ENGINEERING TECHNICAL INFORMATION SYSTEM

FIELD NOTES ● TECHNICAL REPORTS ● TEXTS
DATA RETRIEVAL ● CURRENT AWARENESS

Field Notes

Volume 7 Number 2 February 1975

FOREST SERVICE ● U.S. DEPARTMENT OF AGRICULTURE

ENGINEERING FIELD NOTES

This publication is a monthly newsletter published to exchange engineering information and ideas of a technical or administrative nature among Forest Service personnel. The text in the publication represents the personal opinions of the respective author and must not be construed as recommended or approved procedures, mandatory instructions, or policy, except by FSM references. Because of the type of material in the publication, all engineers and engineering technicians should read each issue; however, this publication is not intended exclusively for engineers.

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Invitation to Readers: Every reader is a potential author of an article for FIELD NOTES. If you have a news item or short article you would like to share with other Engineers, we invite you to submit it to FIELD NOTES for publication.

Material submitted to the Washington Office for publication should be reviewed by the respective Regional Office to see that the information is current, timely, technically accurate, informative, and of interest to engineers Service-wide (FSM 7113). The length of material submitted may vary from several short sentences to several typewritten pages. However, short articles or news items are preferred. The Washington Office will edit for grammar only. All material submitted to the Washington Office should be typed double-spaced, and all illustrations should be original drawings or glossy black and white photos.

Each Region has an Information Coordinator to whom field personnel should submit both questions and material for publication. The Coordinators are:

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Coordinators should direct questions concerning format, editing, publishing dates, etc., to Rita Wright, Editorial Assistant, Engineering Staff Unit, Forest Service, USDA, Washington, D.C. 20250.

F I E L D N O T E S

PROTECT YOUR HEARING

By Rob Harrison
Mechanical Engineer, San Dimas Equipment Development Center

The San Dimas Equipment Development Center has recently published an *Equip Tip* that tells you and the field people who work for you how to "Protect Your Hearing." The most overlooked safety hazard facing Forest Service field personnel is noise. It is well established that deafness caused by noise is permanent and excessive noise can cause deafness. No prosthetic device can restore hearing once it has been lost because of exposure to excessive noise.

A recent Executive Order has reaffirmed that Occupational Safety and Health Administration (OSHA) regulations do apply to Forest Service workers. These regulations include a mandatory hearing conservation program. One aspect of the program is the use of personal hearing protectors.

It must be emphasized that hearing protectors are not the final answer in a hearing conservation program. In fact, they are considered by OSHA to be a last line of defense after engineering controls (i.e., silencing noise at its source) and administrative controls (i.e., rotating workers out of noisy areas and regulating their shifts) have failed.

The best hearing protection for a large number of Forest Service work situations is presented in the *Equip Tip*, "Protect Your Hearing." This publication also lists a large number of hearing protectors available commercially and through GSA, and gives reasons in everyday language why workers should use them. It also presents information which, it is hoped, will dispel the old myth that the use of hearing protectors is unsafe because workers cannot hear their machinery, warning signals, or the conversation of fellow workers in a noisy situation. This argument is, of course, invalid. The ability to hear a wanted sound in a background of noise is related to the ratio of the loudness of the wanted signal to the loudness of the noise (signal-to-noise ratio). The hearing protector will cut down the volume of the background noise as much as it will cut down the volume of the sound that the worker wishes to hear. There is no practical difference in signal detection in a background of noise whether the worker is wearing hearing protection or not.

A number of jobs, such as road construction and maintenance, shop work, building construction activities, vehicular and other transportation activities, fire fighting, road and trail construction, timber cruising, and off-road vehicle activities, are included in the *Equip Tip*

The *Equip Tip,* "Protect Your Hearing," is available directly from the San Dimas Equipment Development Center. Also available is a wide variety of specialized technical publications dealing with acoustical engineering as it applies to the Forest Service. Reports covering the noise of slash disposal equipment; the measurement, control, and effects of the noise of off-road vehicles, including dune buggies, all-terrain vehicles, snowmobiles, and motorcycles; and the effectiveness of motorcycle helmets as hearing protectors may be requested directly from the San Dimas Equipment Development Center.

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COMPUTERIZED SLOPE-STAKING

By Charles Peterson
Civil Engineer, White River National Forest, Region 2

INTRODUCTION

In the past few years, the Forest Service has seen great strides made in computerized road design. The design engineer has made the move into the electronic age. But what about the engineer responsible for construction staking these computer designed roads? He is still using the same method that he has been using for years. There is a better way: the traditional method of using horizontal chain and vertical road can be improved upon by using a slope chain and abney. Previously, the mathematical computations involved in converting slope distance to horizontal and vertical distances have been too involved for field personnel. The introduction of the HP-65 programmable calculator by the Hewlett-Packard Company has changed this.

The HP-65 is a hand-sized, battery-powered mini-computer or programmable calculator costing about $800. It has a capacity of up to 100 program steps. Programming is done through the keyboard with programs being stored on magnetic plastic strips.

This calculator runs on a battery pack with an operating time of about 3-1/2 hours. To allow a full day's operation, a spare battery pack must be carried. Both the HP-65 and the spare battery must be recharged nightly; an additional charging unit is necessary to charge the spare battery.

The HP-65 is quite durable and acceptable for outdoor operation. However, it is an expensive piece of electronic equipment and should be treated with care to avoid excessive dirt, moisture, and impact.

