19. REPORT ON GROOVED RUNWAY EXPERIENCE AT WASHINGTON NATIONAL AIRPORT

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SUMMARY

The Federal Aviation Administration has had an active interest in runway grooving technology since December 1965. A noteworthy accomplishment was the grooving of Washington National Airport runway 18-36 in March 1967 – a first, as far as United States civil airports are concerned. Friction measurements of the runway, which has a 1/8" × 1/8" × 1" groove pattern, show that the grooving alleviates the extreme variations in wet traction caused by surfaces which have been worn smooth and coated with rubber. Tests to determine the effect of environment and traffic on the endurance of 18 groove patterns in concrete and asphalt taxiways are in process at five airports. The cost of grooving the runways at one airport (Chicago Midway) has been included in the Federal Aid to Airports Program. The FAA activities in runway grooving are being coordinated with NASA, the Air Transport Association of America (ATA), and airport authorities who are contemplating implementation of runway grooving.

INTRODUCTION

The Washington National Airport grooved runway 18-36 (fig. 1) has been the focal point of the Federal Aviation Administration interest in runway grooving. After observing the drainage of a grooved runway at Farnsborough, England, during a heavy rain in December 1965, and discussing British experience with several experts in the Ministries, a research and development project was implemented by the Aircraft Development Service to study and apply the technology to civil airports in cooperation with NASA and ATA. A special committee, representing the airport, engineering, and research branches of the agency, was established in the spring of 1966 to investigate, implement, and monitor the science of runway grooving.

The specifications for grooving Washington National runway 18-36 were developed during the summer of 1966. So far as is known, these were the first specifications written for an extremely active civil transport runway in the United States. The specifications were novel because they were gauged to an airport experiencing about 1000 operations a day, had to consider an asphaltic concrete pavement using hard aggregate from two sources, and had to avoid damaging subsurface wiring of the touchdown zone and centerline lighting systems. In short, this work was exposed to the problems normally associated with implementing a known technology in a new area under new conditions.

RESULTS AND DISCUSSION

The grooving job was scheduled to be accomplished during the winter of 1966-67. However, the job did not commence until March 1967. This delay was beneficial because of the large quantities of water needed for the work. The resultant sludge and winter conditions in general would have caused large deposits of ice and slush on the runway.

The contractor used Clipper grooving machines (fig. 2). These are small gasoline-engine-driven vehicles capable of sawing 13 grooves at a time. Since the specifications called for completion of the work in 35 days, seven machines were used. Each was assigned a daily task of 35 feet of runway length, 150 feet wide. Approximately 200 feet of runway length were completed per day. The work was done between 11 p.m. and 7 a.m. to minimize interference with traffic. (See figs. 3 to 7.)

As the NASA tests of various groove patterns had not yet commenced, the 1/8" × 1/8" × 1" groove configuration, which had been successfully developed in England, was chosen for the runway. However, unlike British practice of leaving 500 feet of runway ungrooved on each end, the full length of the runway (6870 feet) was grooved. This was done because the decelerative ability of the entire runway was considered more important for a "first" installation than any potential deterioration problem.

The postgrooving "dust" problem was first detected on this job as a "visibility" problem by landing aircraft. The need for daily thorough removal of postgrooving slurry of pavement grit and water (figs. 8 and 9) thus became apparent and was made known to other airport managers who were considering grooving.

The job was completed in April 1967, on schedule. The workmanship was very satisfactory.

To evaluate the endurance of the grooves, engineering "control" points were established in the touchdown areas to assess wear and tear. (See figs. 10 and 11.) These control points were photographed when the runway was grooved, and were again photographed recently after more than 400 000 operations. Several of these photographs are shown as figures 12 to 15.

No serious deterioration of the grooves was noted after 18 months of use, nor had the grooves collapsed due to summer heat or become filled with touchdown rubber. They were not damaged by snowplows, nor had they packed with antiskid sand. The surface was scarred by airport maintenance equipment on occasion (figs. 16 and 17) and experienced some "pop-outs" (fig. 18). However, the most noticeable recent change has been a shift of a portion of the surface in the touchdown area of runway 36 (fig. 19). This shift seems to be related to the pavement construction and further study is planned.

