DEBRIS REMOVAL FROM
CONCRETE BRIDGE DECK JOINTS

by

William M. Moore
Associate Research Engineer

Research Report No. 12-2F

Improved Methods for Cleaning Joints
In Concrete Bridge Decks

Research Study 2-18-73-12

Sponsored by

The Texas Highway Department
In Cooperation with the
U. S. Department of Transportation
Federal Highway Administration

September, 1974

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

Preface

This is the second and final report issued under Research Study 2-18-73-12, "Improved Methods for Cleaning Joints in Concrete Bridge Decks." The previous report was entitled "A Survey of Distress and Debris in the Joints of Pan-Formed Concrete Bridges," by William M. Moore, Gilbert Swift and Howard L. Furr, Research Report No. 12-1, Texas Transportation Institute, January 1974.

This research was conducted at the Texas Transportation Institute as part of the cooperative research program with the Texas Highway Department and the United States Department of Transportation, Federal Highway Administration.

The author wishes to acknowledge his gratitude to all members of the staff of the Texas Transportation Institute who contributed to this research. Special thanks are expressed to Messrs. Gilbert Swift, John Salyer, C. E. Schlieker and Neil Holley for their efforts and suggestions in the cleaning technique development described in this report.

The support given by the Texas Highway Department personnel is also greatly appreciated, especially the advice and assistance provided by the study contact individual, Mr. Don McGowan of D-18, Maintenance Operations Division and the maintenance personnel in Districts 2, 3, 9, 17, 18, 20 and 21 who experimented with the high-pressure water-jet apparatus and offered many comments and suggestions valuable to this research effort.

The contents of this report reflect the view of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

ABSTRACT

A practical and effective technique for cleaning joints on concrete bridge decks was developed. It employs commercially available high-pressure water-jet equipment and a small simply constructed cart which facilitates operator control of the water jet. The technique was tested by Texas Highway Department maintenance personnel on in-service bridges and found to be far superior to other joint cleaning methods.

An investigation of several techniques for widening very narrow or completely closed bridge joints was made. With current technology, it appears that suitable equipment could be designed; however, it will require an extensive developmental effort which is not believed to be warranted at this time.

Appendices to the report contain (a) an annotated bibliography of ten articles on repair of joints of concrete bridge decks, (b) statements of the experiences of six Texas Highway Department districts with the new joint-cleaning technique (c) specifications for high-pressure water-jet equipment and (d) fabrication details for a jet-gun mounting cart.

KEY WORDS: Joint cleaning, Joint widening, High-pressure water jet, Pan-formed bridges.

SUMMARY

Two different types of joint cleaning for concrete bridge decks were investigated. One involved the removal of debris using a commercially available high-pressure water-jet apparatus and the other involved the widening of very narrow or completely closed joints.

A practical and effective technique for cleaning joints was developed employing the water-jet apparatus and a small simply constructed cart. The cart facilitates operator control and steadies the jet stream for more effective cleaning. The new method removes almost all detectable debris. It was tested on both the fixed-type and expansion-type joints on pan-formed bridges. Joints in pan-formed bridges are believed to be the most difficult to clean because they are from two to three-feet deep. The technique has been partially implemented through its trial use by maintenance personnel in six different Texas Highway Department districts. All found the technique to be far superior to any other that they had tried.

The development of a practical and effective technique for widening deep narrow joints like the fixed joints on pan-formed bridges will require extensive apparatus development. Currently such development is not believed to be warranted.

Almost all of the pier-cap distress found in pan-formed bridges is apparently caused by debris in the fixed joints. It is recommended that these fixed joints be cleaned and sealed on a routine basis to prevent additional pier-cap fractures.

IMPLEMENTATION

Field tests indicate that the joint-cleaning technique developed in this study is practical and effective for immediate implementation by highway maintenance personnel. The initiation of a routine cleaning and sealing program for the fixed-type joints on pan-formed bridges appears warranted as priorities permit.

