waterfalls.

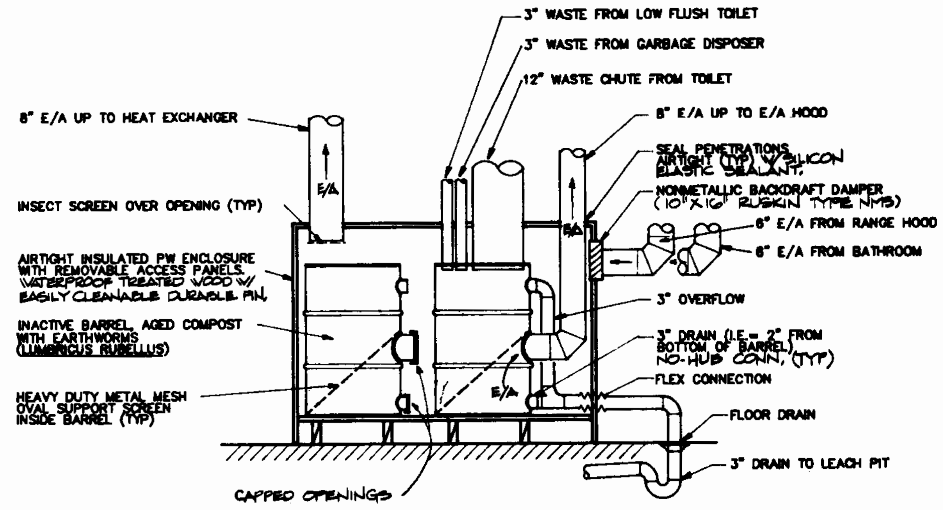
Water from the last biofilter pond drains into a perforated drain pipe buried in the growing bed. The biologically active topsoil is home for a microecology of fungi, bacteria, and earthworms which further recycle the waterborne nutrients into humus. From there the water continues to seep down through the filter fabric and the sand/gravel bed, to be collected in the sump for ultraviolet sterilization and reuse in the house.

Although conventional wastewater treatment systems are biological in the sense that they use bacteria to oxidize wastes, research has shown that such monoculture systems are less ef-



SAND FILTER SECTION

fective and less stable than polyculture systems using a variety of species, each feeding in its ecological niche. Various communities in California and Florida (including Disney's Experimental Prototype Community of Tomorrow—the EPCOT Center) have experimented with the use of aquatic polyculture systems for reclamation of municipal wastewater. In one study conducted by the National Aeronautics and Space Administration (NASA), one acre of water hyacinths (*Eichhornia crassipes*) was able to remove 3500 pounds of nitrogen, 800 pounds of phosphorous, 18,000 pounds of toxic phenol, and absorb 44,000 grams of heavy metals from municipal wastewater.[2]



COMPOSTING TOILET

AQUACULTURE SYSTEM

Water drawn from the bottom of two 500-gallon aquaculture tanks growing a polyculture of algae and fish will be continuously circulated through the biofilter ponds, where it is mixed with (and dilutes) household wastewater. The algae-filled tanks function as effective solar collectors, as well as producing crops of edible fish. At the present time we plan to experiment with growing two annual crops: tilapia (*Tilapia aurea*, a north African warm-water species) during the summer, and trout during the winter. We hope to integrate aquaculture and vegetable growth in a closed system, by circulating the nutrient-rich water from the bottom of the tanks through hydroponic troughs to the biofilter ponds, which in turn purify and remove toxic metabolic byproducts from the fish tank water.[3]

COMPOSTING TOILET

The composting toilet is designed to provide simple, low-cost batch-feed, aerobic decomposition of solid organic wastes, with minimum maintenance requirements. Given the wide variety of "alternative" toilet designs currently available, their high costs, and consumer complaints about their effectiveness, this is a tall order.

In principle, all that is required for successful composting is creating and maintaining an environment conducive to the growth of aerobic bacteria. Environmental parameters that must be kept within tolerable limits include temperature level, moisture content, oxygen level, carbon/nitrogen ratio, and pH. In actual practice, meeting these requirements is not easy. Problems with existing designs center on difficulties with maintaining optimum moisture and temperature levels, providing adequate aeration, and preventing odors and/or insects from entering the house.

