

The Cold Bus Problem

Professor Eb Rice
Dept. of Civil Engineering
University of Alaska
Fairbanks, Alaska 99701

Dear Professor Rice:

Re: Report on Eliminating Problem of Cold Buses
Frost Heave Bus Lines, Inc.

Per your oral request of Tuesday, I am hereby transmitting my report suggesting possible solutions to the "cold bus problem" of Frost Heave Bus Line Service. This report is submitted in partial fulfillment of the term paper requirement for Course No. 604, "Arctic Engineering."

The solutions presented in this report were purposely made general and independent of the characteristics of the particular bus, to allow for the possibility that Frost Heave might either replace or augment their fleet. Whether or not you transmit my suggestions to Frost Heave Bus Lines is left to your discretion; however, it is expressly understood that any consulting fee received from the Bus Line will be split in proportion to the value of the suggestion.

I hereby represent and warrant that the findings contained in this report are submitted without prejudice or regard to remuneration; that I have no present or future contemplated interest in Frost Heave or any other bus line, or any of the companies manufacturing or marketing any of the products or ideas mentioned in this report. By accepting this report, the user of this information agrees that the liability of the undersigned for any costs or damages, including legal fees, incurred because of conflicts with governmental regulations including federal, state, and local laws, infringement of patents or copyrights, lawsuits, or any other cause, arising from the implementation, application, or misapplication of this report, will be limited to the amount of the fee received for this report, and that all other liability on the part of the undersigned is expressly and hereby dissolved.

It is only with the above considerations, waivers, and disclaimers in mind that the attached report is hereby submitted for your consideration. If I can be of any further assistance with regard to this problem, please feel free to call on me.

Yours truly,



Edgar P. Ulbricht
Student of Arctic Engineering

cc: my attorney

Background

It has come to the attention of the Frost Heave Bus Line Company, a certified common carrier operating round trip service between Fairbanks and Anchorage, that several passengers have been making complaints regarding alleged low temperatures in the passenger area of the bus. Investigation by the Bus Company has revealed that the interior of the bus is in fact cold enough to cause some passenger discomfort. Repeated attempts by the Bus Company to raise the bus temperature have failed. The Company is concerned lest they lose passengers to either other carriers or frostbite. They have appealed to Professor Eb Rice and his students of Arctic Engineering to suggest possible solutions to their predicament.

Method of Attack

Normally in making an engineering analysis it is a good practice to examine the object being engineered: in this case, the bus. Such analysis would include information on the following items:

- A. Physical dimensions of bus
 1. Length
 2. Width
 3. Height
 4. Window-size
 5. Size and location of doors
 6. Interior partitioning, if any
- B. Thermal properties of bus
 1. Materials of construction
 - a. Metal type and area
 - b. Glass type and area
 - c. Other
 2. Insulation
 - a. Type and thermal conductivity in

walls, ceiling, and floor

b. Leaks causing drafts

3. Type of seat cushions

C. Engine Characteristics

1. Size

a. Displacement

b. Horsepower

2. Type (gasoline/diesel)

3. Cooling System

a. Capacity

b. Size of radiator

c. Capacity of cooling fan

D. Interior heating system

1. Source of heat (engine or other)

2. Heat distribution system

a. Type

b. Capacity of fan(s) or other distribution aids

c. Number and location of distribution points

3. Theoretical heating capacity of system

4. Measured heating capacity

5. Moisture content of air

E. Passenger Statistics

1. Seating capacity of bus

2. Average number of passengers per trip

3. Size and weight of passengers

4. Physical condition of passengers

5. Typical passenger clothing

6. Passenger common sense failures

a. Sitting alone

b. Blocking heat flow with luggage

c. Leaning against exterior wall

d. Opening windows

Additional pertinent factors might come to light as the analysis progressed.

However, in the present investigation the above information was purposely not obtained so that the inquiry would not be prejudiced by obvious solutions. Instead, general guidelines have been prepared for elimination of complaints about bus temperatures. The suggestions are presented under the headings of heating system, insulation, and psychological factors, in reverse order.



