FIELD EVALUATION OF

TRAFFIC MARKING REMOVAL BY BURNING WITH EXCESS OXYGEN

by

District 3, Wichita Falls, and the
Materials and Tests Division
State Department of Highways
and Public Transportation

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ABSTRACT

Southwest Research Institute, San Antonio, Texas (under contract to the Federal Highway Administration) developed a high temperature burning system using excess oxygen for removal of paint-type pavement markings. Speed of marking removal, operational costs, pavement surface deterioration, and motorist legibility of removed marking were evaluated in the field by District 3, Wichita Falls, Texas, State Department of Highways and Public Transportation.

SUMMARY

A high temperature burning with excess oxygen system for pavement marking removal was developed by Southwest Research Institute, San Antonio, Texas (under contract to the Federal Highway Administration). This system utilizes a high temperature flame (4600°F) of propane and oxygen directed at the pavement surface. A second burner tip directs pure oxygen at the burning surface. The oxygen aids in the oxidation/decomposition of the marking material resulting in a rapid flash burning of the marking material with little or no damage to the pavement surface. The high temperature burning with excess oxygen system was field tested by the State Department of Highways and Public Transportation in District 3, Wichita Falls, Texas. The system performed satisfactorily. Field tests show asphaltic concrete pavements healed themselves very rapidly with no apparent surface deterioration. Portland cement concrete pavements heal much slower than asphaltic pavements with no apparent surface deterioration.

Motorist legibility of the removed marking is nominal to nil depending on the amount of weathering and type of road surface. Pavement markings were removed at a rate of 4.5 - 5.0 feet per minute at a cost of $0.10 - 0.12 per foot.

IMPLEMENTATION

The high temperature burning with excess oxygen system can be constructed with commerically available parts in District shops. The system may be used to satisfactorily remove pavement markings rapidly and economically.

I. PURPOSE

The purpose of this report is to familiarize District personnel of the State Department of Highways and Public Transportation with High Temperature Paint Stripe Removal Equipment and Procedures as developed by Southwest Research Institute (under contract to the Federal Highway Aministration) and evaluated by District 3. The FHWA has published Implementation Package 77-16, "Stripe Removal by High Temperature Burning with Excess Oxygen". Part I of this package covering the study by Southwest Research Institute has been included with this report hereafter referred to as the SWRI Operations Manual.

II. CONCLUSIONS AND RECOMMENDATIONS

Due to the low equipment cost, low operating cost, speed of pavement marking removal, and satisfactory performance of the high temperature burning with excess oxygen pavement marking removal system, it is recommended that other SDHPT Districts consider construction and usage of the system.

III. EQUIPMENT

A. High Temperature Stripe Removal Equipment designed and constructed by Southwest Research Institute (See the SWRI Operations Manual).

B. Oxygen Bottles, 10 gallon.

C. Propane Bottles, 25 gallon.

D. Support Vehicle

E. "Butcher Block" Brush/Broom (See the SWRI Operations Manual).

IV. DISCUSSION

It should be stated that the high temperature stripe removal equipment, discussed in this report, was designed and constructed by Southwest Research Institute, San Antonio, Texas; and that much of the discussion of the

equipment in this report is based on their technical data. The equipment design discussed herein and in Southwest Research's Operation Manual makes reference to the use of components from Victor Equipment Company, Denton, Texas. While the components from Victor have been found to perform satisfactorily, this does not constitute an endorsement by the SDHPT or SWRI. There are other product lines and products on the market that would perform in an equally satisfactory manner.

There are several factors which relate to the pavement marking material removal task for the department. These include:

1. Many maintenance facilities need the capability to efficiently remove pavement markings.
2. Pavement marking removal operations have the characteristic of immediacy.
3. Pavement marking removal operations are relatively small jobs, usually less than 2000 lineal feet.
4. There is an intermittent requirement for pavement marking removal operations.[2]

With these factors in mind, SWRI, under contract from the U.S. Department of Transportation, developed a pavement marking removal system which is economical, easily constructed, and causes minor surface damage. The system developed utilizes high temperature burning with excess oxygen.

A high temperature burning with excess oxygen system may be defined as a system where a burner tip directs a high temperature flame of propane and oxygen at the pavement marking while a second burner tip directs pure

oxygen at the burning surface. This system aids in the oxidation/decomposition of the marking material. The result is a rapid flash burning of the marking material with little damage to the pavement surface. Pavement marking removal by burning is not new. The usual procedure has been to burn butane or propane or mixtures thereof (LPG) in one of several types of burners. The flame temperatures of such burners are approximately 2000°F (1100°C). Since conventional traffic marking paints are largely produced from alkyd-base resins heavily loaded with pigments, extenders and fillers, they do not burn easily. Due to the flame temperature (2000°F) of conventional burners, it was necessary for the pavement surface to be burned for an extended period to destroy the paint film.

This overheating was evidenced in asphaltic concrete by melting, in seal coat pavements by asphalt melting and rising to the surface, and in portland cement concrete (PCC) pavements by surface spalling.(2)

The unique feature of the high temperature burning with excess oxygen system is high temperature or flash burning with the use of excess oxygen. Burning propane with excess oxygen produces a flame temperature of approximately 4600°F (2500°C). Burning is a process of oxidation, and by directing additional oxygen through a second burner tip at the surface being burned, the process of oxidation and decomposition of the unwanted paint film is accelerated. Using a higher temperature flame allows faster lineal travel, transmitting less heat to the pavement surface and consequently reduces pavement surface damage.(2)

After passage of the burner, destruction of the paint marking is evidenced by a gray to whitish ash residue. This residue consists of beads, pigments, extenders and fillers (the resin having been destroyed). This residue must then be broomed from the pavement surface. Discoloration of the pavement surface will vary with the pavement and the number and condition of old paint layers removed. The marking will not be visible at night due to the removal of glass beads.[2]

One feature of the system described in this report is that all parts are commercially available off-the-shelf items. The system consists of parts as shown in Figure 1 and described in the SWRI Operation Manual.
It should be noted that any suitable carriage may be used, such as the golf cart shown or an old lawn mower with the engine removed. All parts are available in most, if not all, localities.

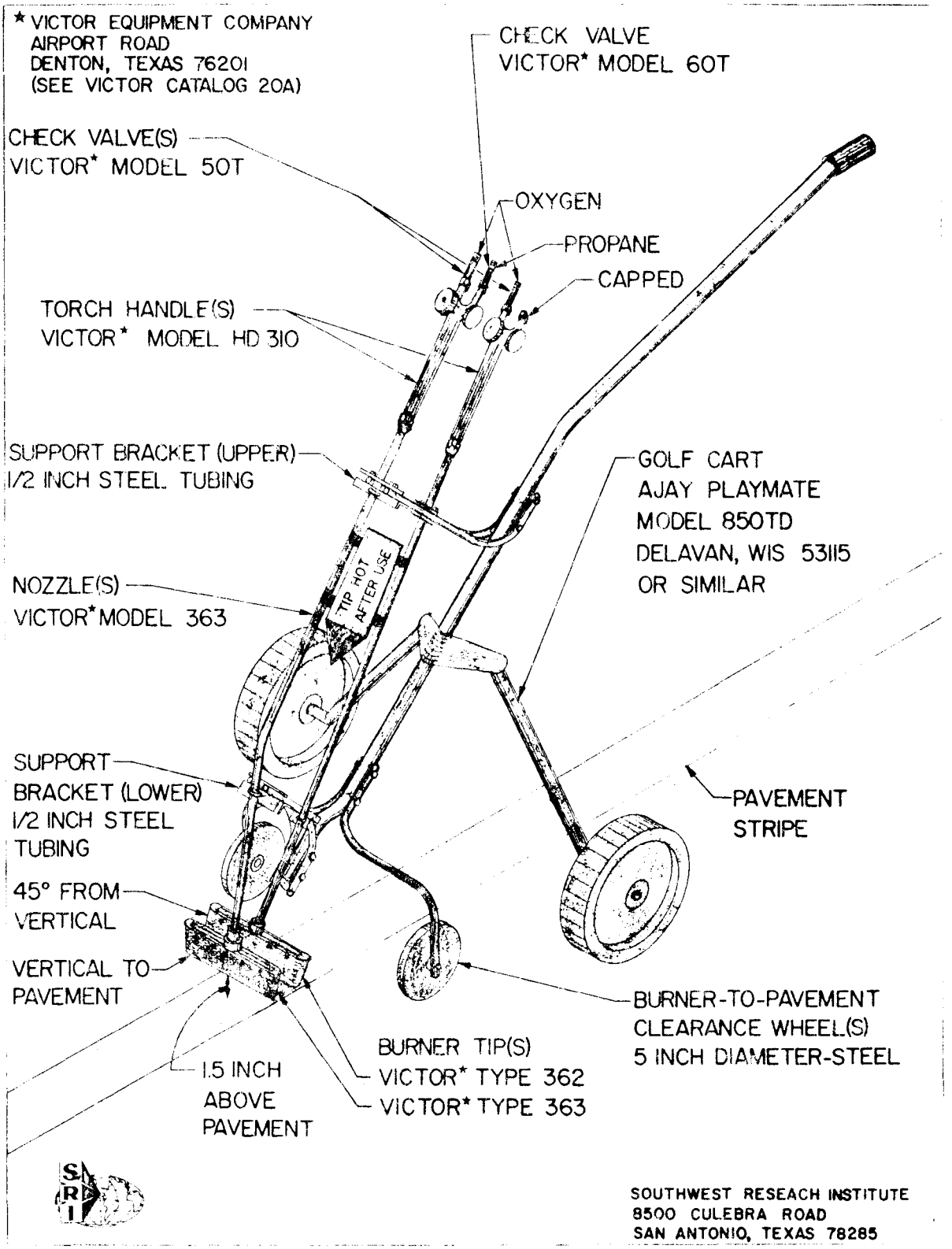
* VICTOR EQUIPMENT COMPANY
AIRPORT ROAD
DENTON, TEXAS 76201
(SEE VICTOR CATALOG 20A)
CHECK VALVE
VICTOR* MODEL 60T
CHECK VALVE(S)
VICTOR* MODEL 50T
OXYGEN
PROPANE
CAPPED
TORCH HANDLE(S)
VICTOR* MODEL HD 310
SUPPORT BRACKET (UPPER)
1/2 INCH STEEL TUBING
GOLF CART
AJAY PLAYMATE
MODEL 850TD
DELAVAN, WIS 53115
OR SIMILAR
NOZZLE(S)
VICTOR* MODEL 363
TIP HOT AFTER USE
SUPPORT
BRACKET (LOWER)
1/2 INCH STEEL
TUBING
PAVEMENT
STRIPE
45° FROM
VERTICAL
VERTICAL TO
PAVEMENT
BURNER-TO-PAVEMENT
CLEARANCE WHEEL(S)
5 INCH DIAMETER-STEEL
BURNER TIP(S)
VICTOR* TYPE 362
VICTOR* TYPE 363
1.5 INCH
ABOVE
PAVEMENT
S.
R.
I.
SOUTHWEST RESEACH INSTITUTE
8500 CULEBRA ROAD
SAN ANTONIO, TEXAS 78285

