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TECHNICAL MEMORANDUM

title: "FIELD TRIALS OF AUTOMATIC SURVEYING AND OF EXPERIMENTAL KIT FOR AUTOMATIC CONTROL OF EARTHMOVER BLADE ELEVATION AND TILT, by

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INTRODUCTION

The Civil Engineering Laboratory (CEL), under the sponsorship of the Naval Facilities Engineering Command (NAVFACENGCOM) and for proponents associated with the construction forces of the Navy and Marine Corps, has for several years been experimenting with automatic surveying (reference 1) and with retrofit automatic control kits for construction equipment (references 2, 3, and 4).

Most recently, an experimental automatic blade control kit was developed for the Case 450 tractor with power-tilt and power-angle blade, as stocked by the Marine Corps. Initial laboratory testing (references 3 and 4) showed that the tractor with the kit was capable of performing finish jobs normally requiring a grader in addition to the heavier, rougher tasks on which the dozer is ordinarily used. This report describes field trials conducted in March 1976, to confirm that capability by direct comparison and measurement, and to determine any savings in job time and labor resulting from use of the new equipment. Both the automatic surveying and the automatic blade control kit were included in the trials. The results indicate the savings possible using this equipment are substantial.

A 15-minute audiovisual (reference 5) documenting the field trials has been produced on 16-mm film and on videotape.

BACKGROUND

Automatic Elevation Surveying System

The automatic elevation surveying system employed in these trials is the Laserplane system, available commercially from Laserplane Corporation, Dayton, Ohio.

The "command post" of the system is a light transmitter which establishes a thin reference plane of light having a single wavelength (laser light) over the work area. Inside the command post, the laser light is produced and projected upward through a collimator. This collimates the light so that it will spread very little as it moves through space. On leaving the collimator, the beam enters a 90° ($\pi/2$ radian) prism which reflects the beam into a horizontal direction. The reflected beam leaves the command post through a hole in the side of a cylindrical cap which surrounds the prism. The prism and cap are coupled and driven together by an electric motor so that the beam rotates like that of a lighthouse beacon, except that it is rotated much more rapidly (5 or 10 revolutions/second). The command post is mounted on a tripod and has provision for precise tilting of the reference light plane to slopes from 0 to 10 percent. The slope is normally set at zero for surveying measurements so that the reference plane is level in all directions. For use in control of construction equipment or for checking grades during construction, the reference plane is usually tilted parallel to the desired grade.

The surveyor's rod (Figure 1) used for elevation surveying has a light-filtered photocell detector which is sensitive only to light having the wavelength of the reference plane set up by the command post. The detector slides up and down on the rod. By a combination of visual and audio signals emitted by the detector, the surveyor can quickly adjust the detector so that it is centered on the reference plane of light. When it is centered, he takes a reading of the position of the pointer of the detector against the scale on the rod. A Lenker tape is used for the scale because it can be adjusted so that the pointer gives direct elevation readings.

The command post establishes a flat plane, but the earth's surface is curved. Therefore, elevation readings taken at very long distances from the command post would indicate that the point measured is lower in elevation than it really is. This error is proportional to the cube of the distance from the command post to the point where the measurement is being made. The error at a distance of 1,000 feet (305 meters) is 0.02 feet (0.61 cm). Therefore, it is not generally desirable to take elevation readings at much more than 1,000 feet (305 meters) from the command post unless the resulting readings are corrected to account for the error.

Because of the characteristics of the reference light beam and the detector, and since elevation measurements at ranges of more than about 1,000 feet (305 meters) are not particularly desirable because they contain an inherent error of more than 0.02 feet (0.61 cm) due to the curvature of the earth, the command post uses a low power laser that has sufficient range but does not endanger people in or near the site. Use of the low power laser makes it possible for the system to operate for about 10 hours on a single charge of one 12-volt automobile battery. The system can be used as well at night as in daytime.

One system, consisting of one command post and four surveying rods, was provided to NMCB THREE and subsequently to NMCB FIVE for field trials at Diego Garcia. NMCB FIVE reported most recently (reference 6) that use of the system resulted in a 50 percent reduction in the man-hours normally required for certain types of elevation surveys. The same system will now be used by NMCB ONE THREE THREE for the large number of elevation surveys that must be made in support of the runway extension project at Diego Garcia.

CEL Case 450 Blade Control Kit

The experimental blade control kit developed by CEL is described in detail in earlier publications (references 3 and 4). Briefly summarized, it consists of two separate controls. These are the blade elevation control, and the blade tilt control.

The blade elevation control uses the command post of the Laserplane elevation surveying system to establish a reference light plane over the work area. A receiver on a telescoping mast and a control box, also manufactured by Laserplane, are installed on the tractor. The mast, with the receiver on top, is mounted on a pad behind the tractor blade. The receiver contains photocells which, like those of the detector on the surveyor's rod, are filtered to sense only light of the wavelength of the reference light plane. Once the blade is set to the desired finish elevation and the mast is extended so that the receiver intercepts the reference light plane, the receiver will produce a signal whenever the blade elevation moves outside a 0.02 foot (0.61 cm) range. This signal is amplified in the control box and is used to actuate the solenoid valve which controls the blade elevation cylinders.

The blade tilt control system was developed by CEL and is not commercially available. The key component, invented by the Laboratory because nothing suitable was available commercially, is the angle sensor shown schematically in Figure 2. It consists of a manometer tube made of glass and stainless steel, closed to eliminate fluid evaporation and contamination. The angle is sensed mechanically by the difference in float elevations supported by the fluid, and detected electrically by two photoelectric cells powered by the light source centered between them. Tilting of the sensor causes the floats to partially cover one photocell and uncover the other, generating a signal whose polarity indicates the direction of tilt and whose magnitude indicates the amount of tilt. This signal is processed in a control circuit developed by CEL and used to actuate a solenoid valve which controls the blade tilt cylinder. On the Case 450, the tilt sensor was mounted with a pivot and linkage as shown in Figure 3; this was done so that the sensor output contains no inaccuracies resulting from tractor accelerations or from angling the blade to either side. A hand screw, not visible in Figure 3, is provided for initial setting of the blade at the desired tilt. Once set, the system controls the tilt within about $\pm 0.3^{\circ}$ ($\pm 5 \times 10^{-3}$ radian).

The hydraulic package, Figure 4, contains the hydraulic components of the kit and has a compartment on top for the electrical controls, Figure 5.

It should be noted that this complete kit is easily installed on the Case 450 with no drilling, cutting, tapping, or welding, and that all parts removed from the tractor are reinstalled as part of the kit. The operator can override or turn off either or both of the automatic controls at any time he wishes to return to manual control of the blade.

Applied to a tractor with power tilt blade, the result is a single machine capable of performing the heavy, rough tasks normal to a bulldozer, plus high accuracy finish jobs normally requiring a motor grader. The system can also work day or night, even with relatively inexperienced personnel, without significantly affecting the job results or efficiency. Surveying is minimized or not needed because the rotating light transmitter establishes an accurate reference plane throughout the area in which the work is being done.

DESCRIPTION OF FIELD TRIALS

Purpose

The field trails were conducted to compare and record the efficiency (i.e., labor, equipment, and time) of completing a typical earthwork project utilizing present conventional Naval Construction Force (NCF) construction procedures and surveying and earthmoving equipment versus the efficiency of completing the same project utilizing the CEL-developed automatic controls kit installed on a Case 450 dozer and Laserplane surveying equipment. The test project was considered representative of earthwork typically encountered by deployed NCF units engaged in permanent construction.

Scope

The test consisted of the construction of three 100 foot by 100 foot (30.5 m by 30.5 m) parking areas by personnel (instructors) of the Naval Construction Training Center (NAVCONTRACEN), Port Hueneme. Each area was sloped with a compound grade as shown in Figure 6. In each area, vertical control was referenced to a temporary bench mark so that earthwork involved only filling operations.

Area No. 1 was constructed using standard NCF Table of Allowance (TOA) equipment; Area No. 2 was constructed using the same standard TOA equipment, but with the Case 450 dozer substituted for the grader; and Area No. 3 was constructed using the same standard TOA equipment, but with the Case 450 dozer with automatic blade controls substituted for the grader and the Laserplane surveying system substituted for the conventional level and rod. All operations were conducted on a regular daytime schedule.

Table 1 lists the basic personnel and equipment involved in construction of each area. Work crew personnel were not changed during the test period. The same individuals operated the same equipment during construction of all three areas, except that the motor grader operator for Area No. 1 operated the dozer on Area No. 3.

The test areas were sited such that differences in quantity of earthwork were minimized. Area No. 1 contained 519 cubic yards (397 cubic meters) and Area No. 3 contained 470 cubic yards (359 cubic meters) of fill upon completion of construction. The differences in fill quantity between Areas 1 and 3 were a result of a slight variance in site topography.