It should be noted that the runway was in very good condition before it was grooved and had no history of slick-runway incidents or accidents. However, some knowledge of the friction characteristics of the runway, dry and wet, before and after grooving was necessary. A Swedish Skiddometer, which the FAA purchased in 1964, was used to obtain these data. This trailer measures the surface drag of a smooth tread ASTM 7.50 × 14 tire at 13 percent slip and records it as a traction number on paper tape in terms of distance and time. The trailer-tow vehicle is also equipped with an FAA-designed 150-gallon water system capable of dispensing 20 000 feet of water film (approximately 0.020 inch thick) in the path of the test tire (fig. 20).

Wet and dry friction surveys of the runway were made at velocities of 10, 30, 50, and 60 miles per hour at locations on the runway centerline, 25 feet each side of the centerline, and along the runway edge. The edge survey was made to compare the friction characteristics of the unused part of the runway with those of the used part. The friction measurement pattern is shown in figure 21.

The resulting data showed that the grooves removed the great variation in the wet traction of the ungrooved runway. In essence, it equalized the wet friction characteristics of the entire runway by removing the "spikes" in the data (fig. 22). These spikes are the effect of rubber deposits, smoothly worn surfaces, and contaminants on the wet friction characteristics of an ungrooved runway.

It thus appears that grooving effects the following improvements in airplane performance on a wet runway:

1. It minimizes the probability of hydroplaning.
2. It alleviates the effect of rubber, contaminants, and smoothly worn surfaces on wet surface traction.
3. As a result of the influence of items 1 and 2, aircraft directional control, deceleration, and nose-wheel steering become more responsive to pilot technique.

These conclusions appear to be substantiated by the reports of airline pilots who have landed on the grooved runway under rainy weather conditions and have stated that aircraft deceleration and control were improved after the runway was grooved.

A more detailed discussion of the wet friction surveys made of the ungrooved and grooved runway will be released in the near future as an FAA Report.

At this point, mention must be made of the environmental test that the FAA Systems Research and Development Service has been conducting on 18 groove patterns at five airports, each in a different climate. This test is being conducted in collaboration with NASA and will serve to evaluate the traffic/wear/environmental effect on 18 groove patterns in concrete and asphalt taxiways. The patterns being tested are in two groups; one being 1/8" deep grooves, the other being 1/4" deep grooves. The spacings are 1", $1\frac{1}{2}$", and 2"; the groove widths are 1/8", 1/4", and 3/8". (See fig. 23.)

The test grooves were installed in 1967 at Miami, Cleveland, New York City (John F. Kennedy International Airport), Salt Lake City, and Las Vegas airports. Taxiways were used, instead of runways, as test beds because of the experimental nature of the project. A typical view of the surface at Salt Lake City is shown in figure 24.

All test beds have experienced at least four seasons. The groove patterns in the concrete taxiways have stood up well. Those in the asphalt taxiways have not been as successful, particularly those in Las Vegas, Salt Lake City, and Miami, because of the effect of high ambient temperature and of traffic on plastic flow and displacement of the stone chips in the wheel track areas. Although the individual reports on each test site have not yet been summarized, the following specific comment by the engineering observers of the Salt Lake City and Las Vegas tests are of interest (fig. 25):

> In all cases, 1/4" deep grooves (in asphalt) are structurally poorer than 1/8" deep grooves. At Salt Lake the 1/8" deep grooves were cut into the stone chips . . . the 1/4" deep grooves penetrated the bituminous course which is more plastic . . . From these observations, the 1/4" × 1/4" × 1" grooves (seem to) have less structural stability than the same pattern only 1/8" deep. 3/8" grooves would remain open longer . . . Grooves spaced 2" apart, 3/8" wide, 1/8" deep had the least deformation . . . All grooves 1/8" deep withstood deformation better than any 1/4" deep.

The report from Miami, after 10 months of service, was similar to that of Salt Lake.