FIGURE 1.

The system is easily operated, and may be put in operation as follows:

1. Set regulator pressure (see the SWRI Operations Manual).
2. Tilt the cart back until the handle contacts the pavement, raising the burner tips from the pavement.
3. Purge each line.
4. Slowly open the propane valve and light the burner tip.
5. Adjust the propane valve until the flame just begins to leave the burner tip (see Figure 2).

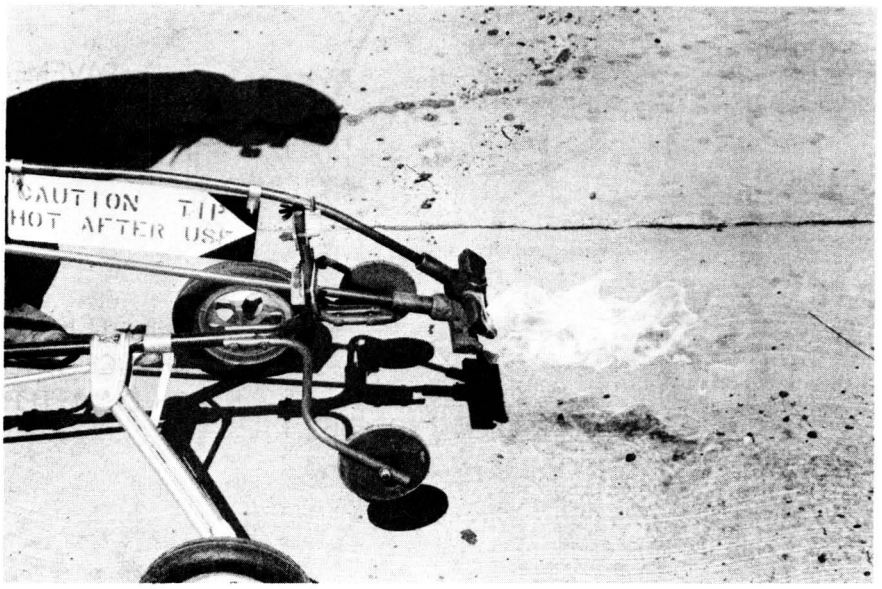

FIGURE 2.

6. The fuel-oxygen valve is now opened until the white inner flame length is reduced to approximately 1/2 inch. (See Figure 3.)

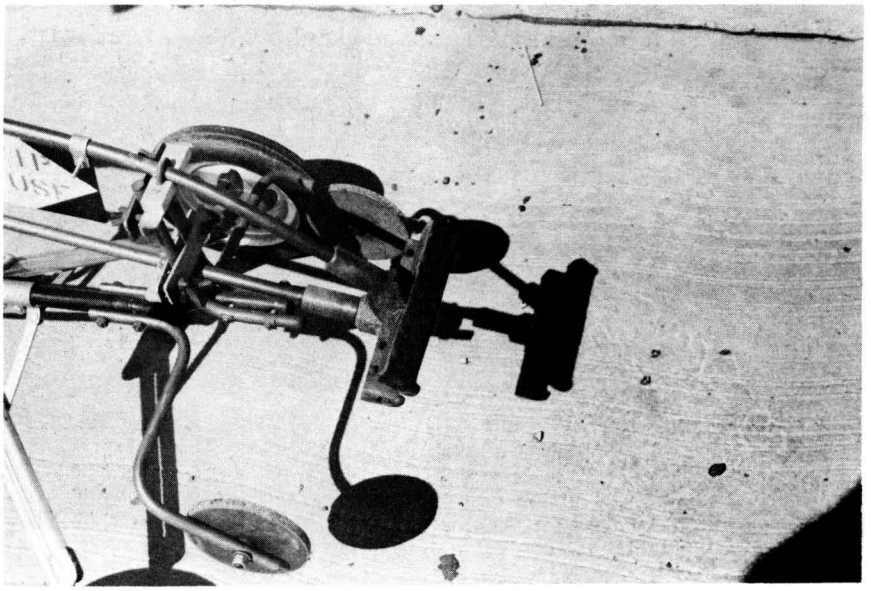

FIGURE 3.

7. The cart is tilted forward to its operating position and the excess oxygen valve is opened until the propane-oxygen flame is deflected forward. (See Figure 4.)

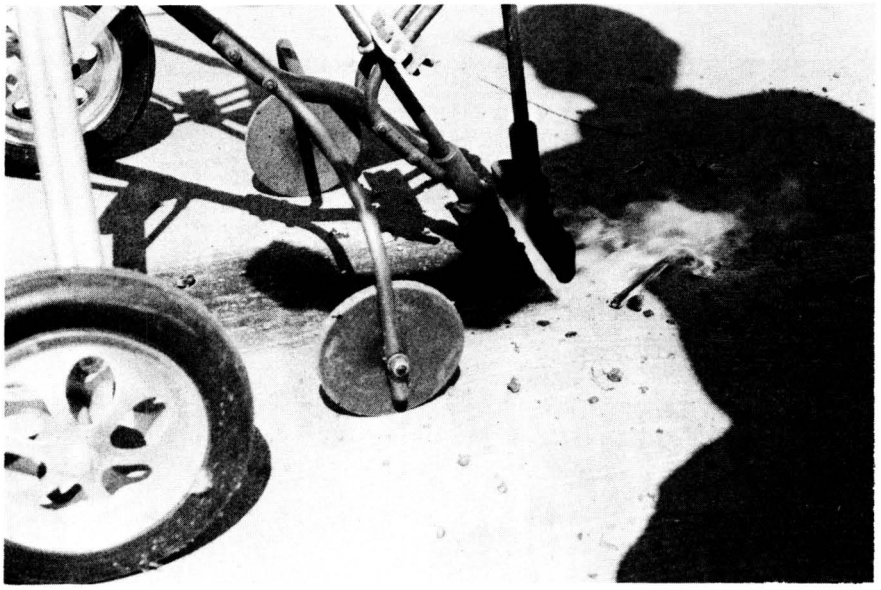

FIGURE 4.

8. The system is now ready for marking removal operations.

For detailed information on operation, see the SWRI Operations Manual.

The high temperature burning with excess oxygen equipment was taken to the SDHPT in District 3, Wichita Falls, Texas, for field testing. Two areas were chosen as test sites for the equipment. These areas were:

1. U.S. 82/287 west of Wichita Falls centered around the intersection of FM 369. This area included newly constructed, but open to traffic, portland cement concrete (PCC) and asphaltic concrete road surfaces. The PCC road surfaces are frontage roadways and the asphaltic concrete pavement road surfaces are entrance ramps.
2. U.S. 287 west of Vernon, Texas, northbound from the Pease River bridge. This area is asphaltic concrete pavement on main lanes.

Both areas were temporarily marked for traffic control during construction. Completion of construction in both areas necessitated removal of the existing marking prior to the application of the final marking system. The temporary markings were chlorinated rubber, alkyd-base Texas traffic paint, white and yellow.