Procedure

A CEL representative observed the tests and recorded the labor, time, equipment, and accuracy for each activity during construction of the three areas. Photographic and videotape documentation of the work was provided by CEL. Surface accuracy of the fills was evaluated using the Laserplane surveying equipment and a ten-foot (3.05-meter) straightedge furnished by CEL.

Immediately following construction of each area (excepting Area No. 2) the fill surface was checked for conformance to the specified grade plane and for surface roughness. The fill surface was divided into 16 grids of 25 feet by 25 feet (7.6 m by 7.6 m), and five random measurements were recorded within each grid for both deviation of the surface from a true plane, and maximum deviation of the surface from the bottom of a ten-foot (3.05-meter) straightedge. A mean error and a standard deviation were calculated for each set of 80 measurements. These measurements are presented in Tables 2 and 3.

A bench mark was established for vertical control, base lines were laid out for horizontal control, and offsets for each of the three areas were initially staked by a two-man NAVCONTRACEN survey party. Layout and setting of controls were common to each area; therefore, labor for this activity was not recorded.

Operations

Area No. 1. Following layout, offset stakes for Area No. 1 were marked for grade by the Engineering Aide (EA) crew, and earthwork was begun. Fill was hauled by two MRS I110, S110 scrapers which were initially loaded form a stockpile by a John Deere front end loader. The stockpile was depleted by the afternoon of the second day of construction and an HD 21 dozer operating as a "push cat" was substituted by the crew supervisor for the front end loader. A Galion Model 118-T road grader was used to level fill deposited by the scrapers and a RayGo 400 self-propelled sheepsfoot drum roller was used to compact fill as it was placed. One equipment operator (EO) alternated between operating the grader and the roller.

On the third day of construction, an EA survey party set grade stakes on two edges of the pad and along the pad centerline. As the fill for Area No. 1 was rapidly approaching grade, one scraper was sidelined, and delivery of fill was further slowed by intermittently depositing fill in Area No. 2. Equipment/personnel hours were logged against the appropriate area. The full day was required to position the few remaining scraper loads and to bring the fill sufficiently close to grade for blue topping.

Some additional grading was performed during the morning of the fourth day and a survey crew set blue top hubs. The grader and operator could not work until the survey party completed setting hubs, and the operator's standby time was recorded. Final blue top grading (Figure 7) and smooth rolling were accomplished on the fifth day of construction, and Area No. 1 was completed.

Table 4 contains the log of equipment/personnel manhours expended on Area No. 1. To ensure objectivity, only actual time spent operating equipment was recorded.

Area No. 2. Two days were spent hauling and placing fill in Area No. 2. It was rapidly evident that the Case 450 without automatic blade controls was incapable of leveling the fill spread by the scrapers. The manually operated controls were too coarse for proper leveling of the fill. The Case 450 was unable to keep pace with the scrapers, and compaction was difficult to obtain over the uneven fill surface. An additional day was spent endeavoring to level the fill until it was decided that no further useful information could be obtained.

Area No. 3. Area No. 3 was completed in three construction days, working only on the regular daytime schedule and not taking advantage of the ability of the dozer with kit to grade at night. Generally, one scraper using a "push cat" hauled and placed fill which was struck off 0.10 foot (3.05 cm) above grade by the Case 450 using the automatic blade control kit. The fill was compacted with the RayGo sheepsfoot drum roller during placement and with the RayGo smooth drum roller after the initial grading by the Case 450 with automatic controls (Figure 8). The third and final day was spent in finish grading by the Case 450 with automatic controls.

During construction of Area No. 3, the equipment operator crew chief set up the Laserplane command post at the start of each day, and EA's were not required. Grade stakes were unnecessary since the elevation of the Case 450 blade was guided by the Laserplane command post and the tilt was also controlled automatically. Moreover, the "cut boss", by using a rod with a sound emitting detector, was able to immediately determine elevation anywhere over the fill surface, thereby allowing him to position scraper loads precisely over low spots.

The operators had not seen or used the Laserplane surveying system or the CEL automatic blade control kit prior to these field trials. Prior to beginning work on Area No. 3, several were given less than one hour's training on use of the Laserplane system for surveying. This period was not counted as job time or labor. At the beginning of use of the automatic controls on Area No. 3, the dozer operator was given about one-half hour of training on how to operate the kit, after which he began to work immediately on construction in the area. Even though this training and the initial use of the controls were not entirely productive in area construction, the time expended was counted as job time and labor.

Table 5 lists the manhours expended on construction of Area No. 3.

RESULTS OF FIELD TRIALS

From Tables 2 and 3 it is evident that the finish surfaces of Areas 1 and 3 are comparable in accuracy. Area No. 1 had slightly less surface roughness, whereas Area No. 3 exhibited somewhat better elevation control. Although the finished products were nearly equal, there was a signficant difference in required labor.

Area No. 3 held a significant labor advantage in the construction activities of surveying, hauling and placing fill, and grading. The manhours required to complete each of these activities by date are illustrated graphically in Figure 9. Overall, Area No. 3 required 50 percent less labor.

These test results can best be evaluated through the following separate analyses of the major construction activities.

Surveying

On Area No. 3, use of the Laserplane surveying system reduced surveying labor by 86 percent, and all surveying (with the exception of initial layout) was performed by equipment operators. It is estimated that a 30 percent reduction of surveying labor would have been produced if the Laserplane surveying system had been used without benefit of automatic blade controls. Automatic blade controls increased surveying labor savings an additional 56 percent by eliminating the necessity for driving and marking grade stakes and blue top hubs.

Loading, Hauling, and Placing Fill

Figure 6 shows a reduction of 9.75 manhours (41 percent) of labor in Area No. 3 for loading, hauling, and placing fill. During part of the construction of Area No. 1, a front end loader was used to load the scrapers from a stockpile. The cycle time for stockpile loading was longer than for "push cat" loading. Area No. 1 also required 49 cubic yards more fill than Area No. 3 as a result of topography. Adjusting for these two factors, it is estimated that there was an actual labor reduction of about 20 percent for this construction activity. The reduction is attributed to both the Laserplane surveying system and the automated controls. The Laserplane surveying system enabled the "cut boss" to more accurately position scraper loads since he could instantly detect low and high areas within the fill. In Area No. 3 the dozer with automated controls initially struck off the fill within 0.10 feet (3.05 cm) of grade, whereas in Area No. 1, the initial grading was not as accurate and some fill was wasted.

Grading

Area No. 3 was constructed using 53 percent less labor for grading than was required in Area No. 1. The majority of the savings is attributed to the use of automated controls rather than the Laserplane surveying system. Usage of automated blade controls eliminated the requirement for grade staking and blue top staking. Setting hubs and blue top grading would have been required in Area No. 1 even had the Laserplane surveying system been used. The most time consuming aspect of final grading consists of the driving of hubs to grade and the final trimming operation which necessitates constantly relocating buried hubs. Automated blade controls completely eliminate the need to set any grade stakes or grade hubs within the fill, thereby affording the reduction in grading labor evidenced in Area No. 3.

Operator Comments

Following completion of the trials, a questionnaire soliciting comments was provided to each of the operators. The results, included in the Appendix to this report, are considered to be particularly relevent to the evaluation. This is because each of the operators, as an instructor at NAVCONTRACEN, is an expert on the equipment and is intimately familiar with normal operating procedures and training problems.

Review of the Appendix shows that the operator comments are very favorable on both the laser elevation surveying system and the automatic blade control kit. The comments do indicate that the operators would have preferred to have had the kit on a machine larger than the Case 450, which would have even further increased the operating efficiency using the kit.

The response of each operator suggests several equipments to which application of the control kits would be beneficial. It is noted that, while all feel the dozer kit will be valuable and should be developed, the grader appears most frequently at the top of the list of suggestions. The first breadboard experimental blade control system developed by CEL was tried successfully on a motor grader in 1973 (references 2 and 4); therefore, although funding support for work on the grader kit was discontinued at that time, there is some background of experience with the grader application. This background, plus the more recent experience with the dozer kit, indicates that the dozer and grader (and probably other types of equipment as well) could use the same basic controls kit. Adapter kits containing mounting plates, electrical cables, and hydraulic hoses and fittings would be developed to permit installation of the basic kit on each type, make, and model of equipment. This would minimize the number and cost of kits required in inventory.

CONCLUSIONS

Based on experimental work completed to date on the bolt-on automatic blade control kit, it is concluded that:

1. The feasibility of the concept of a highly portable bolt-on kit, which includes automatic control of elevation and tilt for finishing operations, has been demonstrated.

2. At least one make of transmitter/receiver is available commercially and satisfactory for elevation surveying and use as the blade elevation control part of the system. Adoption of the laser surveying system, even without the automatic controls, would save considerable job time and labor. (Note: CEL has a concept for a more rugged and less expensive transmitter/receiver combination which could be used for all types of surveying as well as for elevation control. Separate development is being proposed since, although advantageous, the CEL concept is not critical to the feasibility of a useful control system kit.)