Another problem experienced to date is that the application of a seal coat to a grooved surface will fill up the grooves, as shown in figure 26.

Although this experience at locations with high ambient temperatures is different from that with the grooved asphalt runway at Washington National Airport and the asphalt test bed at John F. Kennedy International Airport, the following general conclusions may be observed:

1. The asphalt mix and the size of the aggregate in a runway surface can influence the endurance of the grooves under high ambient temperature conditions.
2. Grooved asphalt surface courses tend to hold up better under traffic and high ambient temperatures than do grooved seal coats.

3. The surface structure of an asphalt runway should be considered when evaluating the potential effect of grooves on pavement endurance.
4. Grooves in portland cement runways appear to have greater endurance and resistance to environmental effects than those in asphaltic concrete runways.
5. Wider (3/8") grooves tend to accumulate debris – as shown in figure 27.

CONCLUDING REMARKS

The Federal Aviation Administration has been actively interested in runway grooving since December 1965. The FAA Washington National Airport runway 18-36 was the first civil transport runway in the United States to be grooved; it has successfully sustained over 400 000 take-offs and landings. The FAA has performed friction surveys of grooved and ungrooved runways with a Swedish Skiddometer. The data indicate that the grooves equalize the traction characteristics of the wet pavement. Airline pilots have reported that airplane deceleration and control during landings under rainy weather conditions are better on a grooved runway. It is believed that this improvement is related to equalization of traction. The FAA is testing 18 groove patterns at five airports to assess the effect of climate and traffic on these groove configurations. It has sponsored runway grooving under the Federal Aid to Airports Program. The FAA research and development activities in the science of grooving are being coordinated with ATA and NASA and will be continued to assure efficient, economic application of the new technology which was pioneered by our friends in the United Kingdom.

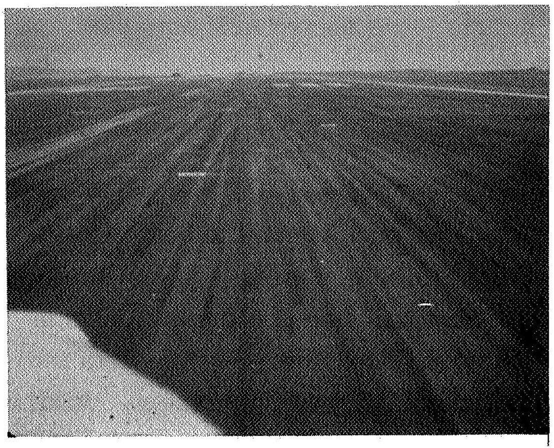
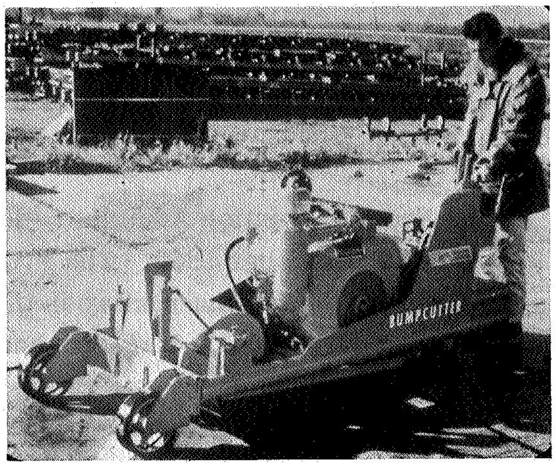


Figure 1



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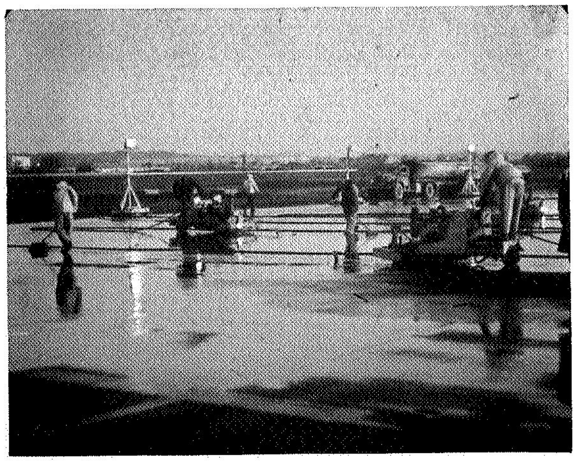