The operating efficiency of the calculator is totally dependent upon the skill of the operator. The operator must have a thorough knowledge of how to stake a slope and how to work the machine. Without such knowledge, the operator is incapable of detecting errors caused by erroneous input.

PERFORMANCE

For about two months our survey has been using the HP-65, and productivity has increased by about 30 percent. We have found that the steeper the terrain and the thicker the vegetation, the more time the crew saves.

The ideal crew size is four or five, depending on P–line offsets and the difficulty of finding P–line stakes. When P–line offsets are great and previous P–line stakes are difficult to find, a five-man crew is ideal.

The crewmen's tasks are as follows:

Crew chief – Oversees whole operation, helps new crew members, and deals with field engineering problems.

Notekeeper – Runs computer and keeps notes.

Experienced instrument man – Helps inexperienced crew members, writes stakes, and operates abney.

Crew members – Hold rod, chain offsets, drive stakes and flag, and go ahead and set new L–line.

THE PROGRAM

The program input consists of data taken directly from the Road Design System Catchpoint printout and from measured topographical data. The program output consists of an error indicator, suggested slope distance for anticipated slope–stake catch, and slope–stake data to be written on the field stake. The slope–stake data is the cut or fill from catch to hinge point (fill shoulder or ditch bottom) and the horizontal distance from centerline to catch point.

CONCLUSION

This method of slope-staking can save time and increase productivity, provided that a responsible, well-trained, and conscientious operator is available to direct the process. For further information on programs, equipment, inputs, and controls, contact:

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Editor's Note: *You should examine all available programmable calculators prior to making an investment in any particular one. This article should not be construed as an endorsement of the HP-65 by Engineering or the Forest Service.*

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USING THE AREA FACTOR FOR OPTIMIZING EARTHWORK DURING ROAD DESIGN

By Lorne E. Hanna
Highway Engineer Technician, Siuslaw National Forest

INTRODUCTION

The Area Factor option in the Region 6 Road Design System computer programs provides output values at each station. This makes calculating adjustments quite simple to grade and permits far greater flexibility for the road designer in improving his vertical alignment than the commonly used Unit Mass method.

Unlike the Unit Mass method, which gives the volume change for a 1-foot change in elevation at a given vertical PI and over the total distance to the two adjacent VPI's, the Area Factor method gives adjusted values of the running total horizontal area between stations along the roadway. A simple subtraction between two of these values and division by the amount of volume change needed are all the designer has to do to find the amount of vertical change necessary.

The Unit Mass method of making volume changes is deceptively mechanical. On the other hand, the Area Factor method frees the designer from mechanical restrictions and permits him to exercise better engineering judgement in making vertical alignment changes that balance cut and fill quantities, permit less expensive direction of haul, and require less total excavation.

DEFINITION OF AREA FACTOR

The Area Factor is a running total area of roadway between cut and/or fill catch points at each cross section station along a road, adjusted by a proportion of the compaction factor determined by the ratio of excavation at the station of embankment (fig. 1). It is used for calculating h, the amount to raise or lower grades to optimize excavation, embankment, and haul quantities in the final stages of road design (fig. 2).

How to Get It:

The Area Factor is an optional output in the Region 6 Road Design System and will be listed on the Design Earthwork printout just below the station. It can be obtained by requesting a *2* punch in column 64 of the DES card.