The system was set up to work out of a pickup truck (See Figure 5),

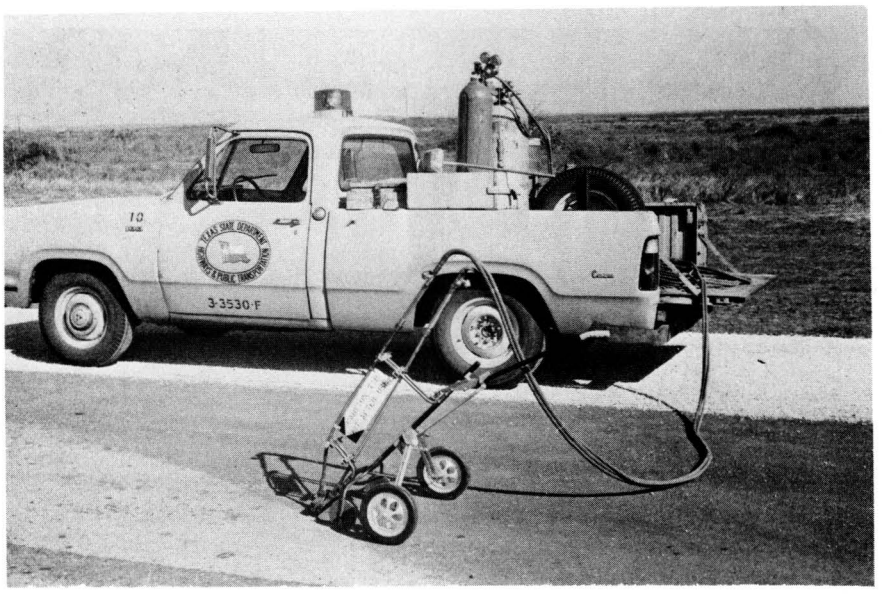

FIGURE 5.

utilizing two 10-gallon oxygen tanks and one 25-gallon propane tank (see Figure 6).

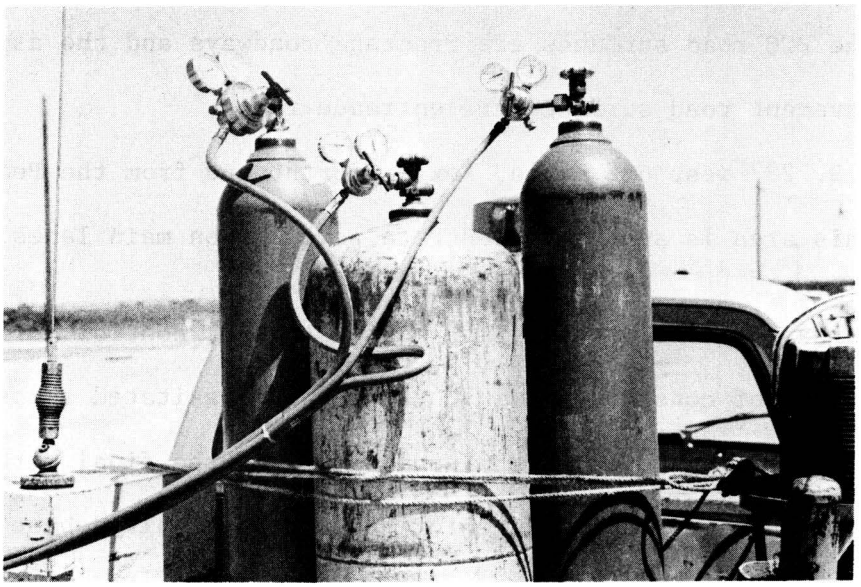

FIGURE 6.

Stripe removal was evaluated on PCC pavement (see Figure 7),

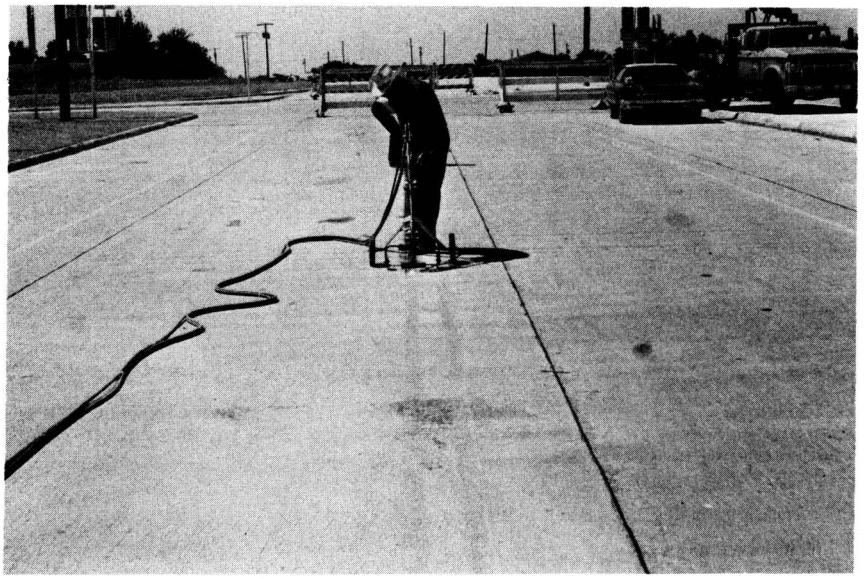

FIGURE 7.

and on asphaltic concrete pavement (see Figure 8).

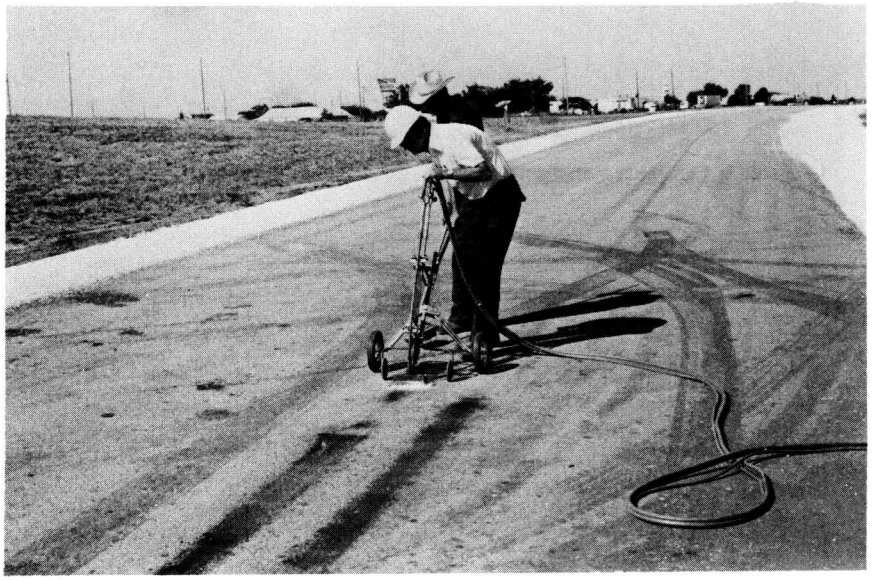

FIGURE 8.

Figures 9, 10 and 11 show a close-up of a solid yellow center lane marking on asphaltic concrete pavement, a solid yellow center lane marking on PCC pavement, and a white edge line marking on PCC pavement after marking removal, respectively.

FIGURE 9.

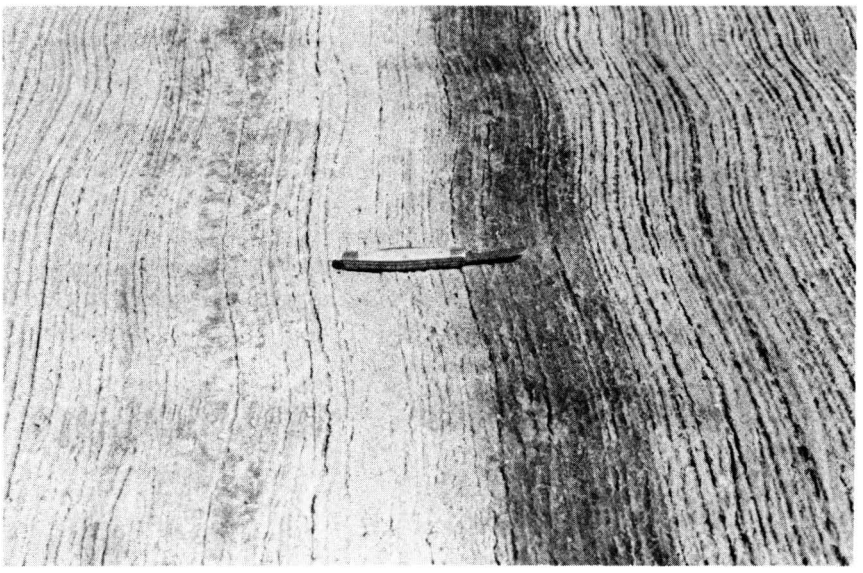

FIGURE 10.