3. A significant increase in efficiency (i.e., labor equipment, and time) resulted from completing a typical earthwork project utilizing the laser surveying equipment and the CEL-developed automatic controls kit installed on a Case 450 dozer versus present conventional NCF construction procedures and surveying and earthmoving equipment. The increase in efficiency would be expected to be even greater had the operators been less skilled than the NAVCONTRACEN instructors who operated the equipment during these trials.

4. Addition of the automatic blade tilt control to the automatic elevation control adds little to the cost but vastly extends the capability for efficient, accurate grading of all types of surfaces.

5. The application of the bolt-on kit to equipments in addition to the dozer appears to be feasible and would be beneficial. For example, application on the grader eliminates most of the surveying and the slow, stop-start operation now inherent in fine grading. Applied to pavers, the same reference would be used for all fine tolerance operations, start to finish. The elevation portion of the kit can be applied to scrapers to control the elevation during cut and fill work, and to ditchers to control elevation and slope. It may be possible to develop a single basic kit with adapter kits for installation of the automatic controls on various makes and models of machines of all these types. Such a development would make possible a substantial reduction in numbers, types, and costs of equipment required in the military inventory, as well as a substantial reduction in the man-power and logistic burden associated with horizontal construction in advanced areas.

6. In the context of needs implicit in future NCF deployments and MARCORPS amphibious operations and logistics support ashore (such as preparation of surfaces for roads, pads, runways, logistics support areas, shelters, advanced base sites, and sloping drainage ditches), the CEL bolt-on kit represents the only practical way to reduce substantially the time, manpower, and equipment needed. The portable bolt-on kit approach offers the high degree of mobility, portability, and flexibility required by the military, while other approaches (e.g., larger machines, special machines, and machines with integral built-in vice bolt-on automatic controls for blade elevation and tilt) would tend to significantly impair mobility and often increase the logistics tail and cost.

RECOMMENDATIONS

1. Development of the bolt-on automatic blade control system kit concept should be continued.

2. The development approach should be to develop a basic control kit and suitable mounting kits (mounting plates, cables, hoses, etc.) as needed to permit installation on a variety of types, makes, and models of horizontal construction equipment used by the military. The types of equipment on which the kit can be installed should initially include at least the dozer with tilt blade and the motor grader.

3. Development tests should concentrate initially on identifying and solving any reliability and field maintainability problems, and on obtaining data with which the impact of the kits on equipment inventory and operations can be quantified.

4. Attempts should be made to transfer the resulting technology development to commercial industry.

5. The substitution of a commercially available laser surveying system for present optical levels should be considered seriously by the military. Proper selection would allow the system to be used immediately for elevation surveying and later as an elevation reference for the control kits.

REFERENCES

1. Naval Civil Engineering Laboratory. Report 64-73-05: Test and Evaluation of the "Laserplane" Elevation Surveying System, by C. J. Ward, Ph.D. Oct 1972.

2. Naval Civil Engineering Laboratory. Technical Film Report FA/LDH 302: Automatic Controls for Earth Moving Equipment (Motor Grader). 1973.

3. Civil Engineering Laboratory. Report 64-75-13: Experimental Adaptive/Automatic Blade Control Kit for Case 450, by C. J. Ward, Ph.D., and W. T. Swindells. May 1975.

4. "Automatic and Adaptive Controls for Construction Equipment," by Carter J. Ward. Presented at-1975 SAE Off-Highway Vehicle Meeting, Milwaukee, Wisconsin, Sept 8 - 11, 1975; to be published in SAE Transactions.

5. Civil Engineering Laboratory. Technical Film Report FA/LDH 603: Earthmover Automatic Blade Control Kit. 1976.

6. NMCB FIVE 240418Z May 76.

Figure 1. Surveyor's rod of Laserplane surveying system. Using the photocell detector and Lenker tape, one man can obtain elevation readings with this type of system.

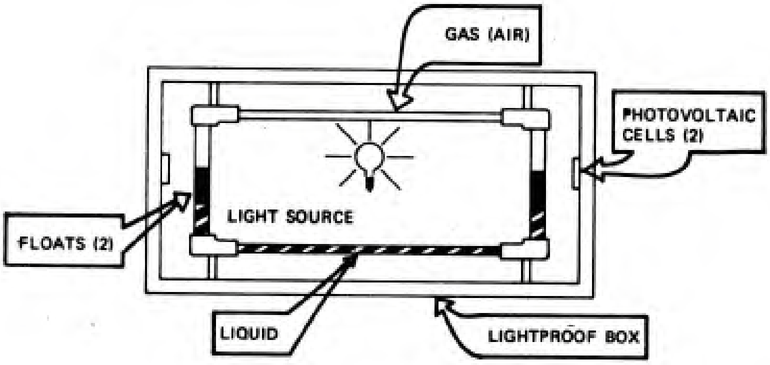

Figure 2. Schematic of angle sensor.

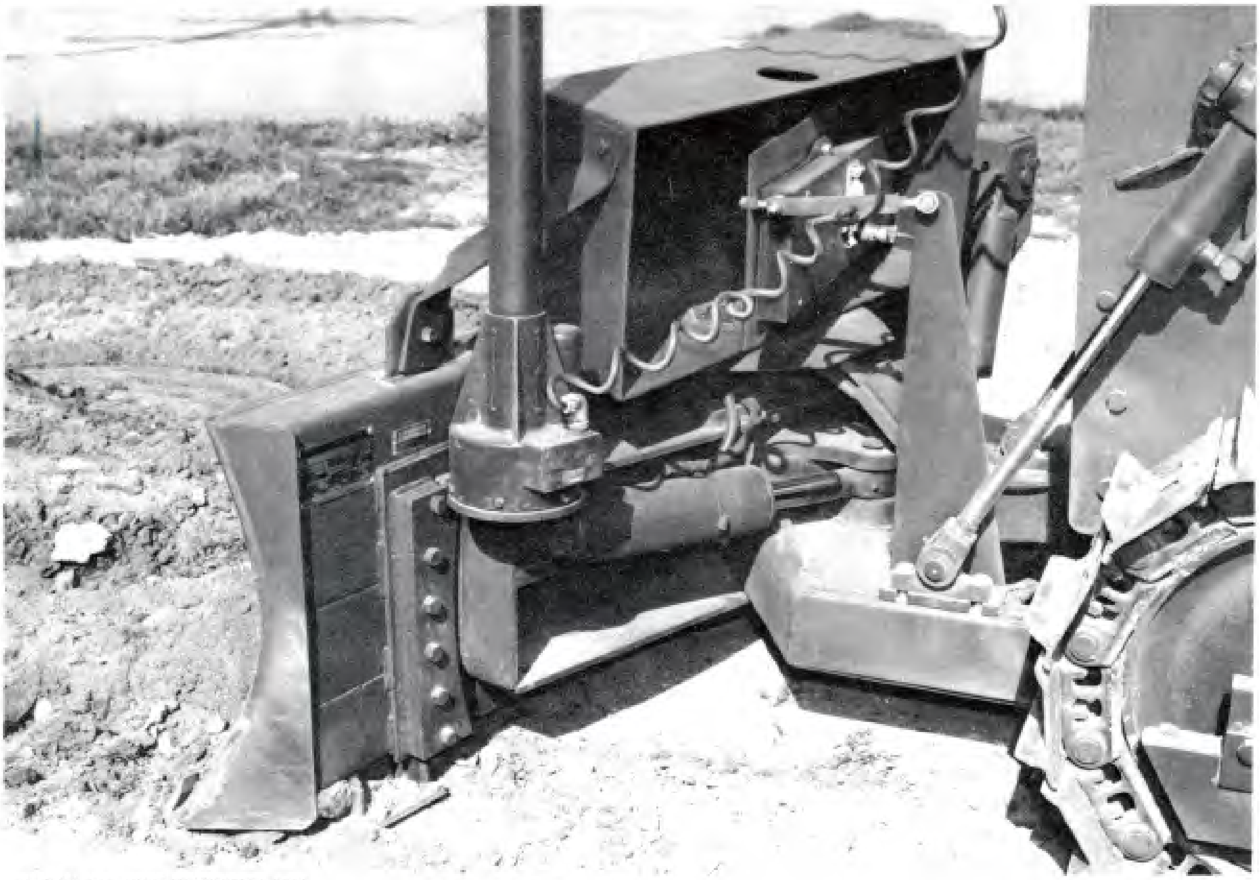

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Figure 3. Blade tilt control sensor with pivot and linkage mechanism. Metal box above blade protects the sensor.