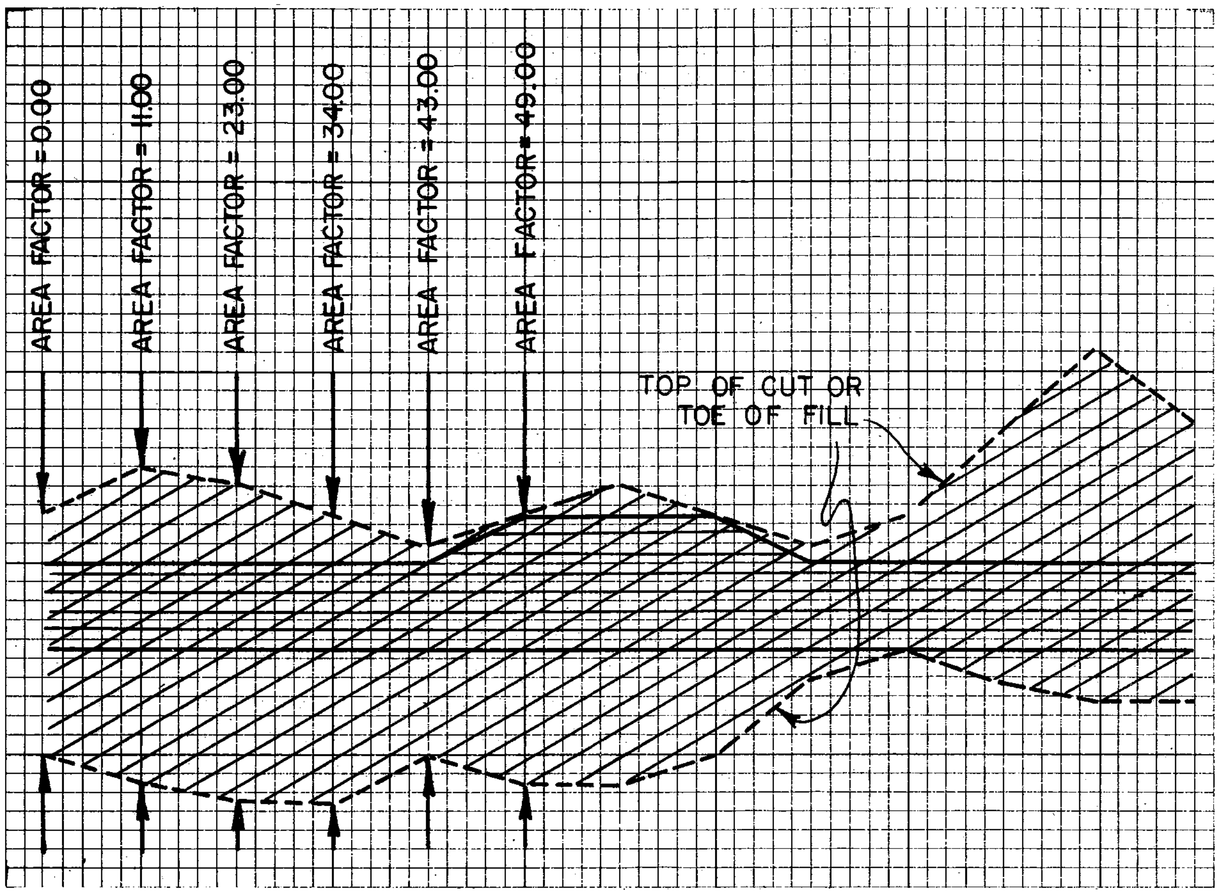

Figure 1. – *Plan view of roadway and possible values of Area Factors.*

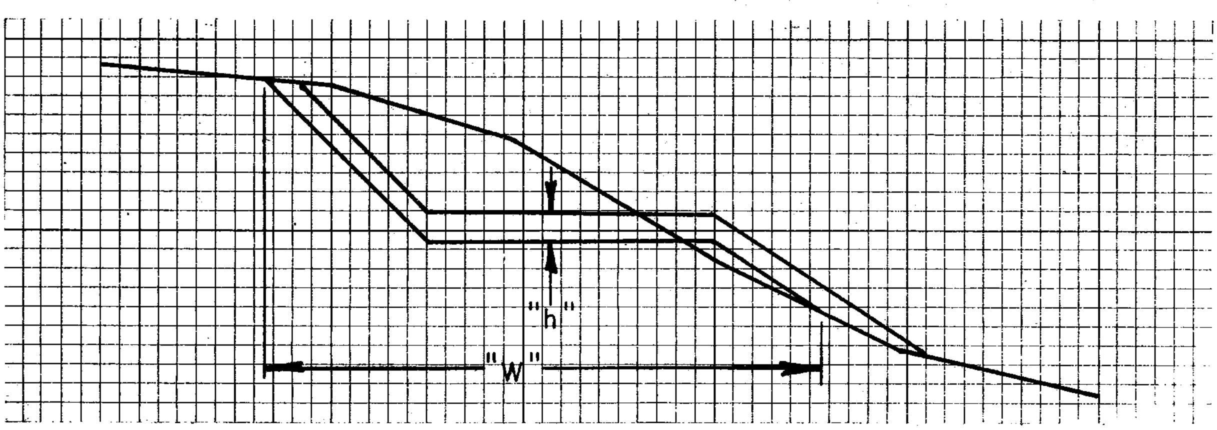

Figure 2. – *The minor difference in width due to changing grade is not significant in the use of the Area Factor.*

How it was Derived:

The formula used to find the Area Factor is derived from the volume formula:

$$V = (h)(w)(l)$$

$$\text{or} \qquad h = \frac{V}{(w)(l)}$$

In order to adapt the formula for this particular use, the area portion, (w)(l), has been isolated and adjusted by an amount of the compaction factor depending on the ratio of excavation or embankment between the two adjacent stations. Finally, this is converted into units to give h in feet when V is in cubic yards.

USE OF THE AREA FACTOR

Examination of the mass diagram in Figure 3 indicates that three mass changes might be desirable in order to decrease the total amount of excavation and reduce haul quantities. The first would be a 200-unit change from station 10+00 to 13+00; the second, a 130-unit change between stations 15+00 and 19+00; and the third, a 70-unit change between stations 19+00 and 22+00.

Since the change is to occur between stations 10+00 and 13+00, the amount of grade adjustment is found by dividing the volume of change desired by the difference of Area Factors at 10+00 and 13+00. If we can assume these factors might be 264.04 and 336.08, the h would be: 200/(336.08 - 264.04) = 0.35. Referring to the profile, there are existing vertical PI's at these two stations. In Figure 4a, it is necessary to *raise* grade to effect the change wanted. Hence, a line parallel to and 0.34 foot *vertically* higher than the existing gradeline is found. The intersection of this new line with the extensions of the existing gradelines, behind the first and ahead of the second VPI's, gives the new VPI's for the revision. Their new stations and elevations can be found either by scaling (accurately enough if the scale is increased to 10:1) or by simple calculations. Be sure to eliminate the old VPI's.