The ride through the Alaska Range can be breathtakingly beautiful, provided passengers have not been overcome with hypothermia.

PSYCHOLOGICAL FACTORS

Several methods of stopping complaints have a proven record of success. The simplest approaches are a form of psychological warfare. The easiest solution is to stop running the bus in winter. This is called diverting the passengers' attention. Their problem is no longer frigid discomfort, but rather how to get between Fairbanks and Anchorage. This solution is said to create alternative problems of busline revenue. These problems might be resolved by converting the bus to a freight operation. Depending on the actual internal temperature of the bus, it might be used to transport orchids, furs, or Eskimo ice cream, presuming that permission could be obtained from the appropriate regulatory bodies.

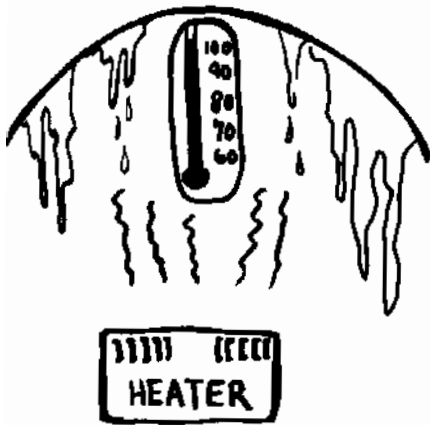
Another solution is to carry hardier human cargoes — such as hockey and curling teams dressed in full uniform. In fact it might pay to remove all the seats and install benches along the walls of the bus, flooding the central area to form an ice rink. Skate rental and hot dog concessions would make the improvements financially self-supporting.

If adequate insurance coverage could not be obtained for passenger participation, spectator sports could be substituted. Midget hockey games could divert the passengers during the long, cold ride to Anchorage, with the return trip featuring something on the order of Holiday-on-Ice.

Once the passengers realized the correlation between the entertainment and the temperature, they would clamor for less heat to prevent melting of the ice.

Less radical expedients include installation of a large thermometer (not necessarily accurate) immediately above the heater, and the painting of warm murals on the walls. Care must be exercised to avoid excessive contrast, however. Too much contrast could invoke a reverse response, as might occur if the bus were decorated with bikini-clad bathers on Waikiki Beach. Appropriate subject matter for the murals might include people cutting lawns and painting their houses. The remainder of the interior should be painted in colors that induce a warm feel-





The thermometer needn't be accurate.

ing, such as the reds, pinks, oranges, pumpkin, squash, tomato, paprika, cayenne, and chili.

Another aspect of psychological temperature is passenger mood. If passengers are reserved and unfriendly, the ride will seem colder. Getting the passengers to talk will warm up the air (a resident politician might be a worthwhile investment) and animated arm gestures will circulate the warm air. The next step is singing and games, which could be profitably enhanced by the introduction of a beer concession. Hot chocolate would warm the tummy, but beer warms the whole body in addition to improving the singing. Wine, on the other hand, warms the soul, and might appeal to a more sophisticated clientele.

The feeling of warmth and *gemütlichkeit* will be further enhanced by asking the passengers to remove their heavy outer garments as they enter the bus. These garments usually contain cold air, so this suggestion goes beyond the merely psychological level. The removal of these barriers to movement and contact will stimulate social involvement. If this suggestion is carried to extremes, a sleeping bag concession may be the ultimate solution to the entire situation.

All the above approaches are directed against the coldness in the passengers' minds. However, if the problem persists in their toes, more physical solutions may be necessary.

INSULATION

Since the heat produced by all sources — including the heating system and the

passengers' own metabolisms — is miniscule when distributed throughout the earth's atmosphere, our attention is directed to methods of retaining this heat within the bus. Inexpensive methods of reducing heat loss probably begin with carpeting on the floor and curtains on the windows. If the passengers persist in breathing, thereby raising the moisture content of the air to the point that condensation occurs on the glass, the curtains will unfortunately increase the frost build-up and the frost will eventually render the windows useless. This is actually a blessing in disguise, since the windows can then be eliminated, or at least covered over with either shutters (for a seasonal heat barrier) or sprayed insulation (rather harder to undo for the summer).