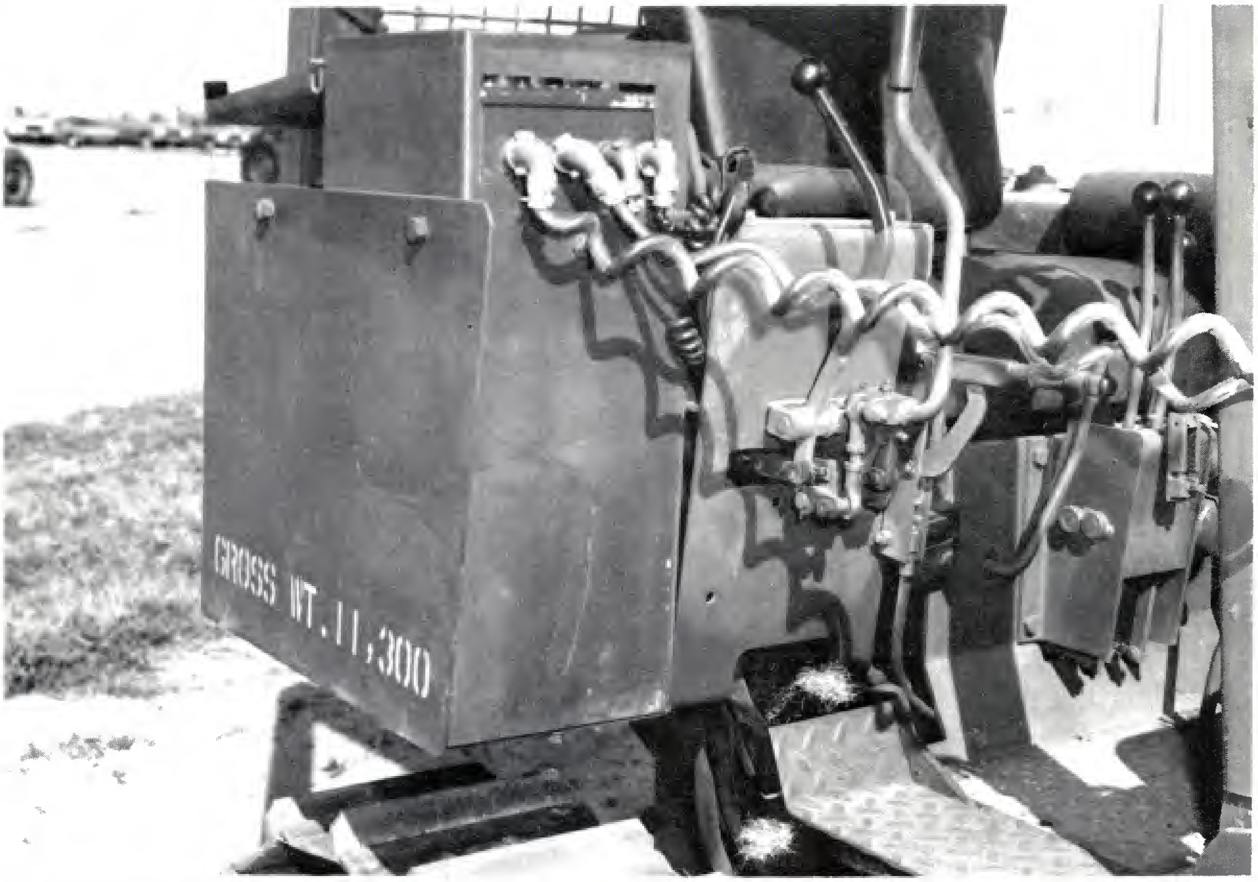

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Figure 4. Hydraulic and electrical portion of control kit.

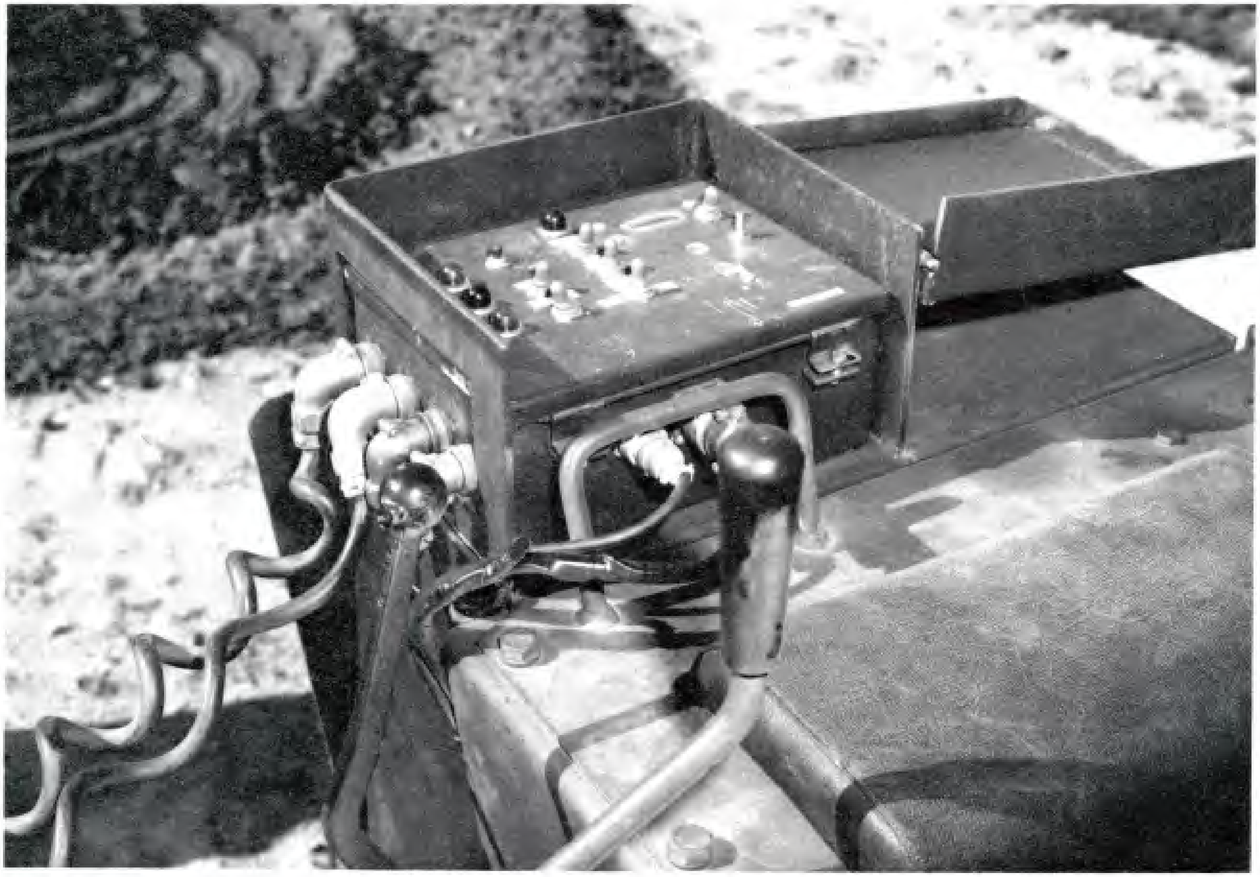

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Figure 5. Control box and electrical switches.

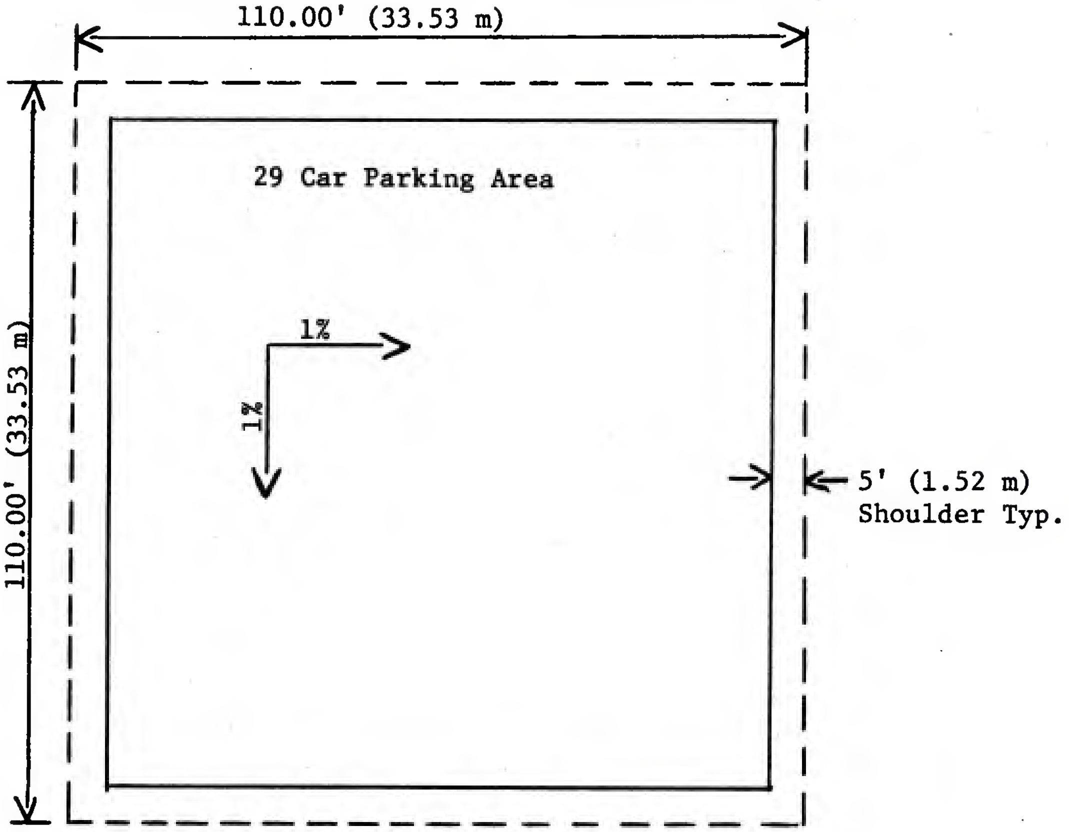

Figure 6. Test area plan view.