In Figure 4b, the 130-unit change will be to raise grade between stations 15+00 and 19+00. Assuming that the Area Factors are 429.66 at 15+00 and 457.61 at 19+00, then h is: 130/(457.61 - 429.66) = 0.215. In this figure, since the side view of the change on the profile is a triangle, h must be doubled to give accurate results. It is not necessary to place the new VPI in the middle of this revision. The designer can locate it to effect the greatest cost saving in either decreased excavation or haul. A new VPI then is located somewhere between 15+00 and 19+00 at a height 0.43 foot above the existing grade elevation at the point chosen. A new VPI is inserted at 15+00 so that the grade behind 15+00 is not affected, and a new one at 19+00 would be inserted if the one in this example had not been there.

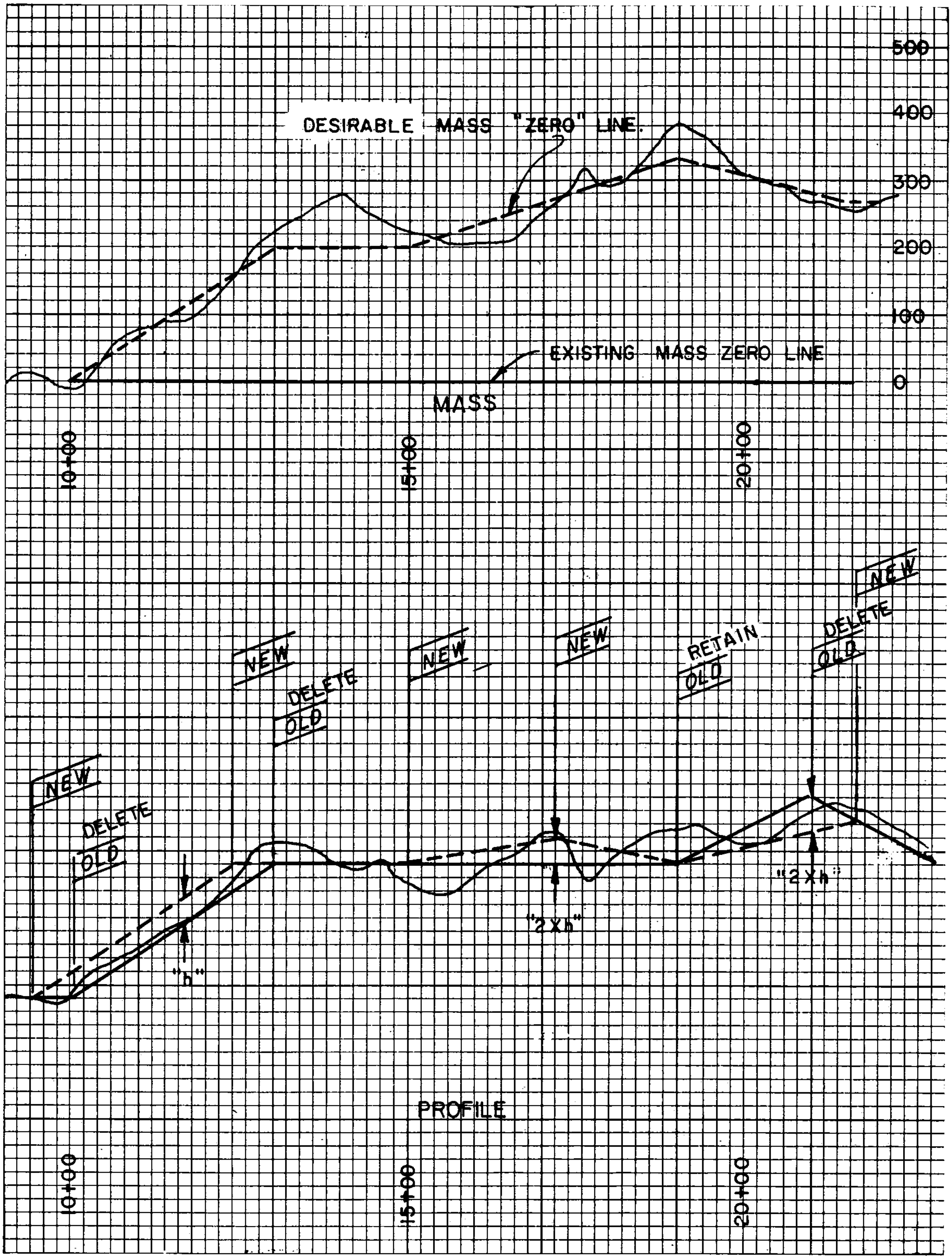

Figure 3. – Mass Diagram.