Even if windows were given away free, they would be a bad investment for a bus in winter. Thirty to forty times as much heat input is required to compensate for heat loss through windows compared to walls.

Windows do have good psychological effects. Even when frosted to total opacity, they dispel insecurity and apprehension by providing an obvious means of escape when the bus turns over. Therefore it may be decided to retain them; if so, they should be small and double glazed.

The entire outside of the bus could be coated with styrofoam or urethane. Solid

styrofoam boards are bulky and would not mold tightly to the bus. Sprayed urethane foam has a lower initial thermal conductivity value than sprayed styrofoam (0.13 compared to 0.21) and therefore is better at first; however, with time the urethane loses its entrained freon gas to the atmosphere, and insulating quality is equalized. Peeling or flaking of the external insulation could be forestalled by enclosing the insulated bus in an additional permeable exterior skin. The entire external insulation idea has the side benefit of providing additional energy absorption in a crash.

In no case should foam be sprayed on the inside of the bus. The walls of the bus would act as a moisture barrier, and the trapped water vapor would impair the insulating properties of the foam. Several people have reported good results with foam sprayed into the wall cavity. Drawbacks of this procedure include the difficulty in directing the placement of the foam, and possible interference with the opening and closing of windows and other operating gear.

A very objectionable personal heat loss can be minimized by replacing the heat-absorbing plastic seat covers with reflecting materials. If the cost is prohibitive, second-hand army blankets will do the job.

Consideration should be given to elevating the seats (or alternatively, to



A beer concession is a good idea.

lowering the ceiling) on the theory that heat rises. Raising the seats provides additional cargo area beneath. Scenicruiers have a center walkway with more headroom, and a few front seats left at floor level for old ladies and wheel chair patients.

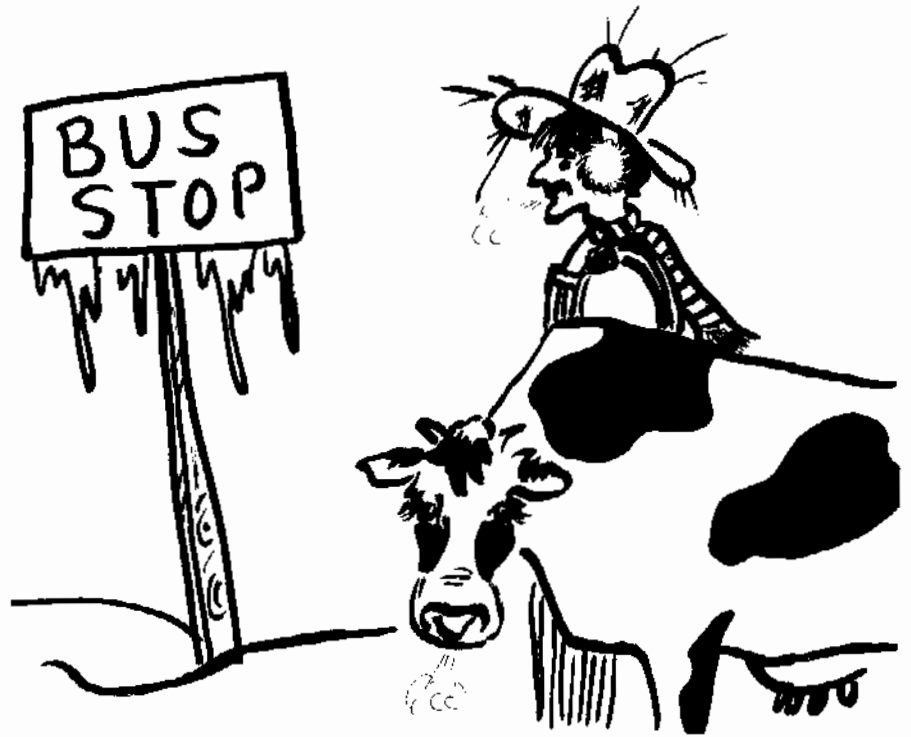
Interior partitioning of the bus into compartments would prevent dispersion of the body heat of small groups of passengers into empty areas of a partially full bus. A separate entryway around the door would avoid potential drafts.