Figure 7. Motor grader performing finish grading of Area No. 1. Two men and numerous grade stakes are required.

Figure 8. Case 450 tractor, with automatic blade control kit, performing finish grading of Area No. 3. One operator can set up the equipment and then operate the tractor. No grade stakes are required.

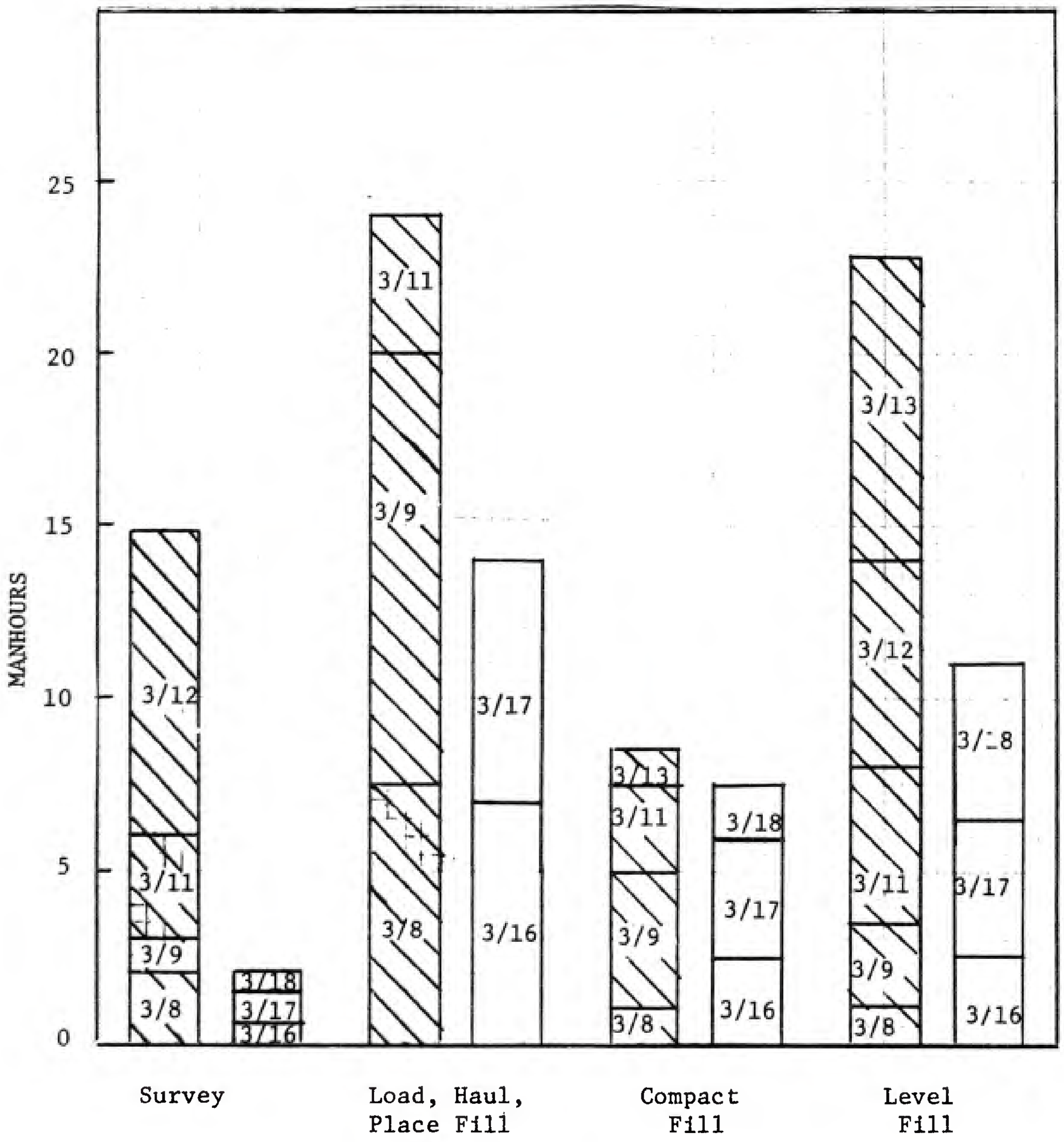

Figure 9. Expended Manhours by Construction Activity

TABLE 1. PERSONNEL AND EQUIPMENT

	AREA NO. 1		AREA NO. 2		AREA NO. 3	
Activity	Crew	Equipment	Crew	Equipment	Crew	Equipment
Supervision	1, EOC	- -	1, EOC	- -	1, EOC	- -
Loading, Hauling, Placing Fill	3, EO	2 scrapers, 1 front end loader or dozer	3, EO	2 scrapers, 1 dozer	2, EO	1 scraper, 1 dozer
Grading	1, EO	1 grader	1, EO	1 Case 450 dozer	1, EO	1 Case 450 dozer with automatic controls kit
Compaction	1, EO	1 sheepsfoot drum vibratory roller, 1 smooth drum vibratory roller	1, EO	1 sheepsfoot drum vibratory roller	1, EO	1 sheepsfoot drum vibratory roller, 1 smooth drum vibratory roller
Surveying	2, EA	transit, level, rod, chain, stakes	2, EA	transit, level, rod, chain, stakes	1, EO	Laserplane system transit, chain, stakes (horizontal layout only)

TABLE 2. AREA NO. 1 SURFACE ACCURACY

AREA/ TRIAL	ELEV. ERROR (FT)	ST. EDGE ERROR (1/16 IN)	AREA/ TRIAL	ELEV. ERROR (FT)	ST. EDGE ERROR (1/16 IN)	AREA/ TRIAL	ELEV. ERROR (FT)	ST. EDGE ERROR (1/16 IN)
A1	-0.07	14	G1	+0.03	2	M1	+0.10	6
2	-0.02	15	2	+0.01	6	2	+0.09	11
3	-0.12	12	3	-0.03	4	3	+0.03	8
4	-0.06	2	4	-0.09	6	4	+0.03	3
5	-0.06	5	5	-0.09	10	5	+0.03	2
B1	-0.11	5	H1	-0.07	10	N1	+0.06	1
2	-0.07	3	2	-0.05	8	2	+0.06	5
3	-0.03	3	3	-0.06	5	3	+0.01	4
4	+0.01	5	4	-0.06	4	4	+0.03	3
5	0.00	11	5	-0.06	5	5	+0.03	8
C1	-0.03	3	I1	-0.03	2	O1	+0.10	5
2	-0.06	3	2	+0.11	3	2	+0.12	11
3	+0.02	6	3	+0.11	5	3	+0.13	10
4	-0.04	3	4	+0.10	14	4	+0.07	3
5	-0.11	7	5	+0.10	7	5	+0.01	6
D1	0.00	8	J1	+0.05	2	P1	-0.03	3
2	0.00	6	2	+0.06	3	2	-0.01	8
3	-0.09	4	3	+0.05	6	3	-0.01	6
4	-0.06	3	4	+0.01	12	4	+0.01	5
5	-0.17	12	5	+0.05	6	5	-0.01	5
E1	+0.04	7	K1	0.00	6			
2	+0.01	7	2	+0.02	4			
3	+0.04	6	3	+0.04	4			
4	+0.04	5	4	+0.04	1			
5	+0.04	8	5	+0.06	3			
F1	+0.04	4	L1	-0.02	3			
2	+0.03	3	2	-0.02	5			
3	-0.03	7	3	-0.01	2			
4	-0.03	5	4	-0.06	9			
5	+0.02	6	5	-0.06	11			

Maximum Error =	+0.13/-0.17	15
Mean ± Std. Deviation =	0.00 ± 0.06	6 ± 3

TABLE 2M. AREA NO.1 SURFACE ACCURACY (METRIC UNITS)