Our design consists of two open-topped 55-gallon plastic drums inside an insulated, airtight plywood box, with a heavy-duty mesh screen laid inside each drum, and with duct and drain connections. Wastes enter the toilet from three locations in the house: (1) a garbage disposer in the kitchen, (2) a low-flush (1-gallon) toilet in the second-floor bathroom, and (3) a chute from the downstairs toilet. All wastes fall into one of the drums. This "active" drum has a drain connection to a small leach pit, so the mass is moistened each time the toilet is flushed or the garbage disposer is used, but is well drained to prevent liquid buildup in the bottom (and consequent anaerobic conditions). The estimated flow rate will be less than 20 gallons per day.

When this drum becomes nearly full, it will be replaced with an empty drum, have earthworms added to it, and be set aside to age. Two species of earthworm in particular, red worms (*Lumbricus rubellus*), and brandling worms (*Eisenia foetida*) thrive and multiply in compost heaps and manure piles, where they continually process the material into humus, aerating and homogenizing the elements.[4] When a drum full has been thoroughly converted into humus, it can easily be sterilized with a barrel heater. Heating the mass to 66°C for 1 hour is enough to destroy most common pathogens and parasites.[5]

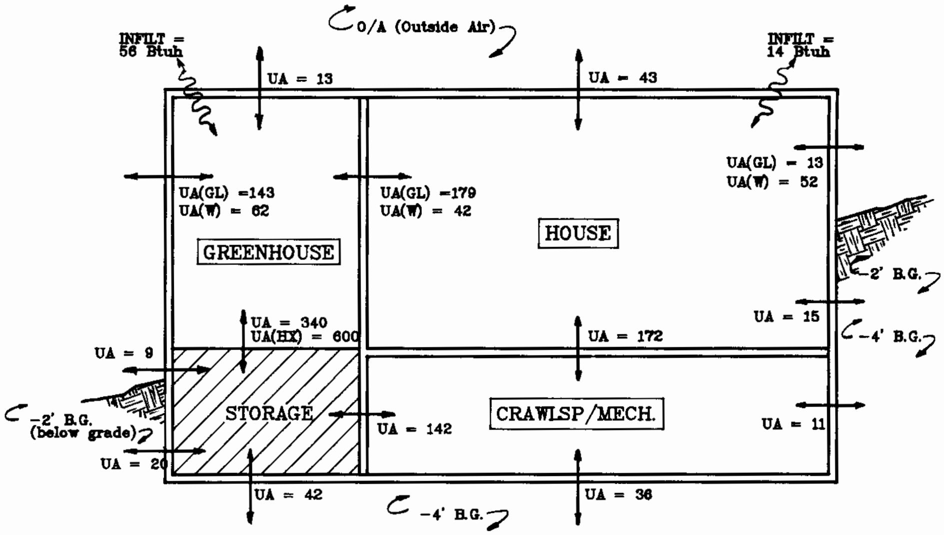
The toilet also functions as an exhaust plenum for the house ventilation system. Two exhaust ducts connect the composter enclosure to a roof-mounted gravity exhauster which is used to maintain negative pressure in the composter, relative to the house. One duct is connected directly to the roof exhauster plenum; the other is connected through an air-to-air heat exchanger. Ducts from the kitchen range hood and a second-floor bathroom exhaust grille are connected to the toilet enclosure through a screened inlet opening fitted with a back-draft damper. Any one of three switches in the house will operate the heat exchanger fans: one on the kitchen range hood, one in the second floor bathroom, and one activated by lifting the toilet chute lid.

ENERGY

Calculations show the bioshelter design to be quite efficient thermally. Two features in particular contribute to this predicted efficency. One is the fact that virtually all of the windows in the house open out into an artifical climate that is more like northern Florida than Alaska. The other is the fact that the bioshelter is able to store much of the energy normally wasted in a conventional house (including virtually all of the energy used for heating domestic water) without overheating the living space. In fact, it is primarily use of this "waste" heat that maintains the artificial climate.

I have constructed a simple thermal model of the bioshelter to estimate its long-term performance. On the next page is a diagram of the model, showing heat flow paths between the building and the environment and between the major components within the envelope. Table 1 shows tabulated results of the calculations.