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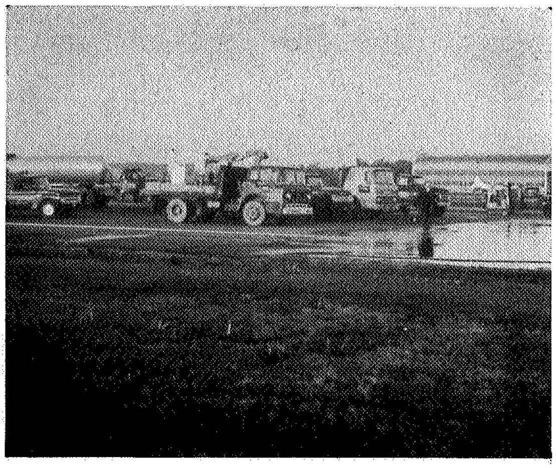

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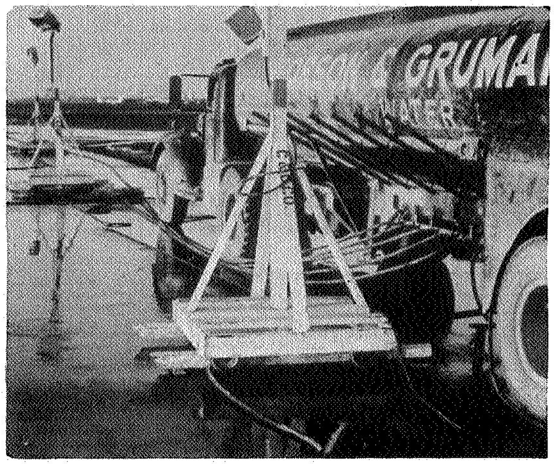
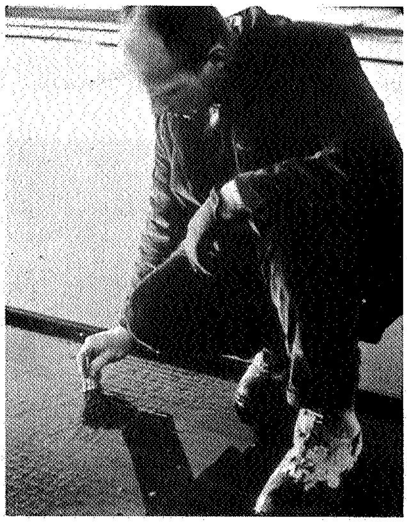


Figure 5

Figure 6



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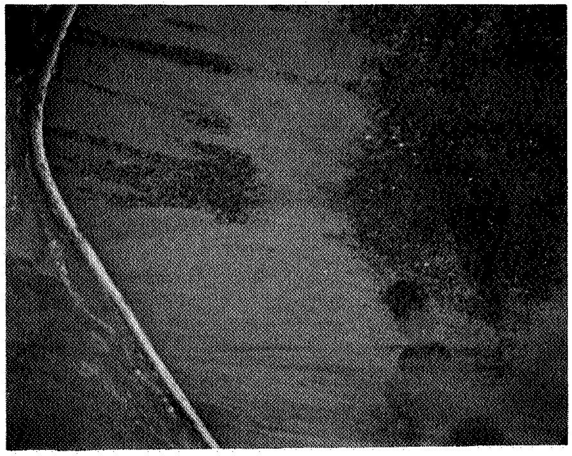