AREA/ TRIAL	ELEV. ERROR (CM)	ST. EDGE ERROR (MM)	AREA/ TRIAL	ELEV. ERROR (CM)	ST. EDGE ERROR (MM)	AREA/ TRIAL	ELEV. ERROR (CM)	ST. EDGE ERROR (MM)
A1	-2.1	22	G1	+0.9	3	M1	+3.0	10
2	-0.6	24	2	+0.3	10	2	+2.7	17
3	-3.7	19	3	-0.9	6	3	+0.9	13
4	-1.8	3	4	-2.7	10	4	+0.9	5
5	-1.8	8	5	-2.7	16	5	+0.9	3
B1	-3.4	8	H1	-2.1	16	N1	+1.8	2
2	-2.1	5	2	-1.5	13	2	+1.8	8
3	-0.9	5	3	-1.8	8	3	+0.3	6
4	+0.3	8	4	-1.8	6	4	+0.9	5
5	0.0	17	5	-1.8	8	5	+0.9	13
C1	-0.9	5	I1	-0.9	3	O1	+3.0	8
2	-1.8	5	2	+3.4	5	2	+3.7	17
3	+0.6	10	3	+3.4	8	3	+4.0	16
4	-1.2	5	4	+3.0	22	4	+2.1	5
5	-3.4	11	5	+3.0	11	5	+0.3	10
D1	0.0	13	J1	+1.5	3	P1	-0.9	5
2	0.0	10	2	+1.8	5	2	-0.3	13
3	-2.7	6	3	+1.5	10	3	-0.3	10
4	-1.8	5	4	+0.3	19	4	+0.3	8
5	-5.2	19	5	+1.5	10	5	-0.3	8
E1	+1.2	11	K1	0.0	10			
2	+0.3	11	2	+0.6	6			
3	+1.2	10	3	+1.2	6			
4	+1.2	8	4	+1.2	2			
5	+1.2	13	5	+1.8	5			
F1	+1.2	6	L1	-0.6	5			
2	+0.9	5	2	-0.6	8			
3	-0.9	11	3	-0.3	3			
4	-0.9	8	4	-1.8	14			
5	+0.6	10	5	-1.8	17			

Maximum Error = +4.0/-5.2 24

Mean ± Std. Deviation = 0.0 ± 1.9 9 ± 5

TABLE 3. AREA NO. 3 SURFACE ACCURACY

AREA/ TRIAL	ELEV. ERROR (FT)	ST. EDGE ERROR (1/16 IN)	AREA/ TRIAL	ELEV. ERROR (FT)	ST. EDGE ERROR (1/16 IN)	AREA/ TRIAL	ELEV. ERROR (FT)	ST. EDGE ERROR (1/16 IN)
A1	0.00	4	G1	-0.01	14	M1	+0.04	11
2	+0.02	6	2	-0.01	17	2	+0.01	5
3	+0.04	6	3	+0.01	8	3	+0.04	12
4	+0.04	14	4	0.00	4	4	+0.01	12
5	+0.04	5	5	0.00	3	5	+0.04	6
B1	+0.04	8	H1	0.00	8	N1	+0.04	11
2	+0.04	10	2	0.00	4	2	+0.01	6
3	+0.03	9	3	+0.02	3	3	+0.01	10
4	+0.01	6	4	0.00	8	4	+0.01	7
5	-0.01	9	5	0.00	5	5	0.00	8
C1	+0.04	10	I1	+0.05	4	O1	0.00	6
2	+0.02	8	2	+0.05	6	2	0.00	6
3	+0.04	8	3	+0.06	10	3	0.00	10
4	+0.03	4	4	+0.04	11	4	+0.01	5
5	0.00	13	5	+0.02	15	5	-0.01	6
D1	0.00	10	J1	+0.02	9	P1	-0.01	6
2	0.00	9	2	+0.03	12	2	-0.01	7
3	-0.01	12	3	+0.02	11	3	+0.03	4
4	-0.01	12	4	-0.02	11	4	-0.03	9
5	0.00	6	5	+0.01	5	5	0.00	6
E1	+0.02	7	K1	0.00	7			
2	+0.02	9	2	-0.01	6			
3	0.00	6	3	-0.03	7			
4	+0.02	4	4	+0.01	17			
5	+0.06	8	5	0.00	19			
F1	+0.01	6	L1	0.00	7			
2	+0.03	13	2	0.00	8			
3	+0.02	10	3	0.00	8			
4	+0.01	3	4	0.00	7			
5	+0.04	12	5	-0.01	12			

Maximum Error = +0.06/-0.03 19

Mean ± Std. Deviation = +0.01 ± 0.02 8 ± 3

TABLE 3M. AREA NO. 3 SURFACE ACCURACY (METRIC UNITS)

AREA/ TRIAL	ELEV. ERROR (CM)	ST. EDGE ERROR (MM)	AREA/ TRIAL	ELEV. ERROR (CM)	ST. EDGE ERROR (MM)	AREA/ TRIAL	ELEV. ERROR (CM)	ST. EDGE ERROR (MM)
A1	0.0	6	G1	-0.3	22	M1	+1.2	17
2	+0.6	10	2	-0.3	27	2	+0.3	8
3	+1.2	10	3	+0.3	13	3	+1.2	19
4	+1.2	22	4	0.0	6	4	+0.3	19
5	+1.2	8	5	0.0	5	5	+1.2	10
B1	+1.2	13	H1	0.0	13	N1	+1.2	17
2	+1.2	16	2	0.0	6	2	+0.3	10
3	+0.9	14	3	+0.6	5	3	+0.3	16
4	+0.3	10	4	0.0	13	4	+0.3	11
5	-0.3	14	5	0.0	8	5	0.0	13
C1	+1.2	16	I1	+1.5	6	O1	0.0	10
2	+0.6	13	2	+1.5	10	2	0.0	10
3	+1.2	13	3	+1.8	16	3	0.0	16
4	+0.9	6	4	+1.2	17	4	+0.3	8
5	0.0	21	5	+0.6	24	5	-0.3	10
D1	0.0	16	J1	+0.6	14	P1	-0.3	10
2	0.0	14	2	+0.9	19	2	-0.3	11
3	-0.3	19	3	+0.6	17	3	+0.9	6
4	-0.3	19	4	-0.6	17	4	-0.9	14
5	0.0	10	5	+0.3	8	5	0.0	10
E1	+0.6	11	K1	0.0	11			
2	+0.6	14	2	-0.3	10			
3	0.0	10	3	-0.9	11			
4	+0.6	6	4	+0.3	27			
5	+1.8	13	5	0.0	30			
F1	+0.3	10	L1	0.0	11			
2	+0.9	21	2	0.0	13			
3	+0.6	16	3	0.0	13			
4	+0.3	5	4	0.0	11			
5	+1.2	19	5	-0.3	19			

Maximum Error = +1.8/-0.9 30

Mean ± Std. Deviation = +0.4 ± 0.6 13 ± 5

TABLE 4. AREA NO. 1 CONSTRUCTION LOG

DATE	ACTIVITY	CREW/EQUIP.	START	STOP	TIME (HR)	MANHOURS
3/8/76	Set Initial Grade	2 EA(CS)	1000	1100	1.00	2.00
	Scarify Surface	1EO(1G)	1130	1145	0.25	0.25
	Load, Haul Place Fill	3EO(2S & 1FEL)	1300	1445	1.75	5.25
			1500	1545	0.75	2.25
	Level Fill	1EO(1G)	1345	1400	0.25	0.25
			1500	1520	0.33	0.33
	Compact Fill	1EO(1SF)	1325	1345	0.33	0.33
			1405	1430	0.42	0.42
			1520	1545	0.42	0.42
3/9/76	Set Grade	2EA(CS)	1335	1405	0.50	1.00
	Load, Haul, Place Fill	3EO(2S,1FEL)	0815	0835	0.33	0.99
			0850	1005	1.25	3.75
		2EO(1S,1FEL)	1020	1130	1.17	2.34
		3EO(2S,1FEL)	1300	1405	1.08	3.24
		3EO(2S,1D)	1425	1440	0.25	0.75
		2EO(1S,1D)	1440	1500	0.33	0.66
			1523	1545	0.37	0.74
	Level Fill	1EO(1G)	0825	0835	0.17	0.17
			0920	1005	0.75	0.75
			1045	1100	0.25	0.25
			1125	1145	0.33	0.33
			1430	1545	1.25	1.25
	Compact Fill	1EO(1SF)	0805	0815	0.17	0.17
			0850	0915	0.42	0.42
			1035	1120	0.75	0.75
			1125	1145	0.33	0.33
			1300	1405	1.08	1.08
			1425	1430	0.08	0.08
			1440	1545	1.08	1.08
3/11/76	Set Grade	1EO(CS)	0935	0945	0.17	0.17
		2EA(CS)	1017	1145	1.47	2.94
	Load, Haul, Place Fill	2EO(1S,1D)	0820	0842	0.37	0.74
			0900	0940	0.67	1.34
			0942	1031	0.74	1.48[2]
			1310	1400	0.83	1.66
	Level Fill	1EO(1G)	0817	0842	0.42	0.42
			0900	0935	0.58	0.58
			0945	1020	0.58	0.58
			1051	1145	0.90	0.90
			1300	1425	1.42	1.42
			1434	1525	0.85	0.85

TABLE 4. AREA NO. 1 CONSTRUCTION LOG
(Continued)