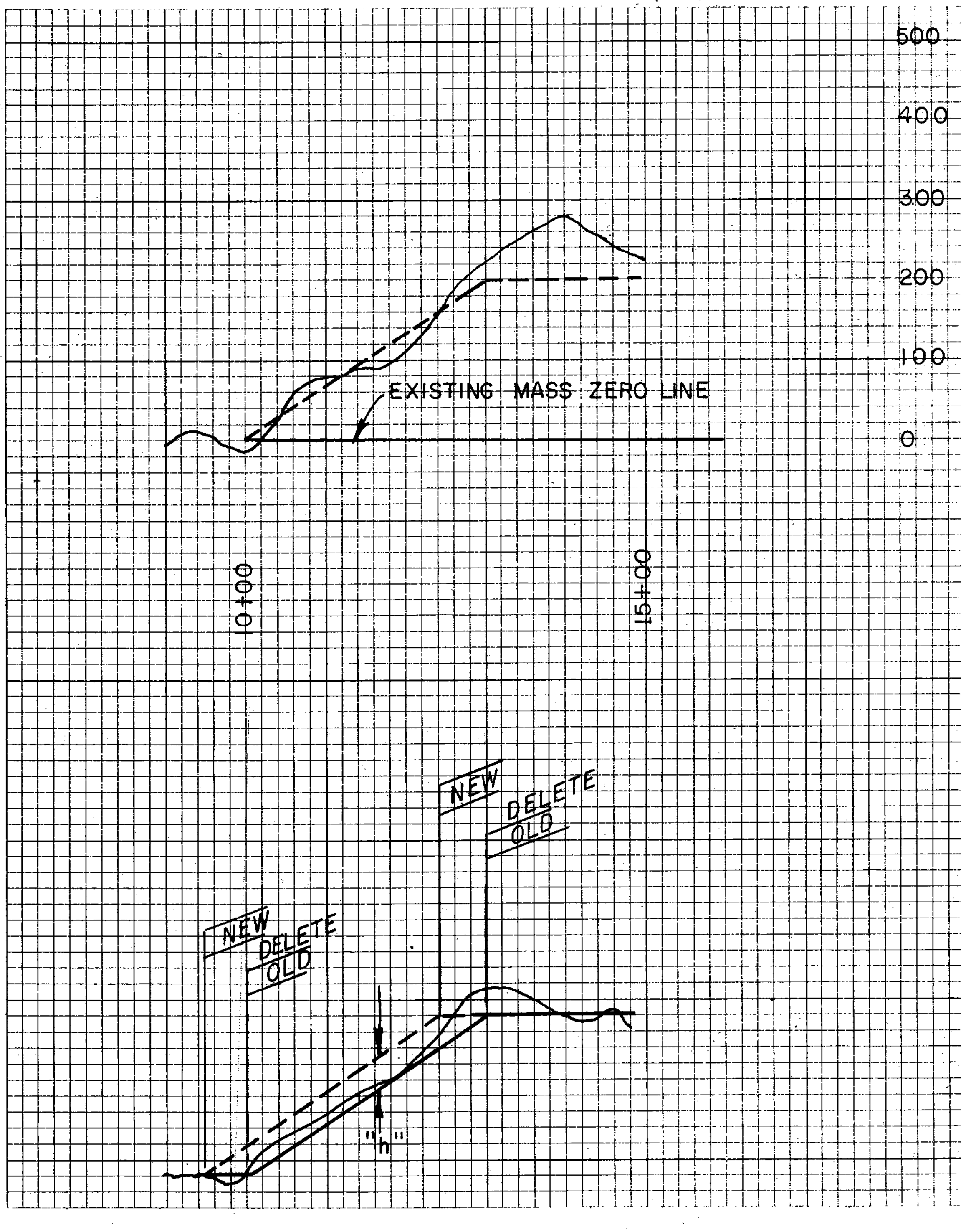

Figure 4a. *— Slab Change.*

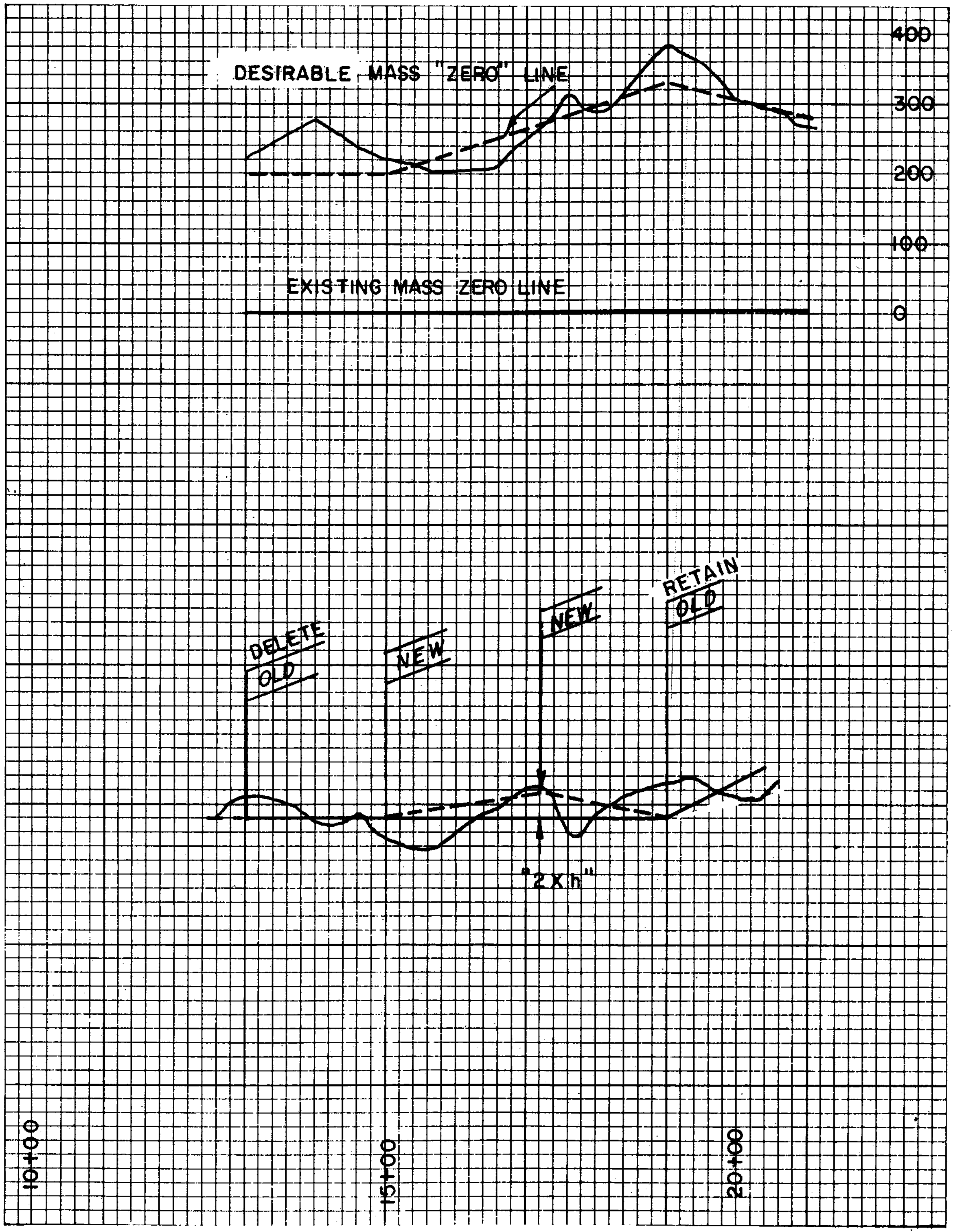

Figure 4b. – Double Wedge.

In Figure 4c, a 70-unit change is needed to lower the mass zero line between 19+00 and 22+00. Using assumed values of 457.61 and 472.10 for these stations gives h equal to 70/(472.10 - 457.61) = 0.207. The profile shows that lowering the grade by advancing the VPI would be an acceptable solution. Since the side view is again a triangle, the h value must be doubled. Hence, a gradeline drawn through a point equal to two times h feet *below* the existing VPI will give nearly the correct grade. The new VPI station and elevation can be found by scaling or by calculation of the intersection of this new gradeline with the grade ahead. Be sure to delete the old VPI at station 21+00. This method is not accurate unless the Area Factor *nearest* the station