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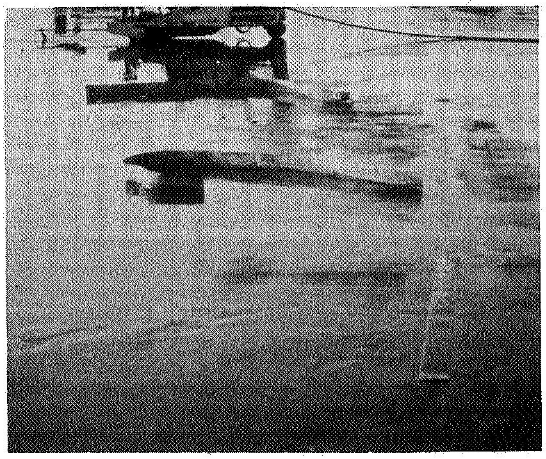

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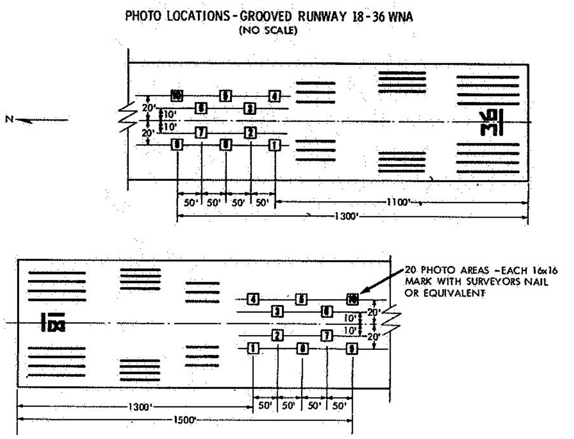

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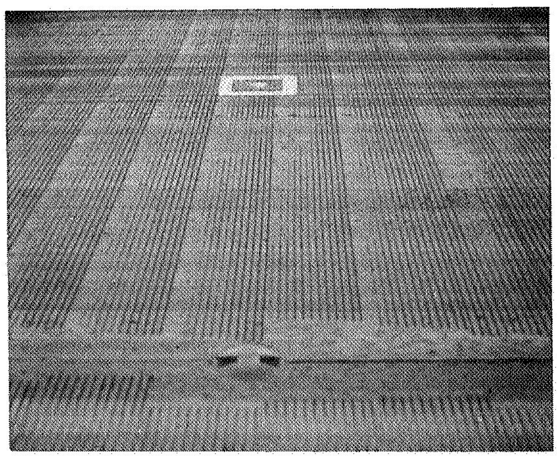

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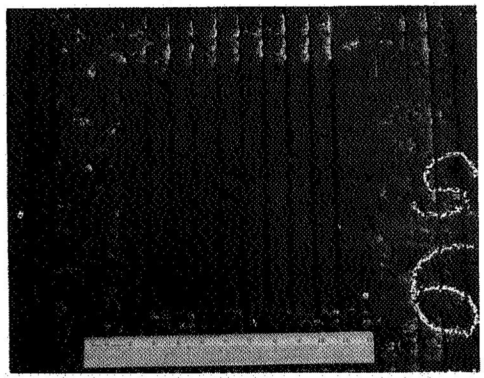

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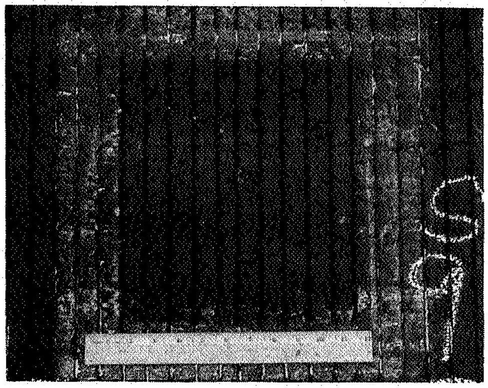

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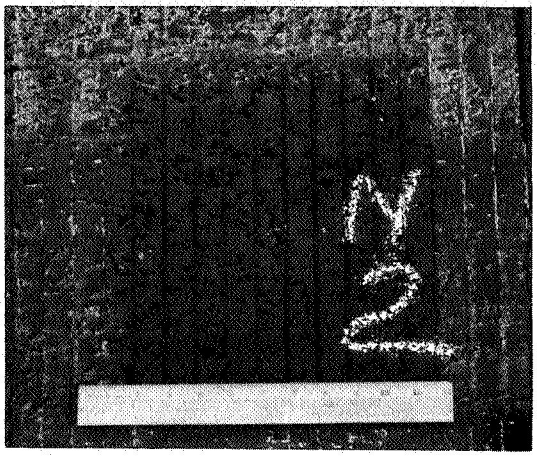