DATE	ACTIVITY	CREW/EQUIP.	START	STOP	TIME (HR)	MANHOUR
	Compact Fill	1EO(1SF)	0815	0842	0.45	0.45
			0900	0955	0.92	0.92
		1EO(1SDR)	1030	1045	0.25	0.25
		1EO(1SF)	1314	1406	0.87	0.87
3/12/76	Level Fill	1EO(1G)	0830	0915	0.75	0.75
			0915	1145	2.50	2.50
			1300	1545	2.75	2.75
	Survey	2EA(CS)	1025	1120	0.92	1.84
			1120	1145	0.42	0.84
			1324	1421	0.93	1.86
		3EA(CS)	1421	1545	1.40	4.20
3/15/76	Blue Top Grading	2EO(1G)	0805	1045	2.67	5.34
			1100	1145	0.75	1.50
			1300	1350	0.83	1.66
	Compact Fill	1EO(1SDR)	1315	1420	1.08	1.08

Notes: 1. Equipment abbreviations:

D - Allis-Chalmers HD 21 dozer
S - MRS I110 scraper
SF - Ray Go 400 vibratory roller with sheepsfoot drum
SDR - Ray Go 400 vibratory roller with smooth drum
LP - Laserplane surveying system
G - Galion model 118 road grader
CS - Conventional Surveying

2. Subtract 1.08 manhours for hauling to Area No. 2

TABLE 5. AREA NO. 3 CONSTRUCTION LOG

DATE	ACTIVITY	CREW/EQUIP.	START	STOP	TIME (HR)	MANHOURS
3/16/76	Survey	1EO(LP)	0850	0915	0.42	0.42
			1245	1300	0.25	0.25
	Load, Haul, Place Fill	2EO(1D,1S)	1000	1017	0.28	0.56
		3EO(1D,2S)	1017	1100	0.72	2.16
		2EO(2S)	1100	1143	0.72	1.44
		1EO(1S)	1315	1405	0.83	0.83
		2EO(2S)	1405	1505	0.92	1.84
		1EO(1S)	1505	1525	0.33	0.33
	Compact	1EO(1SFR)	1010	1045	0.58	0.58
			1045	1048	0.05	0.05
			1117	1143	0.43	0.43
			1320	1338	0.30	0.30
			1400	1405	0.08	0.08
			1415	1500	0.75	0.75
			1511	1520	0.15	0.15
	Grade Fill	1EO(Case 450)	1108	1140	0.53	0.53
			1315	1419	1.07	1.07
			1430	1540	1.17	1.17
3/17/76	Survey	1EO(LP)	0810	0840	0.50	0.50
			1245	1300	0.25	0.25
	Load, Haul, Place	2EO(1S,1D)	0818	1000	1.70	3.40
			1013	1120	1.12	2.24
			1312	1345	0.55	1.10
		1EO(1S)	1345	1400	0.25	0.25
			1420	1425	0.08	0.08
	Compact	1EO(1SF)	0813	1000	1.78	1.78
			1013	1120	1.12	1.12
			1310	1435	1.42	1.42
	Grade	1EO(Case 450)	0850	0950	1.00	1.00
			1020	1125	1.08	1.08
			1310	1425	1.25	1.25
			1430	1455	0.42	0.42
3/18/76	Survey	1EO(LP)	--	--	0.58	0.58
	Final Grading	1EO(Case 450)	0830	1020	1.83	1.83
			1030	1135	1.08	1.08
			1315	1405	0.83	0.83
			1420	1500	0.66	0.66
	Compact	1EO(SDR)	1100	1130	0.50	0.50
			1310	1320	0.17	0.17
			1400	1425	0.42	0.42
			1500	1530	0.50	0.50

Notes: 1. Equipment abbreviations:

D - Allis-Chalmers HD 21 dozer
S - MRS I110 scraper
SF - Ray Go 400 vibratory roller with sheepsfoot drum
SDR - Ray Go 400 vibratory roller with smooth drum
G - Galion model 118 road grader
LP - Laserplane surveying system

Appendix

Operator Responses to CEL Post-Trial Questionnaire

OPERATING PERSONNEL QUESTIONNAIRE
ON TESTS OF
LASERPLANE SURVEYING SYSTEM
AND
EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

Name FRANKLIN A. PIERCE

Rank EO-1

Please answer the following questions related to the tests. Feel free to add any comments you wish to make, using the back of the form if you need more space to write.

1. What were your duties during the test? FINISH GRADER OPER, AND ROLLER OPER (PAD #1) OPERATED CASE 450 ON PAD #3

2. LASERPLANE SURVEYING SYSTEM

A. Did you personally use the Laserplane System in any way for surveying?

Yes [✓ No]

B. Did you closely observe others using the Laserplane System for surveying?

[✓ Yes] No

If your answers to Questions 2A and 2B are both "No," skip to Question 3. If your answer to either is "Yes," please answer the following questions.

C. For what surveying tasks did you use the Laserplane System, or closely observe its use? ROUGH SURVEY AND FINAL SURVEY OF PAD #3. OBSERVING ITS USE THROUGHOUT FILLING & COMPACTION AND FINAL GRADING OF PAD #3

D. What did you like about surveying with the Laserplane System? IT ELIMINATES THE NECESSITY OF SETTING 2-3 SETS OF GRADE STAKES AS GRADE PROGRESSES FROM INITIAL TO FINAL GRADE & ELIMINATION OF PERSONNEL NEEDED ON JOB SITE.

E. What did you dislike about surveying with the Laserplane System? —

F. Based on your overall use and/or observation of it, do you feel the Laserplane Surveying System (or a similar system) should be provided to the NCF?

[✓ Yes]
No

3. EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

A. Did you personally operate the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

B. Did you closely observe others operating the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

If your answers to Questions 3A and 3B are both "No," skip to the end of the form. If your answer to either is "Yes," please answer the following questions.

C. For what tasks did you operate the Case 450 with the automatic blade control kit, or closely observe its operation?

I OPERATED THE CASE 450 W/AUTO BLADE CONTROL ON PAD #3 FROM SEMI-FINISH THROUGHOUT FINAL GRADING AND FOR V.I.P. DEMO.

D. What did you like about the blade control kit? THE SIMPLICITY AND COMPACTNESS OF DESIGN AND THE EASE OF SETTING AND HOLDING A CLOSE GRADE TOLERANCE.

E. What did you dislike about the blade control kit? THE OCCASIONAL OVER RESPONSE TO CONTROLS AND EXTERNAL INTERFERENCE WITH LASER BEAM

F. List below the equipments (such as motor graders, tilt-blade dozer, slip form paver, ditcher, etc.) for which you feel development of the automatic controls would have significant value to the NCF. List them in the order of your preference, starting with the one you think would be best for use by the NCF.

(1) MOTOR GRADER
(2) TILT-BLADE DOZER
(4) DITCHER
(3) ASPHALT PAVER
(5) SLIP FORM PAVER

Franklin A. Pierce
(Signature)

13 APRIL 1976
(Date)

Please forward completed form to:

Carter Ward, Code L64
Civil Engineering Laboratory
Naval Construction Battalion Center
Port Hueneme, CA 93043

OPERATING PERSONNEL QUESTIONNAIRE
ON TESTS OF
LASERPLANE SURVEYING SYSTEM
AND
EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

Name HA, GILBERT

Rank EO1

Please answer the following questions related to the tests. Feel free to add any comments you wish to make, using the back of the form if you need more space to write.

1. What were your duties during the test? AN OPERATOR (SCRAPER, ROLLER, PUSH CAT, END LOADER, & WATER TRUCK)

2. LASERPLANE SURVEYING SYSTEM

A. Did you personally use the Laserplane System in any way for surveying?

Yes
[✓ No]

B. Did you closely observe others using the Laserplane System for surveying?

[✓ Yes]
No

If your answers to Questions 2A and 2B are both "No," skip to Question 3. If your answer to either is "Yes," please answer the following questions.

C. For what surveying tasks did you use the Laserplane System, or closely observe its use? CHECKING GRADE ON PAD #3 AND MEASURING DIVIATIONS.

D. What did you like about surveying with the Laserplane System? SIMPLICITY ONCE IT WAS SET UP.

E. What did you dislike about surveying with the Laserplane System? NOTHING REALLY, IT JUST TAKES TIME TO GET USE TO IT.

F. Based on your overall use and/or observation of it, do you feel the Laserplane Surveying System (or a similar system) should be provided to the NCF?

[✓ Yes]
No

3. EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

A. Did you personally operate the experimental automatic blade control kit installed on the Case 450?

Yes
[✓ No]

B. Did you closely observe others operating the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

If your answers to Questions 3A and 3B are both "No," skip to the end of the form. If your answer to either is "Yes," please answer the following questions.

C. For what tasks did you operate the Case 450 with the automatic blade control kit, or closely observe its operation?
THE BUILDING OF PAD #3 & FINAL GRADING

D. What did you like about the blade control kit? Self leveling kit & accuracy of blade control

E. What did you dislike about the blade control kit? you have to go to slow because of the way the doze response to the laser.