where the new VPI will be located is used. A variation of this figure would be to lower the VPI at 21+00 an amount equal to two times h feet and insert another VPI at 22+00.

CONCLUSION

Other variations of the use of the Area Factor are possible; indeed, some others are quite necessary as well as desirable.

Many road designers are acquainted with, and use, Unit Mass for marking grade changes. However, the Area Factor seems to be much simpler and provides for greater latitude in making the best revisions for final grades. It can measurably reduce the number of earthwork revisions. Although the Area Factor option is not included in the Road Design System programs at the Fort Collins Computer Center, it might be included if enough requests for it are received.

For further details contact:

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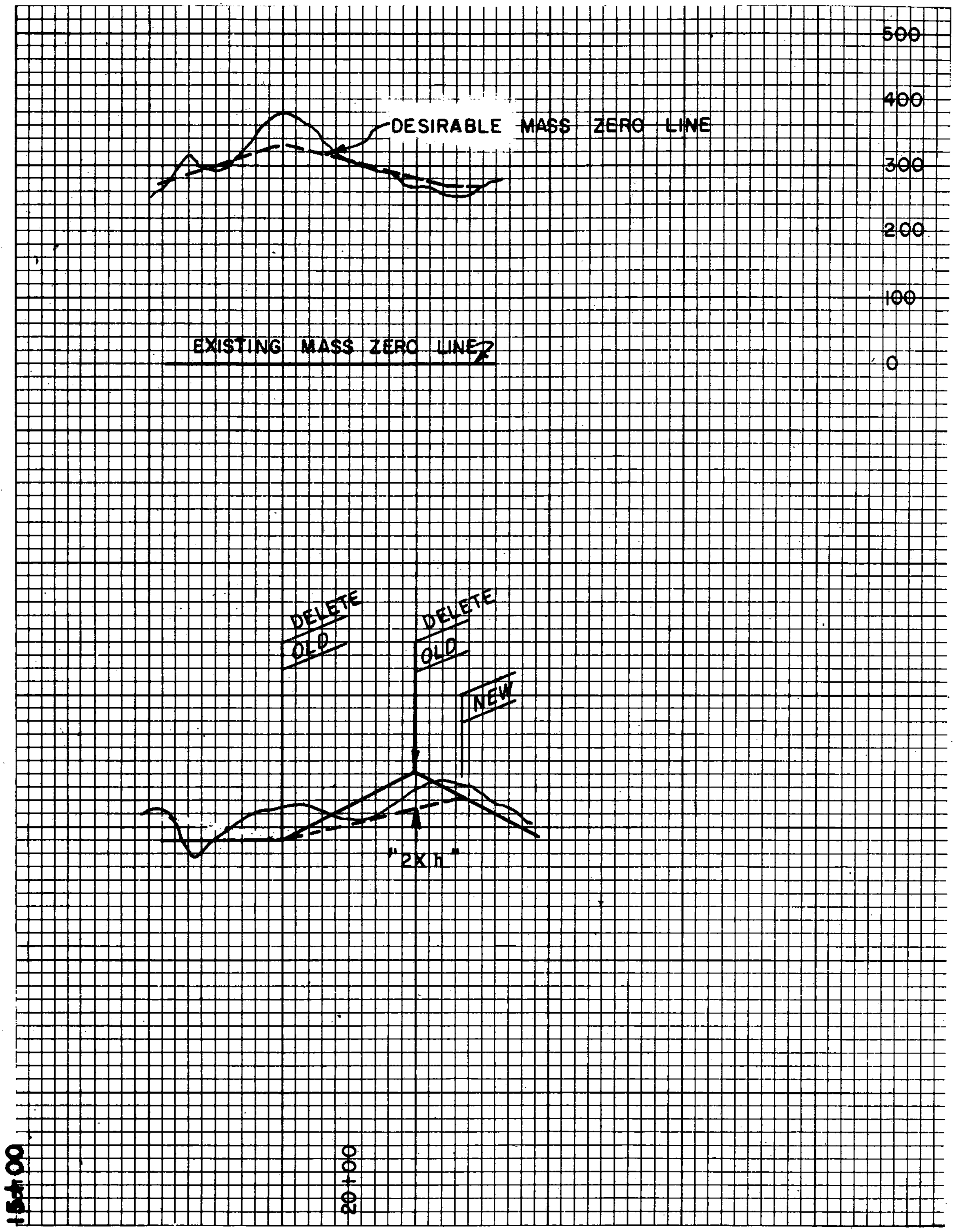