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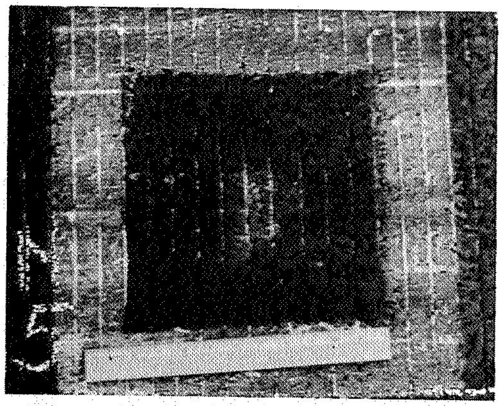

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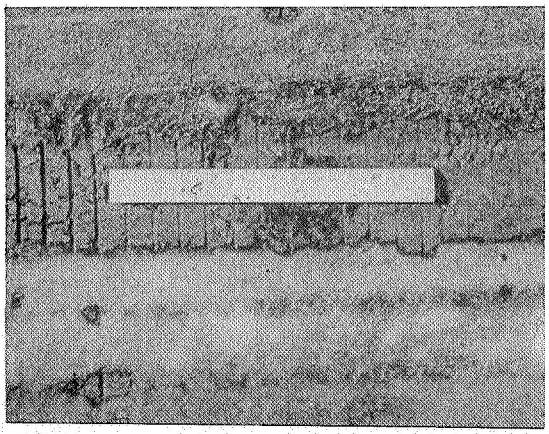

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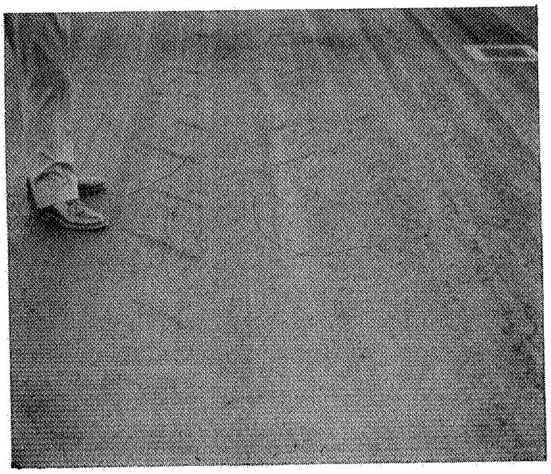
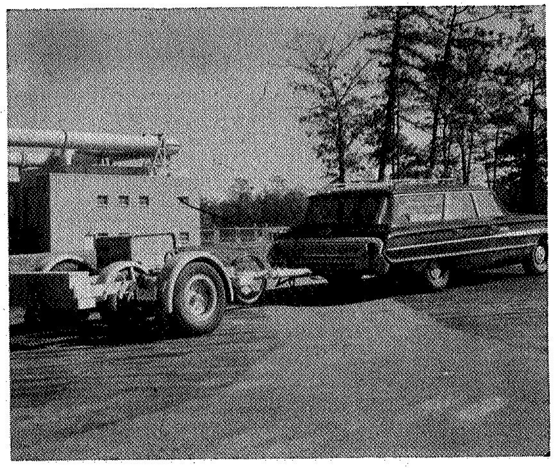