F. List below the equipments (such as motor graders, tilt-blade dozer, slip form paver, ditcher, etc.) for which you feel development of the automatic controls would have significant value to the NCF. List them in the order of your preference, starting with the one you think would be best for use by the NCF.

(1) Scrapers
(2) Graders
(3) Dozers
(4) Ditcher
(5) ____________

(Signature)

13 April 74
(Date)

Please forward completed form to:

Carter Ward, Code L64
Civil Engineering Laboratory
Naval Construction Battalion Center
Port Hueneme, CA 93043

OPERATING PERSONNEL QUESTIONNAIRE
ON TESTS OF
LASERPLANE SURVEYING SYSTEM
AND
EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

Name MADSEN, ALAN E.

Rank EOC

Please answer the following questions related to the tests. Feel free to add any comments you wish to make, using the back of the form if you need more space to write.

1. What were your duties during the test? CREW LEADER. ACTED AS FILL BOSS - OVERALL MILITARY CONTROL OF CREW - EQUIPMENT LIASON WITH MAINTENANCE DIVISION OF NCTC.

2. LASERPLANE SURVEYING SYSTEM

A. Did you personally use the Laserplane System in any way for surveying?

[✓ Yes]
No

B. Did you closely observe others using the Laserplane System for surveying?

[✓ Yes]
No

If your answers to Questions 2A and 2B are both "No," skip to Question 3. If your answer to either is "Yes," please answer the following questions.

C. For what surveying tasks did you use the Laserplane System, or closely observe its use? OBSERVED ITS USE AS SURVEYING TOOL - PERSONALLY USED IT TO CONTROL AMOUNT OF FILL HAULED INTO PART OF THE PROJECT.

D. What did you like about surveying with the Laserplane System? EASE OF OPERATION - AUDIO/VISUAL CONTROL BY 1 MAN VICE 2 OR 3 - LESS CHANCE OF ERROR /MATH/ROD READING

E. What did you dislike about surveying with the Laserplane System? COMPLEXITY OF INITIAL MATH CONCERNED WITH THE LENKER ROD - ROD IT'S SELF

F. Based on your overall use and/or observation of it, do you feel the Laserplane Surveying System (or a similar system) should be provided to the NCF?

[✓ Yes]
No

3. EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

A. Did you personally operate the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

B. Did you closely observe others operating the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

If your answers to Questions 3A and 3B are both "No," skip to the end of the form. If your answer to either is "Yes," please answer the following questions.

C. For what tasks did you operate the Case 450 with the automatic blade control kit, or closely observe its operation?

INITIAL AND FINAL GRADING

D. What did you like about the blade control kit? EXCELLENT CONTROL OF GRADE - EASE OF OPERATOR INSTRUCTION AND USE

E. What did you dislike about the blade control kit? SLOW REACTION TIME OF TILT CONTROL OVERALL SPEED OF UNIT.

F. List below the equipments (such as motor graders, tilt-blade dozer, slip form paver, ditcher, etc.) for which you feel development of the automatic controls would have significant value to the NCF. List them in the order of your preference, starting with the one you think would be best for use by the NCF.

(1) GRADER
(2) SCRAPER
(3) DOZER
(4) DITCHER
(5) ASPHALT PAVER?

EOC
(Signature)

13 APRIL 1976
(Date)

Please forward completed form to:

Carter Ward, Code L64
Civil Engineering Laboratory
Naval Construction Battalion Center
Port Hueneme, CA 93043

OPERATING PERSONNEL QUESTIONNAIRE
ON TESTS OF
LASERPLANE SURVEYING SYSTEM
AND
EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

Name SCHAEFER J. J.

Rank EO2

Please answer the following questions related to the tests. Feel free to add any comments you wish to make, using the back of the form if you need more space to write.

1. What were your duties during the test? GENERAL CREW SCRAPER + WATER TANK + ROLLER OPERATOR.

2. LASERPLANE SURVEYING SYSTEM

A. Did you personally use the Laserplane System in any way for surveying?

Yes
[✓ No]

B. Did you closely observe others using the Laserplane System for surveying?

[✓ Yes]
No

If your answers to Questions 2A and 2B are both "No," skip to Question 3. If your answer to either is "Yes," please answer the following questions.

C. For what surveying tasks did you use the Laserplane System, or closely observe its use?

FIGURING CUTS + FILLS

D. What did you like about surveying with the Laserplane System? IT TAKES LESS PEOPLE TO SET UP + OPERATE. AND IT CAN RUN MORE THAN 1 UNIT AT A TIME. I.E. ROD + DOZER.

E. What did you dislike about surveying with the Laserplane System? NOT MUCH OF ANYTHING REALLY.

F. Based on your overall use and/or observation of it, do you feel the Laserplane Surveying System (or a similar system) should be provided to the NCF?

[✓ Yes]
No

3. EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

A. Did you personally operate the experimental automatic blade control kit installed on the Case 450?

Yes
[✓ No]

B. Did you closely observe others operating the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

If your answers to Questions 3A and 3B are both "No," skip to the end of the form. If your answer to either is "Yes," please answer the following questions.

C. For what tasks did you operate the Case 450 with the automatic blade control kit, or closely observe its operation?

SPREADING FILL + FINAL GRADE FOR A 100'X100' PARKING LOT PAD.

D. What did you like about the blade control kit? THE ACCURACY IT GIVES THE MACHINE.

E. What did you dislike about the blade control kit? WHEN ANOTHER MACHINE OR OBJECT PASSES THROUGH THE BEAM, YOU HAVE TO STOP + RESET.

F. List below the equipments (such as motor graders, tilt-blade dozer, slip form paver, ditcher, etc.) for which you feel development of the automatic controls would have significant value to the NCF. List them in the order of your preference, starting with the one you think would be best for use by the NCF.

(1) GRADER

(2) PAVER

(3) DITCHERS

(4) DOZERS

(5) SCRAPERS

J Schaefer
(Signature)

14 APR 76
(Date)

Please forward completed form to:

Carter Ward, Code L64
Civil Engineering Laboratory
Naval Construction Battalion Center
Port Hueneme, CA 93043

OPERATING PERSONNEL QUESTIONNAIRE
ON TESTS OF
LASERPLANE SURVEYING SYSTEM
AND
EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

Name THOMAS D. PALMER Rank EO1

Please answer the following questions related to the tests. Feel free to add any comments you wish to make, using the back of the form if you need more space to write.

1. What were your duties during the test? SCRAPER, BULL CAT, ROLLER AND WATER TRUCK OPERATOR

2. LASERPLANE SURVEYING SYSTEM

A. Did you personally use the Laserplane System in any way for surveying?

Yes [✓ No]

B. Did you closely observe others using the Laserplane System for surveying?

[✓ Yes] No

If your answers to Questions 2A and 2B are both "No," skip to Question 3. If your answer to either is "Yes," please answer the following questions.

C. For what surveying tasks did you use the Laserplane System, or closely observe its use? INITIAL AND FINAL SURVEY OF PAD #3 + STAGES INBETWEEN AS FILL MATERIAL WAS BROUGHT IN + COMPACTED

D. What did you like about surveying with the Laserplane System? CUTS DOWN THE TIME INVOLVED IN SETTING GRADE STAKES BY ELIMINATING THE NECESSITY OF SETTING MORE STAKES AS THE GRADE MOVES FROM INITIAL TO FINISH.

E. What did you dislike about surveying with the Laserplane System?____________________

F. Based on your overall use and/or observation of it, do you feel the Laserplane Surveying System (or a similar system) should be provided to the NCF?

[✓ Yes]
No

3. EXPERIMENTAL AUTOMATIC BLADE CONTROL KIT

A. Did you personally operate the experimental automatic blade control kit installed on the Case 450?

Yes
[✓ No]

B. Did you closely observe others operating the experimental automatic blade control kit installed on the Case 450?

[✓ Yes]
No

If your answers to Questions 3A and 3B are both "No," skip to the end of the form. If your answer to either is "Yes," please answer the following questions.

C. For what tasks did you operate the Case 450 with the automatic blade control kit, or closely observe its operation? OBSERVED ITS OPERATION FROM THE BEGINNING OF PAD #3 UNTIL ITS COMPLETION.

D. What did you like about the blade control kit? THE EASE WITH WHICH IT HELD TO A CLOSE GRADE WHILE SPREADING MATERIAL.

E. What did you dislike about the blade control kit? THE SLOW SPEED OF OPERATION.

F. List below the equipments (such as motor graders, tilt-blade dozer, slip form paver, ditcher, etc.) for which you feel development of the automatic controls would have significant value to the NCF. List them in the order of your preference, starting with the one you think would be best for use by the NCF.

(1) SCRAPER
(2) GRADER
(3) DOZER
(4) PAVER
(5) DITCHER

Thomas C Palmer
(Signature)

14 APR 76
(Date)

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