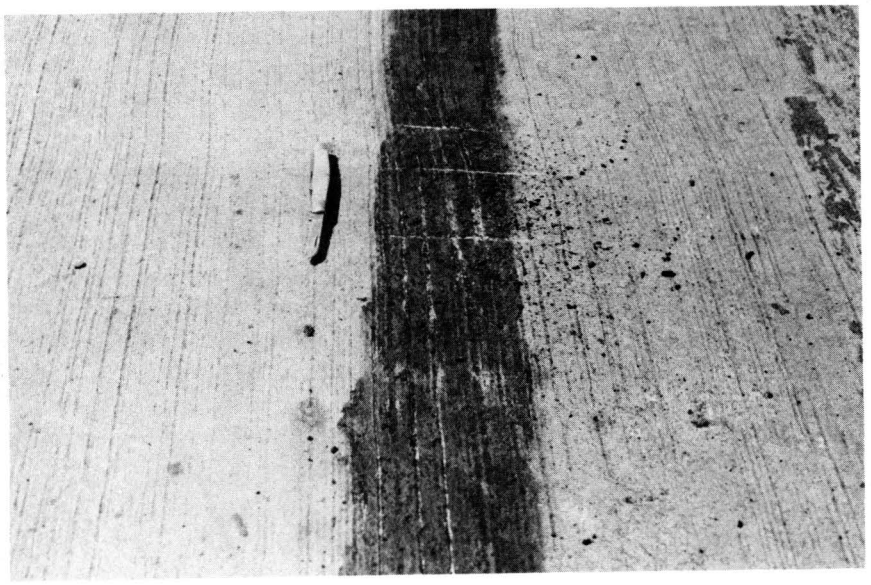

FIGURE 11.

It can be observed that there is a small amount of surface deterioration on the asphaltic concrete pavement roadway (Figure 9), and that the residue from the white edge line is "gummier" (Figure 11) than the residue from the yellow center line (Figure 10).

Two problems evolved during the field testing of the equipment. These problems were:

1. During the second day of field tests wind speeds were 10-15 mph. This caused the flame pattern to be blown out from under the burner tips, lowering the efficiency of the equipment. When this condition was noted, the equipment was taken into District 3's maintenance shop and

a wind screen was fabricated. This corrected the condition and wind ceased to be a problem (see Figure 12).

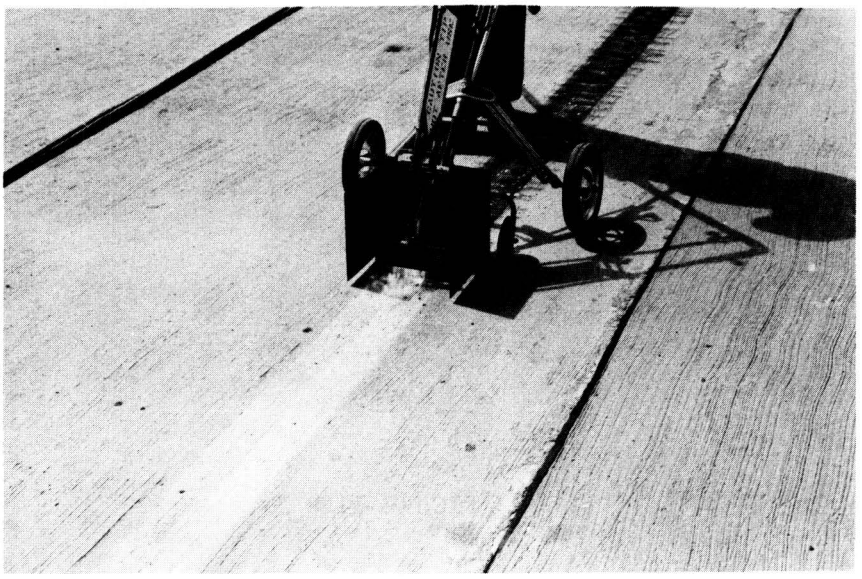

FIGURE 12.

2. Due to the broomed texture of the PCC pavement, the residue from the burned marking was more difficult to remove than was expected. Four methods were tried to remove this residue. These included:

   A. Cleaning the residue with a mobile sweeper (see Figure 13). The resulting marking after brooming may be observed in Figure 14.

FIGURE 13.

FIGURE 14.

B. Washing with water (at approximately 60 psi) with the resulting residue as observed in Figure 15.

FIGURE 15.

C. Hand brushing with the "Butcher Block" brush. This brush can be observed in the workman's hand in Figure 16.

FIGURE 16.

D. Lightly sandblasting the residues.

Of the four methods attempted, hand brushing with the "Butcher Block" brush was the most effective method. Observations of the other three methods were:

1. Cleaning with water at 60 pounds pressure would not remove the residue from the surface texture of the PCC roadway.
2. Due to the large diameter size of the bristles on the mobile sweeper brushes, the sweeper could not effectively remove the residue from the surface texture.
3. Sandblasting would remove the residue; however, it required as long to remove the residue as it did to remove an unburned marking.

As can be observed in Figure 17,

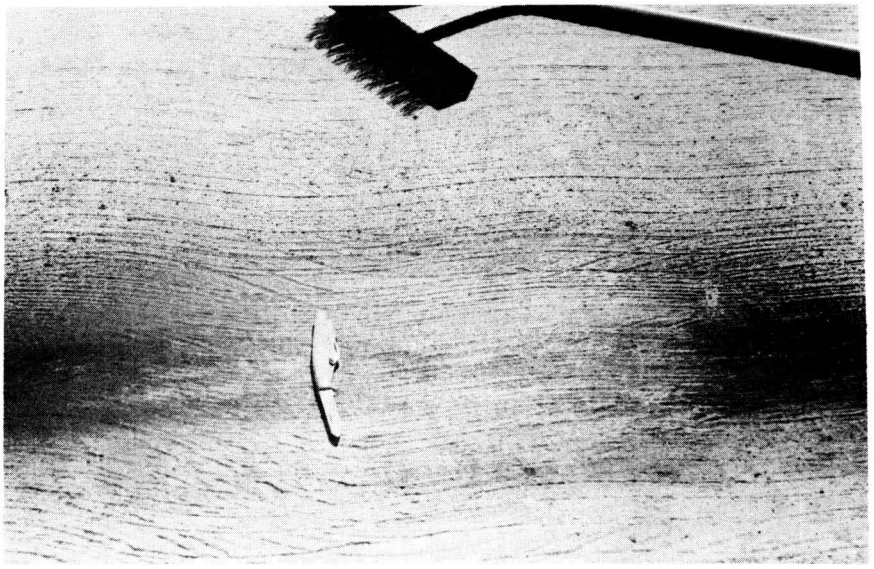

FIGURE 17.

the hand brush will remove the residue if enough effort is given to the removal task.

Discussion of the removal process yielded two things:

1. To concentrate on utilizing the hand brush. The bristles on the hand brush were a little large for the surface texture. If a hand brush were available with smaller bristles, it would do a more effective job.
2. If some sort of a vertical-axis, powered, rotary wire brush with small bristles were constructed, it could do an effective job of cleaning the residue from a broomed PCC road surface. However, a system of this type has not been constructed or utilized. It should be noted that residue is no problem with asphaltic concrete pavements.

Approximately one month after the markings were removed by high temperature burning with excess oxygen, they were again observed for weathering. Figures 18 and 19 show an asphaltic concrete pavement entrance ramp on U.S. 82/287 where a double yellow center marking was removed and replaced by a white skip line marking.

FIGURE 18.

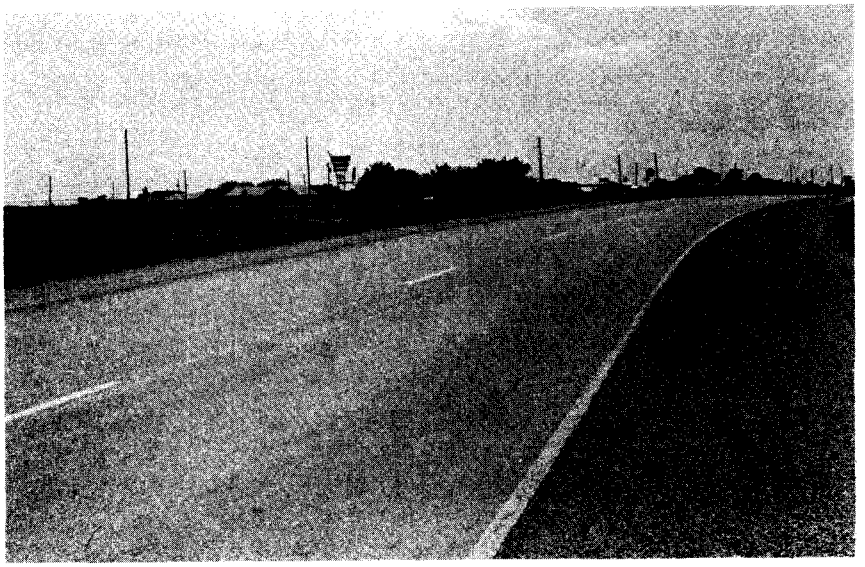

FIGURE 19.

As can be observed, the removed marking has, for all purposes, weathered out. This is the same ramp shown in Figures 10 and 11.

Figures 20-23 show two PCC road surfaces (at two intersections) where a double yellow center marking was removed and replaced by a white skip line marking; one white edge line was removed and replaced with a white skip line; and one white edge line was removed and replaced with a yellow edge line.

FIGURE 20.