Figure 4c. — Single Wedge.

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COST OF MAINTAINING ROADSIDE DITCHES ON THE MT. HOOD NATIONAL FOREST

By T. L. Pickett
Mechanical Engineer, San Dimas Equipment Development Center

Recently, the San Dimas Equipment Development Center obtained data from which the actual costs of several road maintenance tasks were extracted and some of which are presented here as useful information for field personnel. These data were discovered in the course of ongoing project work at San Dimas when we found that the Mt. Hood National Forest had computerized their road maintenance records. This discovery was very important to equipment development projects at San Dimas and also at the Missoula Equipment Development Center, and the Mt. Hood agreed to supply us with all of their data for Fiscal Year 1974.

The cost data presented do not include any sick leave, annual leave, or other overhead expenses but are limited to actually incurred labor, material, and equipment expenses. Four "activity" codes, or tasks, were accumulated, totaled, and averaged here at San Dimas. These are summarized in Table I and cover most of the work usually associated with roadside ditch maintenance.

The average cost of the "cleaning and reshaping ditches" task on the Mt. Hood National Forest in FY 1974 was about $46 per ditch-mile. The most expensive example seen for this task was $632 per ditch-mile for over 3 miles of ditch. The least expensive noted for the year was $6 per ditch-mile for over 9 miles of ditch. A large variety of equipment was used, including tractors, stakeside trucks, and 4x4 utility trucks. Usually a motor grader with a regular cab pickup or a six-passenger pickup was used, and about 20 percent of the time a front-end loader and dump truck were also used.

The average cost of the "slough removal with end haul" task was $2.23 per cubic yard of debris. The maximum cost was $7 per cubic yard for over 280 cubic yards and minimum cost was less than $1.00 per cubic yard for over 375 cubic yards. This task was usually performed with a front-end loader and one or two 10-yard-capacity dump trucks, along with a personnel-carrying vehicle such as a regular cab or six-passenger pickup. About 40 percent of the time, a motor grader was also used.

The average cost of the "slough removal without end haul" task was $1.58 per cubic yard. The most expensive operation of this task cost $11 per cubic yard for about 30 cubic yards of debris. The least expensive was just under $1.00 per cubic yard for quantities from 40 to 260 cubic yards. For this operation the Mt. Hood National Forest usually used a front-end loader and a personnel-carrying, six-passenger pickup; however, about half the time they used a motor grader, presumably for smoothing the ditch and road behind the end loader.

Table I. – Ditch Maintenance Cost Summary

ACTIVITY	LABOR		EQUIPMENT COSTS ($)	TOTAL COSTS ($)	COMPLETED WORK UNITS	COST PER UNIT ($)
	HOURS	COSTS ($)				
CLEAN AND RESHAPE DITCHES	1,200	6,877	4,279	11,156	241 ditch-miles	46.26/ditch-miles
SLOUGH REMOVAL WITH END HAUL	831	5,024	4,948	9,972	4,485 cu yd	2.23/cu yd
SLOUGH REMOVAL WITHOUT END HAUL	191	1,165	704	1,868	1,185 cu yd	1.58/cu yd
MACHINE CLEANING OF CULVERTS	2,070	11,937	11,807	23,518	2,263 culverts	10.39/culvert

The average cost of the "machine cleaning of culverts" task was $10 per culvert. The most expensive operation of this type cost $195 per culvert. This was for cleaning only one culvert inlet on a road. Usually, when there was only one culvert that needed cleaning on a road, the cost exceeded $100 per culvert. The minimum cost was less than $2.00 per culvert, and this low cost was frequently, but not always, associated with a large number of culverts needing cleaning on a road. The Mt. Hood National Forest used front-end loaders for this task, with regular cab or six-passenger pickups for personnel transportation. About 14 percent of the time they needed dump trucks, and 8 percent of the time they needed a motor grader.

The data for other tasks will remain unpublished for some time; however, if anyone is interested in the cost of a particular task, he may obtain it by contacting the San Dimas Equipment Development Center.

To Center personnel, one of the more interesting aspects of the data presented in Table I is that the total expenditures for machine cleaning of culverts exceeded the combined costs of all the other ditch maintenance tasks.