Given the estimated heat input, average outside air temperature, ground temperature, and wind velocity for the date, and assuming a fixed house air temperature of 68°F, the program calculates the equilibrium air temperature of the greenhouse. This is the temperature at which the sum of the gains (from sun, lights, equipment, graywater, and heat gain from the house) balances the loss to the environment. The program then calculates the net total system loss (i.e., greenhouse+house+storage) to the environment, using these internal temperatures. During the transition months when the average equilibrium temperature of the greenhouse exceeds the house set temperature, the excess heat available will be used to heat the house, so the program subtracts this quantity from the calculated house heating load, and the equilibrium temperature of the *total* system is then calculated (instead of just the temperature of the greenhouse/storage portion).



HEAT FLOW PATH DIAGRAM (Not to Scale)

Given values are the product UA where U is the heat transfer coefficient given in (btu/hr)(ft²)(°F) and A is the component area in square feet. The overall building UA to the environment is 530 btu/hr. GL = Glass; W = Wall; HX = Heat Exchanger.

The program does not allow for time lags or response factors for heat flow through the storage mass and building components. It assumes average daily temperatures and does not account for fluctuations or variations in intensity that will actually occur in real life. However, it should be sufficiently accurate for purposes of estimating long-term performance. Two factors which help justify these simplifications are (1) the large amount of thermal capacity relative to the rate of gain or loss, and (2) the ability to add and remove heat from storage at a controlled rate, with a fan and heat exchanger.

It is beyond the scope of this article to provide complete program listings or detailed computer printouts, but basic calculation methods used, program notes, and some conclusions are listed below.

PROGRAM NOTES AND CALCULATIONS

- Solar heat gain factors are calculated for 61 degrees north latitude, using the method described in the 1977 edition of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' (ASHRAE) handbook, Fundamentals, chapter 26. Values are assumed to be a monthly average, calculated for the twenty-first day of each month. Site shading is accounted for. High performance (Heat Mirror™) glazing is used, with a shading coefficient of 0.70, U = 0.26. Inside glass is Thermopane™ with U = 0.56. Net solar gain is computed as follows:

Total = SHGF (% Possible Sun) (A) (SC) (% Absorbed in Space)

Table 1. Annual Heating Performance

Month	Avg. Temp. Outside Air (°F)	Avg. Temp. Ground @ 2' depth	Avg. Wind (mph)	Greenhouse Loss (btu/hr)	Greenhouse Gain (btu/hr)	Greenhouse Eq. Temp. (°F)	Excess Gain (btu/hr)	House Loss (btu/hr)	Total System Net Loss (btu/hr)	Days per Month	Aux. Heat Required (btu/mo x 10^6)
January	20	31.7	6	4631	4635	47.1	0	11932	11932	31	8.88
February	26.6	31	6.6	7287	7290	54.5	0	9158	9158	28	6.15
March	32.8	29.5	6.7	9691	9695	62.3	0	6373	6373	31	4.84
April	43.8	30.4	7.1	9584	9585	68.5	0	3892	3892	30	2.80
May	55.2	32.1	8.4	6150	9113	68.5*	2963	2838	0	31	0
June	62.9	35.3	8.2	5494	8078	73.5*	2585	2498	0	30	0
July	65.6	48.8	7.1	5720	8138	77.5*	2418	2258	0	31	0
August	63.8	53.1	6.5	5546	8398	76.2*	2853	2703	0	31	0
September	55.7	51.1	6.1	6227	8015	71.1*	1825	1788	0	30	0
October	41.8	46.4	6.4	6300	6298	62.1	0	4787	4787	31	3.56
November	28.3	35.1	6.1	4320	4318	50.8	0	9860	9860	30	7.10
December	20.6	32.7	5.9	2966	2969	44.3	0	12733	12733	31	9.46
Annual	43.09	38.1	6.76								42.8

*Total system (vs. greenhouse) equilibrium temperature.

• Climate data, including average air temperature, wind velocity, and percent of possible sunshine, is from the National Oceanic and Atmospheric Administration (NOAA), using Anchorage statistics. Ground temperature data is from the Institute of Agricultural Sciences (University of Alaska) for Anchorage. Infiltration is calculated using the crack length method described in the 1977 ASHRAE Fundamentals book, chapter 21. The program uses values from Tables 2, 3, and 4. The total pressure difference is assumed to be the sum of wind and thermal pressure differences, calculated as follows:

$$P_{thermal} = 0.52\ (14.7\ \text{psi})\ (\text{Building Ht.})\ (1/T_{out} - 1/T_{in})$$