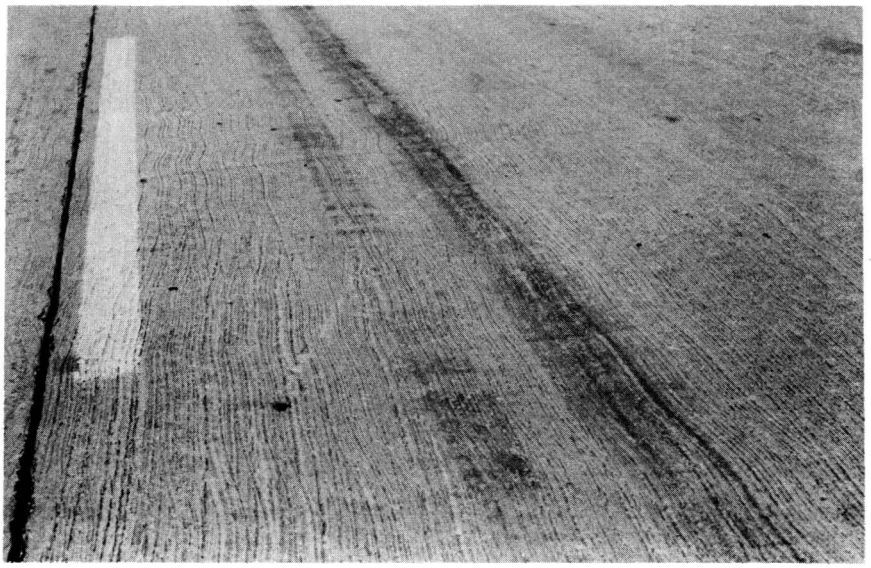

FIGURE 21.

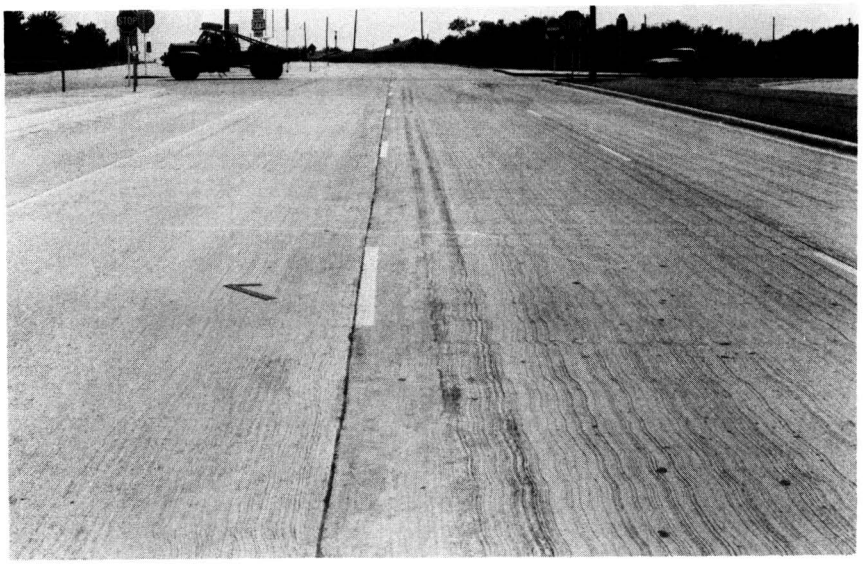

FIGURE 22.

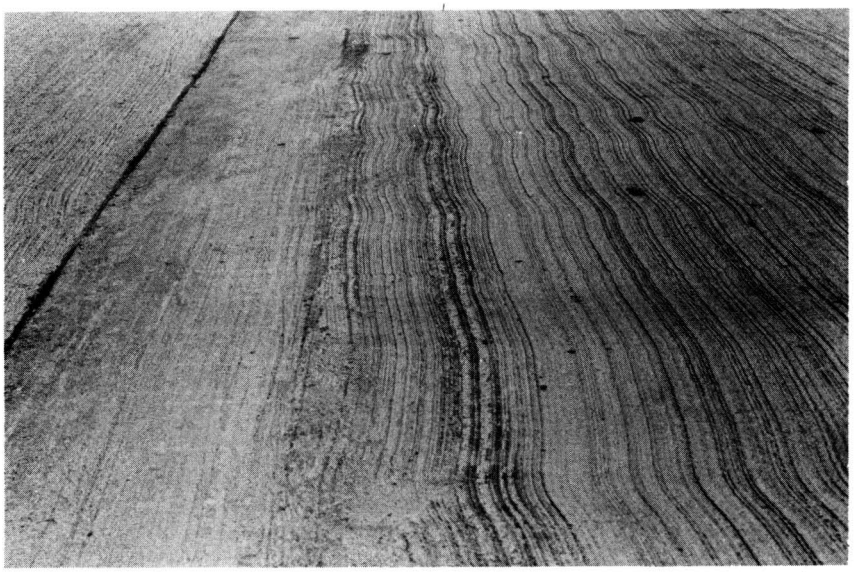

FIGURE 23.

As can be observed, the removed marking is weathering well. District 3 personnel report that each rainfall accelerates the weathering. It can also be observed that the removed edge lines are not weathering to the extent of the removed double yellow center lines, possibly due to a lesser traffic load.

Figures 24-27 show a gore that has been partially removed from an asphaltic concrete section of U.S. 287 west of Vernon. The gore had been placed, while the northbound lanes were under construction, to direct two-lane traffic into four-lane traffic at the Pease River Bridge. Both north and southbound lanes are now open to traffic necessitating removal of the gore and remarking with a standard marking system. As can be observed in Figure 24, from a motorist standpoint, the marking has been effectively removed. (These photographs were taken the day after the marking was removed.)

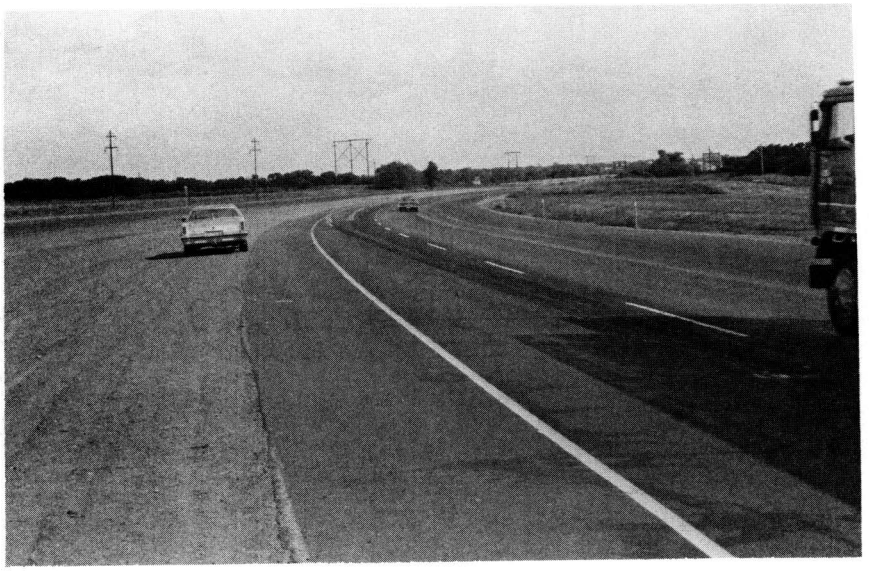

FIGURE 24.

Figures 25 and 26 show two different views of the removed marking.

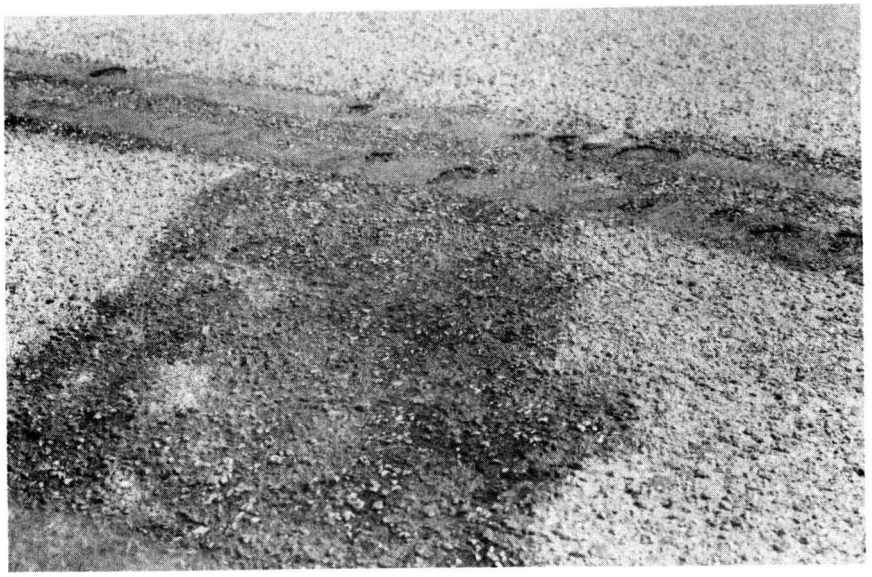

FIGURE 25.

FIGURE 26.

It should be noted that the surface deterioration observed in Figures 25 and 26 did not result from burning but existed prior to marking removal. This surface deterioration may be observed in Figure 27.

FIGURE 27.

Figures 26 and 27 are the same section of the gore. Using the parked car as a reference, Figure 26 was taken southbound and Figure 27 northbound.

In all cases where cleaning was applied to a burned marking, there was loss of retroreflective beads and no nighttime motorist recognition of the marking.

In the removal of 12,500 feet of stripe the following direct costs were experienced in operations in District 3.