HEATING SYSTEM

Conventional heat sources normally included as standard equipment on buses will have been investigated *ad nauseum* by the Bus Company. Therefore this discussion will be limited to less conventional approaches. Except for the passengers themselves, biological heat sources have probably been overlooked.

It is strongly recommended that heat-releasing cargoes be carried in the storage space under the seats. Green pea silage would be a good choice, although perhaps hard to come by. As the material ferments, it will release heat into the interior of the bus. Half-price fares should be given to any farmers traveling with one or more cows. Cows give off tremendous quantities of heat, and they would offer a ready market for the pea silage stored under the seats. The manure would be used to fertilize the plants in the window boxes. The green plants convert solar radiation into heat, in addition to absorbing excess CO₂ from the exhaust fumes, which would be vented into the passenger compartment as a further heat source. Heat-absorbing evapotranspiration of the plants can be reduced by failing to water them, coating the underside of the leaves with vaseline, and packing the plants tightly together.

An obvious, but sometimes ignored, heat source is our sun, affectionately known as "Old Sol." He does a better job at some times of the day than at others; bus schedules should be planned accordingly. Since temperatures tend to be lower in Fairbanks than in Anchorage, Fairbanks arrivals and departures should occur around 2:00 p.m. Naturally the bus should take the shorter route, Highway 3, which happens to coincide with areas of less extreme temperatures, rather than the Richardson Highway-Glenn Highway



Half-price fares should be given to farmers traveling with one or more cows.

route, where lower "lows" are encountered.

The passengers might be induced to supply heat to the bus in the form of hot water bottles. These would be filled from the radiators of their cars prior to boarding the bus. Eventually the hot water bottles will reach an equilibrium temperature. However, at the end of the trip the contents can be poured back into the passenger's car. Since the inside of the bus is at a higher temperature than the ambient air, the effect on the car will also be beneficial.

Of the various electrical heaters, heat lamps installed in the ceiling should not be omitted from consideration.

Of the combustion systems, a Yukon stove or other woodburning facility possesses a special advantage. There is an old adage that wood warms a person twice: once when he tries to start his chain saw to cut it, and again when he burns it. The stove could be economically supplied with fuel by taking out a wood-cutting permit from the Bureau of Land Management. The bus could stop for periodic wood-cutting breaks, in which the coldest passengers would be allowed to improve their circulation while filling the woodbox.

According to the adequacy or inadequacy of the oxygen supply, com-

plaining passengers might be silenced by the stove in still another way.

CONCLUSIONS

A number of suggestions, some more facetious than others, are presented for maintaining morale, retaining presently available heat, and introducing additional supplies of heat. However, in all seriousness, I feel that the most effective measure would be to reduce the initial load on the heating system by delivering warm passengers to a warm bus. The problem is then reduced to one of maintaining a temperature level.

At each stop, the bus should ideally be loaded and unloaded in a heated garage connected internally with a heated waiting room. Where this is impractical, heated air should be piped into the bus to pre-warm it, and all passenger, luggage, and cargo movement and loading should take place in short, covered walkways, similar to those used by airlines.

Gar Ulbricht, formerly the District Soils Engineer for the Milwaukee Metropolitan District of the Wisconsin Division of Highways, is now a Soils Engineer with R & M Engineering and Geological Consultants, Inc., Fairbanks, where he is working on thaw settlement and construction problems related to the Trans-Alaska Pipeline. He is a member of the Highway Research Board's "Environmental Factors other than Frost" subcommittee.