Figure 17

Figure 18

Figure 19



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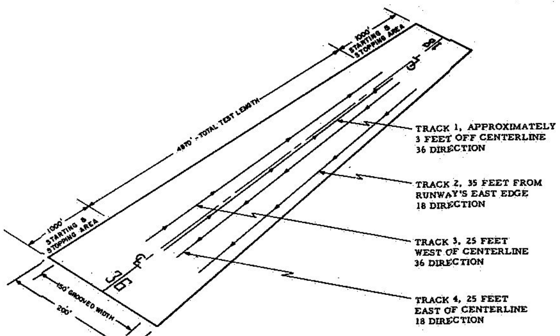
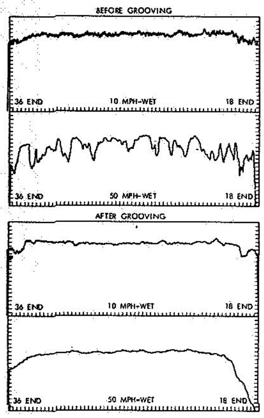


FRICTION MEASUREMENT PATTERN

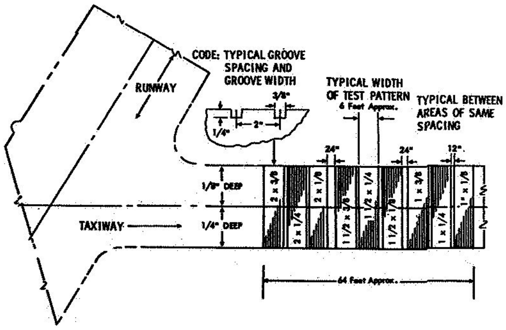
Figure 21



TRACK 4, 25 FT. EAST OF CENTERLINE - WET TESTS

Figure 22

GROOVED TAXIWAY TEST PATTERNS



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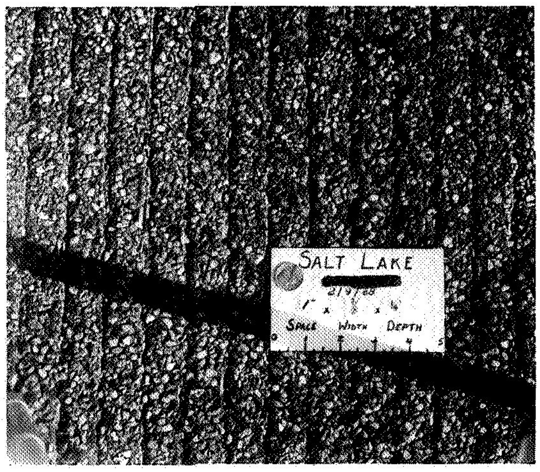

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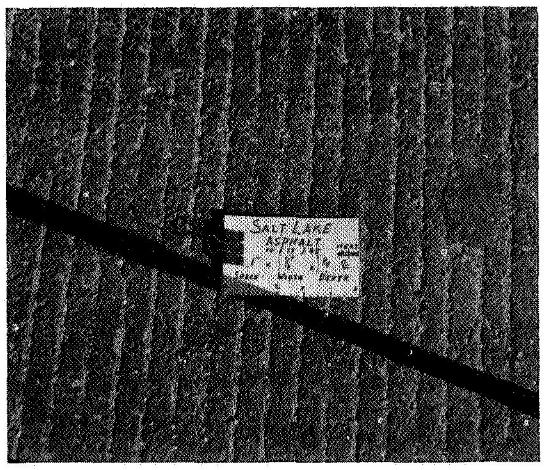

Figure 25

Figure 26

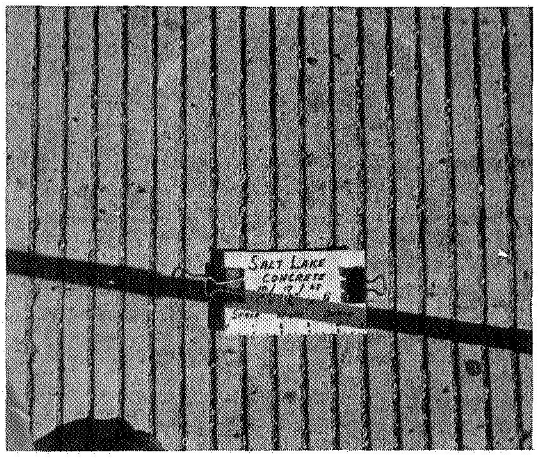

Figure 27