(T is in degrees Rankine)

$$P_{wind} = (\text{fpm}/4005)^2$$

• It is assumed that 90 percent of the heat from domestic hot water remains inside the envelope. Estimated consumption is 75 gal/day heated 50°F. Total gain is computed as follows:

$$\text{Total} = \text{gal/day}\ (8.3\ \text{lb/gal})\ (T_{in} - T_{out})\ (\%\ \text{To Space})$$

• Direct gain calculations to the greenhouse from lights and equipment assume sixteen 40-watt tubes turned on for 12 hours per day, two 1/4-horsepower pumps, and one 1/3-horsepower fan on for 8 hours per day. Gain is computed as follows:

$$16\ (40\ \text{watts})\ (12\ \text{hr}) = 7.68\ \text{kwh/day}$$

$$(1/4\ \text{hp} + 1/4\ \text{hp} + 1/3\ \text{hp})(0.746\ \text{kwh/hp})(8\ \text{hr}) = 4.97\ \text{kwh/day}$$

$$(7.68\ \text{kwh} + 4.97\ \text{kwh})\ (3413\ \text{btu/kwh}) = 43{,}185\ \text{btu/day}$$

$$\text{Avg. Daily Operation Cost} = 12.65\ \text{kwh}\ (\$0.075/\text{kwh}) = \$0.95/\text{day}$$

• The average internal gain to the house is assumed to be 2000 btu/hr. This includes heat from solar gain (there is a reflector on the skylight), people, lights, appliances and composter. This estimate is based on energy use in our present house. The program subtracts this quantity directly from the calculated heat loss from the house. (Rather than using a reduced internal temperature base, i.e., 65°F, to allow for miscellaneous internal gains, I feel it is more accurate to subtract the internal gains directly from the calculated loss.)

• The model predicts an annual auxiliary heat requirement of 4.28×10^7 btu. Assuming a natural gas cost of $0.25/100 ft³, an electric rate of $0.075/kwh, a fuel oil cost of $1.00/gal, 85% annual fuel use efficiency (AFUE) for gas, 80% AFUE for oil, the estimated annual heating costs for the various fuels would be as follows:

$$\text{Natural Gas} = \$0.25/100\text{ft}^3 \left(\frac{4.28 \times 10^7\ \text{btu/yr}}{0.85\,(100{,}000\,\text{btu}/100\,\text{ft}^3)}\right) = \$125/\text{yr}$$

$$\text{Electricity} = \$0.075/\text{kwh} \left(\frac{4.28 \times 10^7\ \text{btu/yr}}{3413\ \text{btu/kwh}}\right) = \$940/\text{yr}$$

$$\text{Fuel Oil} = \$1.00/\text{gal} \left(\frac{4.28 \times 10^7\ \text{btu/yr}}{0.80\ (138{,}000\ \text{btu/gal})}\right) = \$388/\text{yr}$$

• The combined heat storage capacity of the enclosed concrete, water, and gravel is about 100,000 btu/°F. The overall building U, the UA, is about 530 btu/°F. Dividing the storage capacity by the rate of loss gives us a system time constant of about 188 hours. This ratio expresses the amount of time it would take an existing temperature difference to be reduced to zero if the temperature continued to change at a constant rate. The rate of temperature change is not constant, however, but decreases in proportion to the remaining temperature difference, so that after one elapsed time constant, the temperature difference is reduced by the factor (1 − 1/e), or about 63 percent of the original difference. If we assume a sudden and total loss of all heat input to the house, with a constant outdoor temperature of 10°F, and an inside starting temperature of 70°F, the average interior temperature after 1 time constant (188 hours) would be:

$$70^\circ\text{F} - [(70 - 10)(1 - 1/e)] = 32.1^\circ\text{F}$$

Thus, under these conditions, it would take over one week for the house to freeze. Under more typical conditions, i.e., at average ambient winter temperatures, and with minimal internal gains, it would take somewhat longer for the house air temperature to drop to 32°F.

• Heat loss through the various components of the envelope appears to be fairly well distributed. By contrast, in a more conventional house usually over 50 percent of the total heat loss escapes through the doors, windows, and the cracks around them, though their surface area may account for only a small fraction of the total. As more insulation is added to a house, an ever increasing proportion of the total heat loss escapes through windows and doors. An analysis of a typical "superinsulated" house, with wall and roof R-values of 45 and better, shows that over 90 percent of the total loss occurs through these weak links in the thermal barrier. At its best, removable window insulation is an imperfect solution to the problem.