1. 196 man-hours charged at $5.00/hour.
2. 50 cylinders of oxygen used at $4.25/cylinder.
3. 125 gallons of propane used at $0.30/gallon.
4. 300 vehicle miles charged at $0.12/mile.

Costs were:

1. Labor cost - $0.0784/ft.
2. Fuel cost - $0.02/ft.
3. Vehicle cost - $0.0029/ft.
4. Total cost - $0.1013/ft.

It should be noted that this cost represents one workman and one pickup truck. If two workmen were utilized, and resulted in a more efficient operation, the cost per foot should be in the range of $0.10 - $0.12. The rate of marking removal, for the 12,500 feet removed, was 4.5 - 5.0 feet per minute.

Based on this field study it appears that marking removal by high temperature burning with excess oxygen may offer several advantages to previously utilized marking removal systems. These include:

1. The equipment necessary to construct a system is commercially available and the system can be constructed at Department shop facilities.

2. The system is semi-portable, can be mounted in a pickup truck, and therefore ties up equipment only when removal operations are in progress.
3. The system would cause less hindrance to traffic than previously utilized marking removal systems.
4. The system causes very little, if any, deterioration to the roadway surface.
5. The rate of marking removal compares with previously utilized marking removal systems.
6. The operational cost of the system is less than previously utilized marking removal systems. (Cost of marking removal by sandblasting experienced in District 3 is approximately $0.32 per foot.)

Based on this field test, pavement marking removal by burning with excess oxygen offers a low cost system which will effectively remove existing pavement markings with low motorist recognition and minimal pavement surface deterioration.

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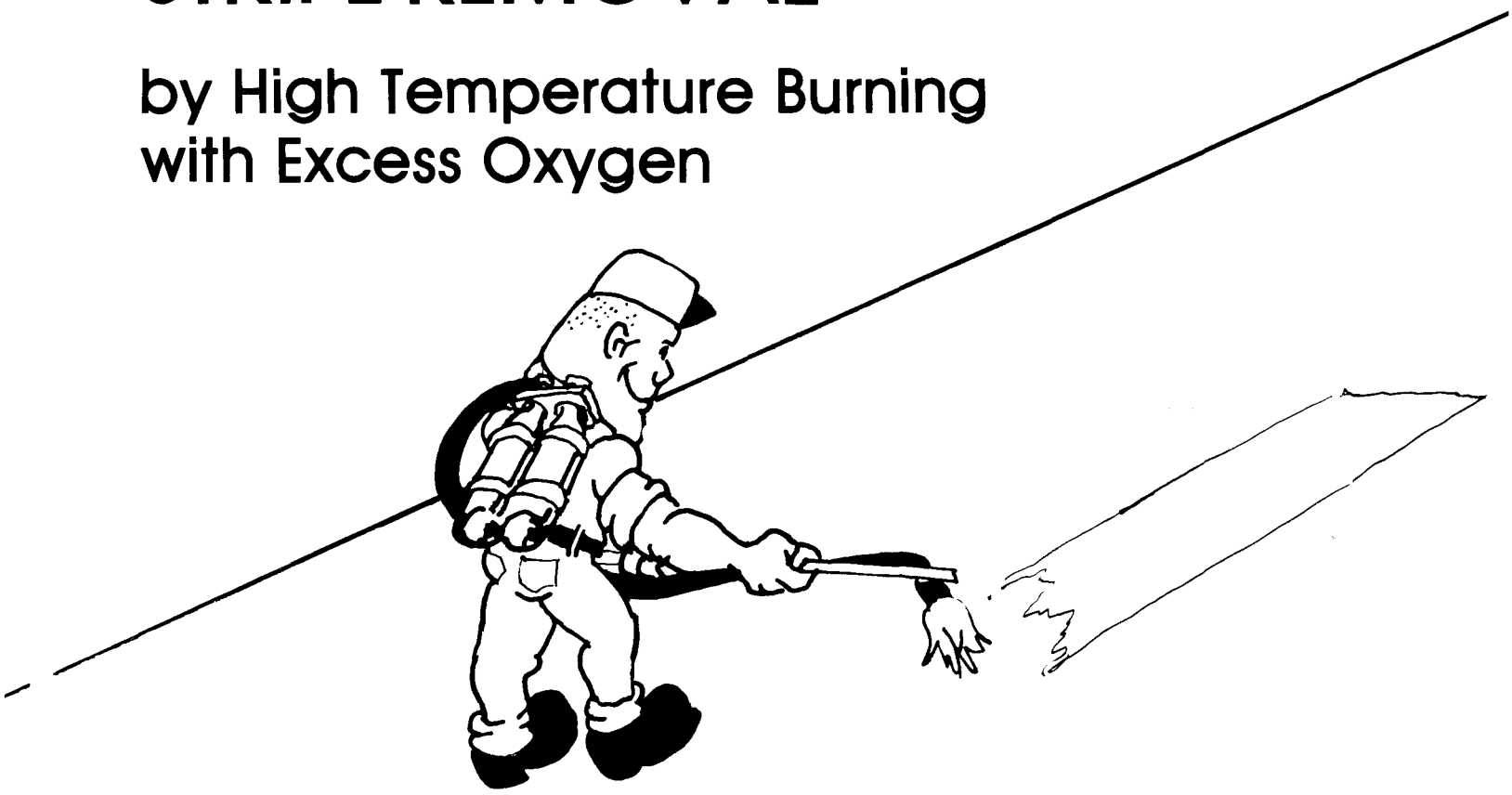
Special acknowledgement is given to those individuals in District 3 and D-9 who worked directly in this effort and made this study possible. In particular, we wish to thank those individuals who did the actual work on the roadway.

77-16
IMPLEMENTATION PACKAGE

STRIPE REMOVAL

by High Temperature Burning with Excess Oxygen



U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration
Offices of Research and Development
Implementation Division

June 1977

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INTRODUCTION

The Offices of Research and Development initiated three contract studies aimed at developing innovative methods of traffic stripe removal which are efficient, practical, and relatively easy to use, but must not disturb the pavement surface to the extent that visible scars or traces remain. Two contractors have independently approached the problem by developing simple and highly portable LP or propane fired burners supplemented with excess oxygen.

Part I of the Implementation Package describes the design, operation, and maintenance of the device developed by Southwest Research Institute. Part II includes similar information on the equipment that Midwest Research Institute has developed.

Both of these devices employ the same principal--burning with excess oxygen. However, there are some differences. The following table is a comparison of the two devices.

	SWRI	MRI
Fuel	Propane	LP Gas
Pressure at Regulator		
Oxygen	60 psi*	30 psi
Fuel	15 psi*	30 psi
Burners	2 Burner Tips	Single Block Burner

*With 25 feet of ¼" hose (7.7 metre of 0.6 cm hose)

Note: 1 psi = 6.89 Pa

PART I

Southwest Research Institute

FOREWORD

There are certain factors that relate directly and indirectly to the marking material removal task that must be considered:

1. Every highway maintenance facility needs the capability to efficiently remove pavement markings. This means many removal units for each state or authority.

2. Pavement marking removal operations have the characteristic of immediacy. The system and equipment should be available for use on short notice.

3. Pavement marking removal operations are relatively small jobs, typically involving 45 to 2000 lineal feet of marking.

4. There is an intermittent requirement for pavement marking removal operations. At a given location, about 20 days per year or less are utilized in pavement marking removal operations.

This research program was begun as a conceptual effort to explore new concepts for removing pavement markings with as little damage or scarring of the pavement as possible. Of the many concepts considered, the method of high temperature burning with excess oxygen was finally chosen for further study. Laboratory work resulted in the design and development of a method of operation and equipment.

This method of stripe removal has the advantage of burning the unwanted marking material off rapidly with little damage to the pavement. Discoloration, color or contrast differences between the burned and unburned surfaces can vary from excellent to poor, depending upon the type, nature and surface condition of the pavement. It is not expected that this method will replace all existing methods or be of use in all situations, although it does offer a number of advantages over most other methods. The equipment and its operation is simple and inexpensive. Much of the required equipment and operating experience necessary to employ the method already exist in most highway division maintenance facilities.

TABLE OF CONTENTS

	PAGE
METHOD	1
DESIGN	3
OPERATION	8
MAINTENANCE	9
SAFETY	9

LIST OF FIGURES

FIGURE		PAGE
1	Burner Tip	3
2	Pavement Stripe Removal Unit	4
3	Brush/Broom	6
4	Assembly	7

METHOD

Pavement marking removal by burning is not new. The usual practice has been to burn butane or propane or mixtures thereof (LPG) in one of several types of burners. The oxygen supply for the burners is air which contains approximately 21 percent oxygen. The flame temperatures of such burners is approximately 2000°F (1100°C). Since conventional traffic marking paints are largely produced from alkyd base resins heavily loaded with pigments, extenders and fillers, they do not burn off easily. It is necessary to direct the flame from current fuel - air burners at the surface to be burned for an extended period to destroy the paint film. The rate of burning is slow and the heat from the flame has an opportunity to penetrate the surface of the pavement which can result in damage to the pavement. Overheating is often evidenced in asphaltic concrete by melting; in seal coat pavements by the asphalt melting, rising to the surface and bubbling; and in Portland cement concrete pavements by surface spalling.