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FUEL AND MATERIAL SHORTAGES

By Theral R. Neilsen
Consultation and Standards, Washington Office

The recent fuel crisis and subsequent increased fuel costs and construction material shortages have given us cause to take a closer look at our management of the Forest Service Transportation System. Considerable energy and materials are expended in building, operating, and using the road system. Movement of goods and services safely and economically, with consideration given to esthetics and environmental concerns, has been our objective. It should not change, but as energy and resources become more scarce and costly, our solutions to problems relating to planning, design, construction, operation, and user needs become more difficult. This concern, along with the suggestion that opportunities in conservation of energy and materials be explored, was expressed during the October 1973 Regional Engineer meeting.

Road location, design, construction, operation, and use allow for numerous trade-off combinations. Proper management for maximum economy of fuel and construction materials will be increasingly difficult and may require new and different bases for assessment. Some examples are as follows:

- Steep grades work against economy in consumption of fuel. A 5-percent grade requires twice the horsepower needed to negotiate a 1-percent grade. Recent road tests indicate that the road surface condition affects speed and resulting economy. A soft, poorly maintained, dirt surface requires slower speeds and up to three times the energy consumption of an asphalt paved road.
- Excess length costs more than just the extra energy to build and drive over the road. Energy consumed in maintenance must also be considered.
- Balancing the excavation and embankment becomes more important as a measure of energy conservation. Precision in measurements and in shrinkage and swell factors attains more importance.
- Use of renewable resource materials such as timber becomes more attractive.
- Closure of certain roads to reduce maintenance and to allow improvement of the more important remaining roads may be a solution.

During the relatively brief brush with the energy and materials crunch, you've undoubtedly had to make adjustments in your road system management procedures. We would like to hear about your solutions, through either articles to FIELD NOTES or letters to the Editor.

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LETTER TO THE EDITOR

(Reference: FIELD NOTES,
Volume 6, Number 6, June 1974,
Washington Office Engineering News,
Operations, by Harold L. Strickland)

The Forest Service owns and operates many vehicle air conditioners primarily for passenger comfort in high-temperature zones and not for dusty conditions. The intent of the article published in the June 1974 FIELD NOTES was to encourage project managers to carefully examine the need for passenger comfort versus fuel economy in determining whether or not replacement units should be air-conditioned.

As pointed out by Rob Harrison and ED&T Project 1642, factory-installed air conditioning in motor vehicles is the most economical way to reduce dust levels inside vehicle cabs. The Forest Service should continue to purchase air conditioners for vehicles to be used in areas where dust levels inside vehicles will endanger the health of passengers.

Ollie A. Broadway

Equipment Management Engineer
Washington Office Engineering

TECHNOLOGICAL IMPROVEMENTS

Heyward T. Taylor
Assistant Director

SPEL – SPECIAL PRODUCT EVALUATION LIST

Through the joint efforts of AASHO and FHWA, a publication has been prepared documenting the evaluations of many products and materials used in highway construction and maintenance work. Evaluations were made by various State highway departments for nearly 3,000 products in 24 major categories. The information given for each product includes (1) name of product, (2) manufacturer's name and address, (3) description of product and use, (4) State making the evaluation, along with the status of the evaluation (i.e., accept, not accept, pending), and (5) a reference number along with brief remarks or explanation of the evaluation.

The categories in which the products were evaluated are:

- Adhesives
- Aggregates
- Barriers, Fencing and Roadside Structures
- Bituminous Materials and Additives
- Bituminous Rejuvenators and Preservative Treatments
- Culverts and Drainage Structures
- Deicing Chemicals
- Joint Sealers and Fillers
- Mulch and Erosion Controls
- Patching Materials
- Portland Cement Concrete Admixtures
- Portland Cement Concrete Curing Materials
- Portland Cement Concrete Finishing Products
- Reflective Crack Controls
- Rust Passivators
- Skid Control Systems
- Soil Sterilization and Weed Control Materials
- Soil Treatments
- Structural Materials and Components

Structural Paints
Testing and Construction Equipment
Traffic Marking Materials
Waterproofing Membranes and Materials
Miscellaneous

The compilation of information on trade name products is an activity of the AASHO Subcommittee on Materials. The 200-page listing of products was made available to the Forest Service because of its membership and participation in the AASHO Subcommittee on Materials.

Copies of SPEL have been sent to all Regional Materials Engineers, San Dimas Equipment Development Center, and Missoula Equipment Development Center by memorandum dated December 17, 1974 (file designation – 7170 Materials Engineering). The Regional Materials Engineers and the Centers are in the best position to decide on the usefulness of the various trade name products with respect to their use in a forest environment. They should be consulted for further information.

CONSULTATION AND STANDARDS

Charles R. Weller
Assistant Director

LASER RANGE POLE PROGRESS

During a recent survey project on the common boundary between the States of Virginia and Tennessee, another improvement was made which should further increase the efficiency of the Forest Service boundary-marking program.

International Telephone and Telegraph has developed a nighttime sensor which will detect the laser beam at a range of 1 mile. It uses the principle of infrared heat and laser light sensing. To date, it has been tried only at night, but we are working with NASA to develop a daylight model. NASA has expressed the opinion that there will be no restrictions once the units have been engineered for maximum compatibility.

This would significantly reduce the cost of the required instrumentation and should increase outputs. We have not yet evaluated the proper configuration of instruments for maximum production. This modification should eventually put the cost within the reach of most Forest budgets.

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