FINAL WORDS

As noted above, the project is currently under construction. At the time of this writing, we have the first floor enclosed and insulated, with temporary roofing installed on the second floor deck. The spring has been developed, both cisterns (fresh and recycled water) are built and full of water, the greenhouse growing bed/sand filter is in place and operational, and we have water hyacinth cuttings started.

We anticipate completing the project by winter 1985. Construction costs are competitive with more conventional houses, with the cost of the added systems being offset by savings in well and septic system costs. We hope to be able to report on actual performance of the system in the near future. Meanwhile, we continue to be excited by the possibility of applying the concepts developed here to areas (including much of Alaska) where potable water is a scarce and valuable resource.

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INDEX TO VOLUME 16

AUTHOR

SUBJECT/TITLE

Back of the Book

● meetings

Advances in Geotectural Design: The Second International Earth Sheltered Buildings Conference will be held in Minneapolis, June 16-19, 1986. The University of Minnesota will host the four-day meeting of earth-shelter experts from around the globe. A copy of the Call for Papers and more information about the conference can be obtained by writing or calling *John S. Vollum, 222 Nolte Center, 315 Pillsbury Dr. SE, University of Minnesota, Minneapolis, MN 55455;* phone *(612)373-3157.*

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The principal themes of the **8th Symposium on Wastewater Treatment** will be fundamental and applied research, operation of treatment plants, and environmental effects—in short, everything from disposing of sludge to draining off downpours will be fair game for the participants, but the emphases are such that the symposium should be of greatest use to people involved in the technical aspects of municipal and industrial wastewater treatment.

Dates for the meeting are 19-20 November 1985; location is the Hotel Méridien in Montreal, Quebec. For further information, write *Mr. Alain Jolicoeur, Chief, Technology Transfer and Training Division, Technical Services Branch, Environmental Protection Service, Environment Canada, Ottawa, Ontario K1A 1C8, Canada.*

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The fourth international symposium on **Utilities Delivery in Cold Regions** has been scheduled for 4-6 November 1985 at the Edmonton Convention Centre in Edmonton, Alberta, Canada. The objective of the meeting is to promote the exchange of information on new concepts, designs, and installations for water, wastewater, solid waste, and energy systems in cold regions. Subtopics will include regional summaries, system planning, public health considerations, conservation of water and energy, fire protection, technology developments, performance prediction, and system case studies.

The symposium is sponsored by the Environmental Protection Service, Environment Canada; the Department of Civil Engineering, University of Alberta; the Civil Engineering Department, University of Alaska-Fairbanks; and the Environmental Engineering Division, Canadian Society for Civil Engineering. More detailed information is available from *Dr. Daniel W. Smith, Department of Civil Engineering, University of Alberta, Edmonton, Alberta T6G 2G7, Canada.*

● publication

Simply titled **The Guide and The System** is a double package of materials intended to help building owners and designers deal economically with the requirement to make public facilities accessible for handicapped people. The package includes illustrated design solutions, product literature, copies of national standards, slides accompanied by a narrative tape, a step-by-step building survey complete with reproducible forms, and a self-evaluation checklist. The materials were designed by Ronald L. Mace, AIA, an architect who is also disabled. The Guide and The System can be purchased from *Information Development Corporation, 360 St. Alban Court, Winston-Salem, NC 27104,* for just under $300—but more detailed information is available free from the same address.

● letter

Squeak-hater speaks. . .

Editor:

The article "Energy Saving House for Southcentral Alaska" by Debra and Ronald Bisset (*TNE* 16:3) I found most amusing in its naiveté, to wit: ". . . floors will be constructed . . . with two layers each way of *rough sawn decking* . . . covered with half-inch particle board . . ."

This person is obviously fond of floors that crack, squeak, are uneven and wavy and will ruin whatever finish floor is applied.

This is just one example of many and it typifies the ignorance of the properties of building materials expressed in the article.

The economic breakdown tends to overlook such items as the not-inconsiderable cost of loading and hauling the many tons of stone used in the foundation, the benefits of which are absolutely lost to me. I can't understand why anyone would propose to pay $10,000 engineering fees for a two-bedroom house—ludicrous!

Bluntly yours,
Larry Kozycki
Fairbanks, Alaska

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