The unique feature of the method described herein is high temperature or flash burning with the use of excess oxygen. Burning propane with pure oxygen produces a flame temperature of approximately 4600°F (2500°C). Burning is a process of oxidation, and by directing additional or excess oxygen through a second tip or head at the surface being burned the process of oxidizing and decomposition of the unwanted paint film is accelerated. The use of the higher temperature flame and the excess oxygen makes this method much faster than the older burning methods. Since lineal movement can be more rapid, less heat is transferred to the underlying pavement surface, thereby reducing the possibility of damaging the pavement. When properly conducted, this method of removal proceeds at a rate of 5 to 10 feet per minute. The rate of removal varies with the situation; the most important factor is the number and condition of the old paint layers to be removed. One to several layers can be removed at a rate such that very little heat is transferred to the pavement structure. This is evidenced by the fact that it is possible to touch the burned surface with the bare hand several feet behind the burner.

After passage of the burner, optimum removal conditions are indicated by the presence of an ash on the surface composed primarily of the inert and inorganic materials contained in the original paints. The ash consists largely of glass beads, pigments, extenders and fillers; the resinous binder materials that were holding these materials together having been burned away. With white stripes the ash is normally gray in color, whereas yellow stripes leave an ash that can vary from gray to a gray-yellow. The ash and remnants of the marking material tend to be separated from the pavement surface more easily after they have cooled. Thus their removal is more easily accomplished 10 feet (3.3 m) or more behind the burner. Broom brushing by hand is effective. Brooms with fiber or composition bristles are not as effective as those with steel bristles. "Butcher Block" brushes made with bristles of flat steel strips mounted under a steel plate are very effective in removal of the

ash. This very coarse acting brush is not only efficient in removing the ash but it also provides the individual using it an opportunity to blend, by the degree of brushing employed, the color of the burned surface into that of the unburned surface.

As a method of stripe removal, high temperature burning with excess oxygen does very little damage to the pavement surface when compared to many other methods of removal. The only portion of the pavement damaged is the top several thousands of an inch. There is no observable groove left in the pavement. The color match between the surface where a stripe has been removed by this method can be excellent to poor in the daytime. This is largely a function of the type and condition of the pavement, and the number and condition of the old paint layers removed. No post treatments with paints, oils, asphalts, etc. are recommended with this method. Self-healing of the discolored areas normally takes place rapidly and is a function of the pavement type, time of year, amount of rainfall and amount of traffic.

At night, stripes removed by this method are indeed removed in terms of the visual perspective of the motorist in that the glass beads through which pavement markings are perceived at night are gone. Similarly, color contrasts in the pavement surface due to burning are largely imperceptible to the motorist at night. They are also offset by the many other contrast situations existing in pavements due to patching, crack sealing and the many other maintenance operations conducted on pavements. Since this method does not leave a groove in the pavement that can hold water, there is no visual impression during wet weather either in the daytime or at night of an existing stripe, but particularly at night in the presence of oncoming headlights.

One of the principal features of this method relates to its low equipment and operating cost. The only equipment unique to this method are the two burner tips (propane-oxygen and the excess oxygen), both of which are commercially available off-the-shelf items. Torch handles, hoses, regulators, propane and oxygen bottles available in most all district highway maintenance yards are considered adequate. Any of the equipment not available can be obtained as off-the-shelf items from most local vendors. At many locations where shop facilities exist it should be possible to buy any needed equipment for as little as several hundred dollars.

The cost of the propane, oxygen, and excess oxygen required to remove marking material varies with quite a number of factors. Normally one can expect the cost of these gases to be somewhere between $0.015 to $0.02 per foot ($0.046 to $0.061 per metre) of stripe removed.

DESIGN

It should be kept in mind that the most important thing is the concept of high temperature burning with excess oxygen. How one chooses to design and build the equipment is not that important. The design and selection of equipment shown here reflects one approach, but not necessarily the optimum approach. The design approach recommended is that of utilizing to the greatest possible extent the equipment already available in one's own shop. Most shops are equipped with oxygen and propane bottles, regulators, hoses, check valves, goggles, and torch handles. The items that are probably not available and are specific to this operation are the burner tips, a cart or method to position the tips the right distance above the surface to be burned and a brush/broom that is abrasive enough to remove the ash with one or two passes and restore as closely as possible the surface to that of the adjacent surface.

The single most important part of this unit is the propane-oxygen burner tip. The burner tip selected for use is shown in Figure 1. This

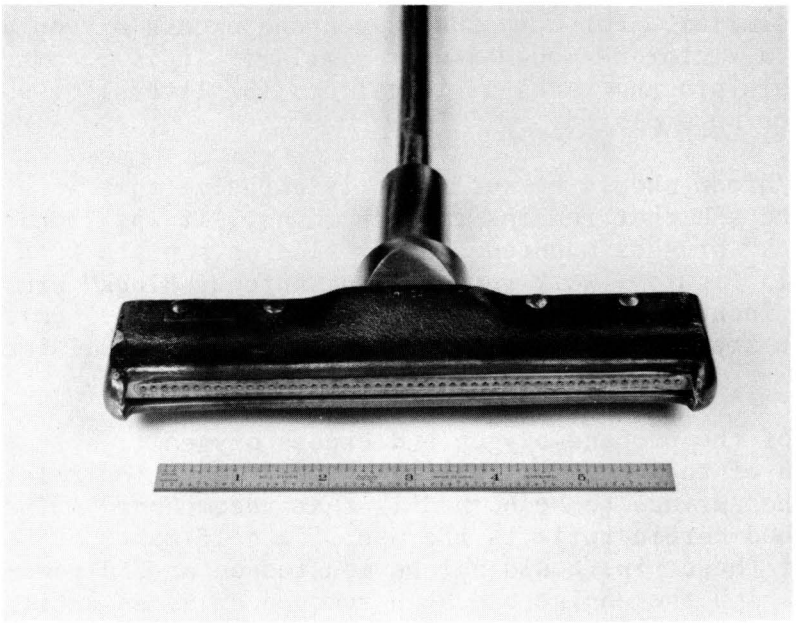

Figure 1. Burner Tip

tip is approximately 6 inches (15 cm) long by 0.5 inches (1.2 cm) wide and has multiple burning ports. The 6-inch (15 cm) length of the tip is ideally suited for stripe removal in that while most stripes are applied as 4-inches (10 cm) wide stripes, restriping operations invariably lead to overlapping of one edge or the other such that the width of the stripe to be removed is almost always wider than 4 inches (10 cm), but very seldom wider than 6 inches (15 cm). Thus the tip is the right width for most situations encountered. The tip should bemounted vertical to the pavement surface and 1.5 inches (3.8 cm) above the pavement surface. Immediately to the rear of the propane-oxygen burner tip is the excess oxygen tip which is of the same configuration as the propane-oxygen tip but with slightly smaller ports. The excess oxygen tip is mounted just to the rear of the propane-oxygen tip at an angle of 45° from the vertical and 1.5 inches (3.8 cm) above the pavement such that the excess oxygen will impinge on the surface being burned by the propane-oxygen burner. Both of these tips are attached to nozzles that in turn attach to torch handles. Check valves are used on the torch handles. These components as shown in Figure 2 are mounted on a cart or platform, which in this case is a modified golf cart.

Hoses of 1/4 inches (0.6 cm) in diameter should not be used in excess of 25 feet (7.7 m) in length because the pressure drop in the lines is too great. For those who wish to have hoses from 25 feet (7.7 m) to 100 feet (30.5 m) in length, 3/8 inch (0.9 cm) diameter hose is recommended. Regulators should be large enough to supply the volumes of propane and oxygen required. An example propane regulator is a Victor SR-411-B-510 or similar. For both the oxygen and excess oxygen an example regulator is a Victor SR-400-D-540 or similar. It is recommended that where possible propane tanks of 10 gallons (37 liters) or 95 lbs (4.3 Kg) or larger be employed.

The brush/broom should be sufficiently abrasive that it will readily remove the ash that remains after burning. It was found that two "Butcher Block" brushes mounted side-by-side on a plate with a long handle as shown in Figure 3 work very well. "Butcher Block" brushes are normally 7.5 inches (19 cm) x 2.5 (3.7 cm) x 1 inch (2.5 cm). The bristles are flat steel strips 0.110 inches (.275 cm) x 0.017 inches (0.042 cm).

Mounting of the propane-oxygen and excess oxygen tips is strictly at the discretion of the operator so long as their position relative to one another on the surface to be burned is that recommended. The equipment described herein reflects the use of a golf cart, but there is no reason that these tips could not be mounted on an old power lawn mower base from which the engine had been removed or as an outrigged dolly from the side of a truck. Golf cart mounting is not only quick, easy and inexpensive, but golf carts can be easily tilted back to raise the flame away from the surface. This adds a measure of convenience to lighting and adjusting the flame and movement from one location to another as in the case of removal of skip stripes.

This design makes several references to the use of components from

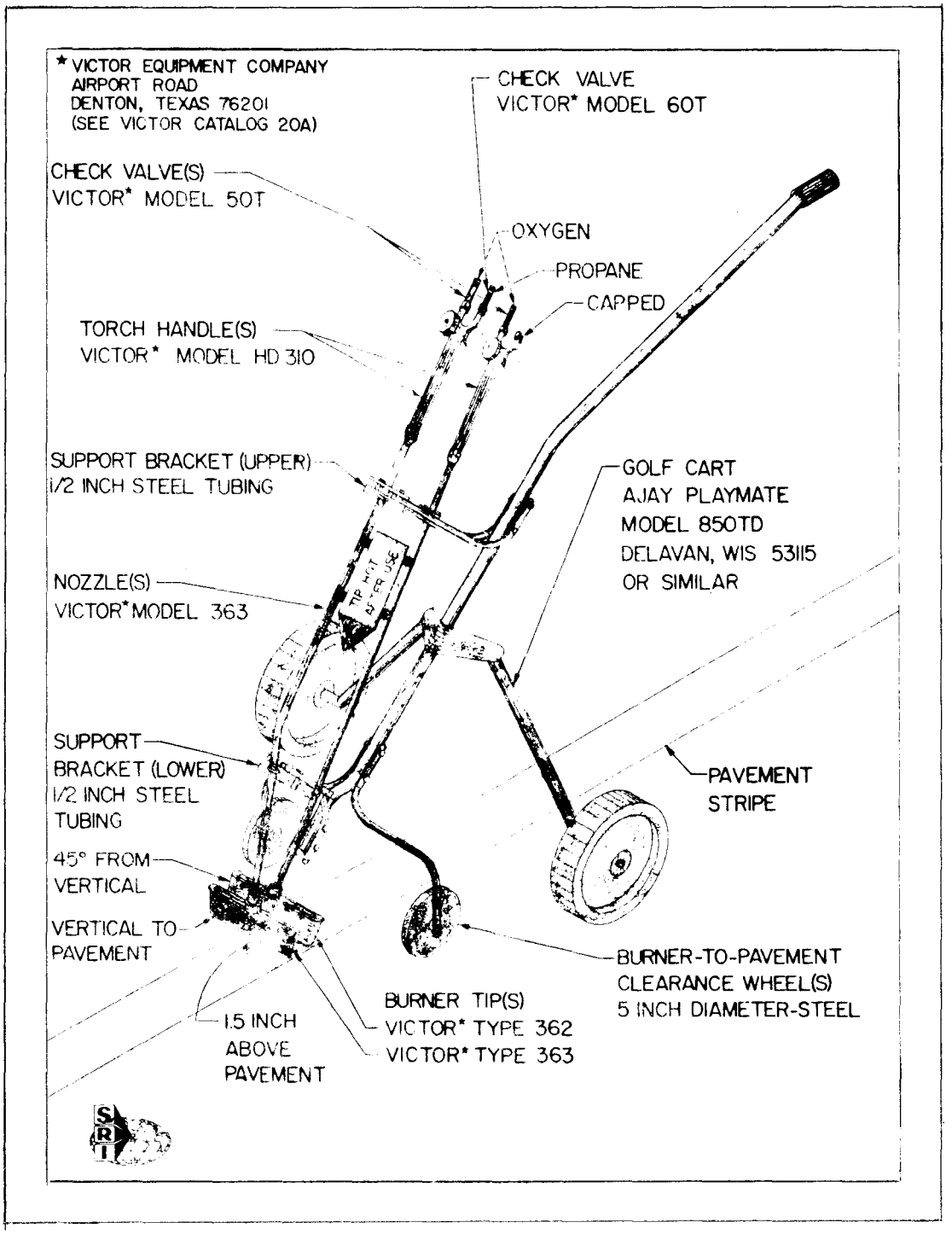

Figure 2. Pavement Stripe Removal Unit

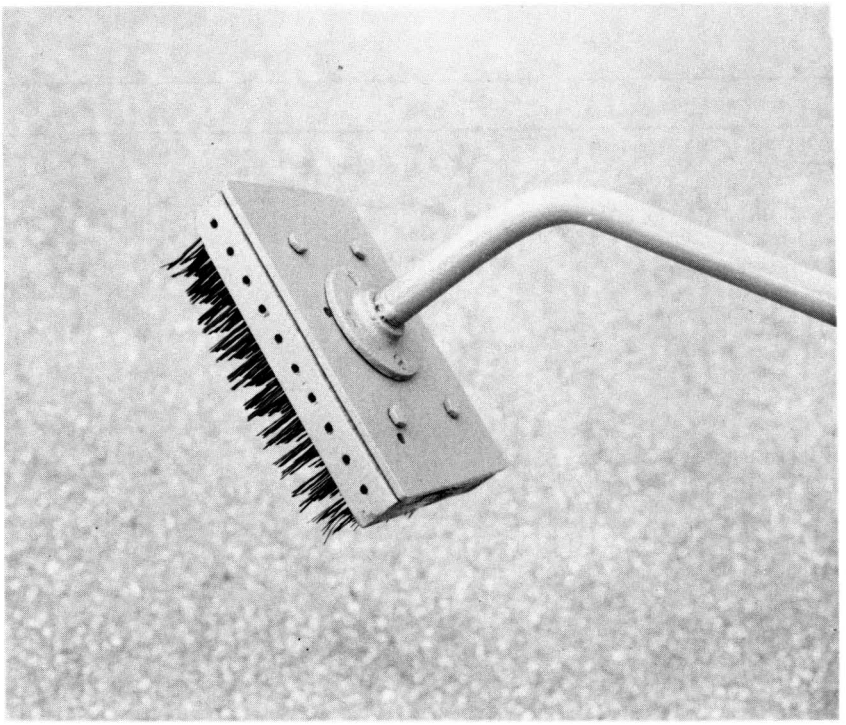

Figure 3. Brush/Broom

Victor Equipment Company, Airport Road, Denton, Texas. While the components from Victor have been found to perform most satisfactorily, there are other product lines and products on the market that would perform in an equally satisfactorily manner.

Figure 4 shows all the equipment assembled with the exception of the vehicle used to transport the propane and oxygen bottles. Any of a variety of trucks or trailers can be used to transport the propane and oxygen bottles. The burning operation can be conducted in front, to the side or to the rear of the vehicle.

Figure 4. Assembly

OPERATION

After the equipment has been assembled the propane and oxygen pressures are set at the regulators. The pressures employed vary with the diameter and length of the hoses used. Example pressures are as follows:

		Pressure at Regulator Psi/Pa		
Length of Hose, Feet/Meters		25/7	50/15	100/30
1/4 inch (0.6 cm) hose	Propane	15/104	-	-
	Oxygen	60/410	-	-
	Excess Oxygen	60/410	-	-
3/8 inch (0.9 cm) hose	Propane	10/69	15/104	25/170
	Oxygen	50/345	60/410	75/520
	Excess Oxygen	50/345	60/410	75/520

In lighting the burner, the cart is tilted back until the handle contacts the pavement. This raises the propane-oxygen tip off the pavement and places it in a convenient location for lighting. Each line should be individually purged. With welding goggles in place and both oxygen valves closed, the propane valve on the torch handle is slowly opened, the propane is lighted with a spark lighter and the valve opened further until the flame begins to leave the tip. The oxygen valve on the troch handle with the propane valve is slowly opened until the white inner flame length is reduced to approximately 1/2 inch (1.25 cm). At this point the temperature of the flame is at or near its maximum. The burner tip is designed to operate with a large flame in that the propane and oxygen gases coming to the tip also cool the tip. During operation any popping of the flame is an indication of insufficient fuel being delivered to the tip and the flame should be adjusted to use more fuel. It could also be due to dirty ports in the tip restricting the fuel flow. Whenever popping occurs the operation should be stopped and the situation corrected before proceeding.

The cart is tilted forward to its operating position and the excess oxygen valve on the lower torch handle is opened and excess oxygen is added until it is seen to impinge on the burning surface and cause the propane-oxygen flame to be deflected forward. The unit is then ready for stripe removal operations.

The rate of travel in the burning operation is a function of how easily the marking material can be reduced to ash and removed.

No post treatment of the burned and brushed surface has been found that is useful as a means of disguising the burned surface. The best procedure found is to let the pavement surface heal itself. This takes place as a function of the time of year, the environment and the type and amount of traffic.

MAINTENANCE

The only maintenance associated with this unit is that of keeping the burner tips clean and the ports in the tips open. The tips can be wire brushed periodically and the ports on the propane-oxygen tip can be opened with a Number 60 drill bit. The ports on the excess oxygen tip can be opened with a Number 59 drill bit.

SAFETY

The precautions that relate to the use of this equipment are much the same as those used in welding shops as outlined by OSHA Regulation Section 1910.252. Greasy or oily clothing should not be worn. Lines should be purged before using. Fire extinguishers should be available. Welding goggles should be worn by those viewing the burner. Those operating the burner or working near the burner should wear respirators and avoid breathing any of the products of combustion. Ideally the direction of operation is selected so that any prevailing wind will carry the products of combustion away from the operator. Particular care should be exercised in the burning of yellow pavement marking materials since the most common type of yellow pigment used in pavement marking materials is lead chromate. Both lead chromate and vapors of lead chromate are hazardous. Check valves should be used where the hoses attach to the torch handles.

A sign should be attached permanently just above the burner tips that states "CAUTION - TIPS HOT AFTER USE" to remind everyone that the tips right after use can cause severe burns.