Table of Contents

		Page
1.	Introduction	1
2.	Preliminary Investigation	2
3.	Developmental Water-Jet Testing	9
4.	Joint Widening Investigation	16
5.	Field Test	19
6.	Conclusions and Recommendations	24
7.	References	25
	Appendix A: Repair of Joints of Concrete Bridge Decks	A-1
	Appendix B: District Experimentation	B-1
	Appendix C: Specifications for High-Pressure Water-Jet Equipment	C-1
	Appendix D: Jet-Gun Mounting Cart	D-1

1. Introduction

This is the final report of a research study entitled "Improved Methods for Cleaning Joints in Concrete Bridge Decks." The study was initiated because of the need of highway maintenance personnel for a practical and effective technique for removing debris from joints of in-service bridges. At the beginning of this study the technique being used was to loosen the debris by hand with picks and chisels and then to blow out the loosened material with an air hose. Although the technique was effective for joints wide and shallow enough to accommodate hand tools it was difficult and time consuming.

At the outset of the study there was no known effective technique for removing debris in the deep and narrow joints of pan-formed bridges. It was recognized that these joints which are less than one-inch wide and about two to three-feet deep did not provide much access for debris removal. To loosen and remove debris when the only access was a very narrow slot posed a difficult problem. Thus, early in the study primary emphasis was placed on cleaning pan-formed bridge joints. It was concluded that a satisfactory cleaning technique for these joints would also be suitable for other joints which are generally shallower and more accessible.

2. Preliminary Investigation

An extensive search of the literature pertaining to repair of joints in concrete bridge decks was made by Mr. Frederick S. White, Research Librarian. It resulted in the annotated bibliography contained in Appendix A. However, none of the ten articles found were specifically directed toward debris removal.

Contacts with highway department engineers in several states provided pertinent information. For example, it was learned that some experimental bridge-deck joint cleaning has been done by the maintenance staff of the Louisiana Department of Highways [1]. Informal reports and photographs were obtained from Louisiana describing some demonstration tests which had been conducted there using a high-pressure water-jet apparatus for removing debris and deteriorated seal material from bridge-deck joints. Similar information was also obtained on the trial use in Louisiana of a tractor-mounted cutting wheel for widening joints in pavements and bridge approach slabs which had become closed. The Louisiana Department of Highways appeared to regard both of these techniques as offering potentially practical solutions to joint problems and was contemplating purchase or lease of both types of apparatus for further experimental use.

On the basis of this information a pilot demonstration of a high-pressure water-jet apparatus was arranged (Figure 1). With the cooperation of the Houston district the demonstration was held in December 1972, on a pan-formed bridge a few miles north of Houston. The equipment and operators were furnished by the American Water Blasters Company,

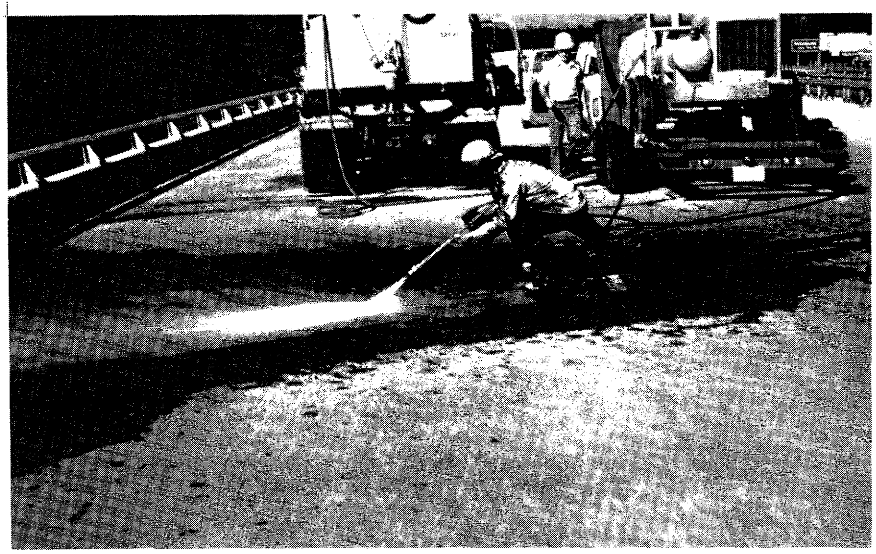


Fig. 1. A high-pressure water-jet apparatus was investigated early in the study for joint cleaning application.

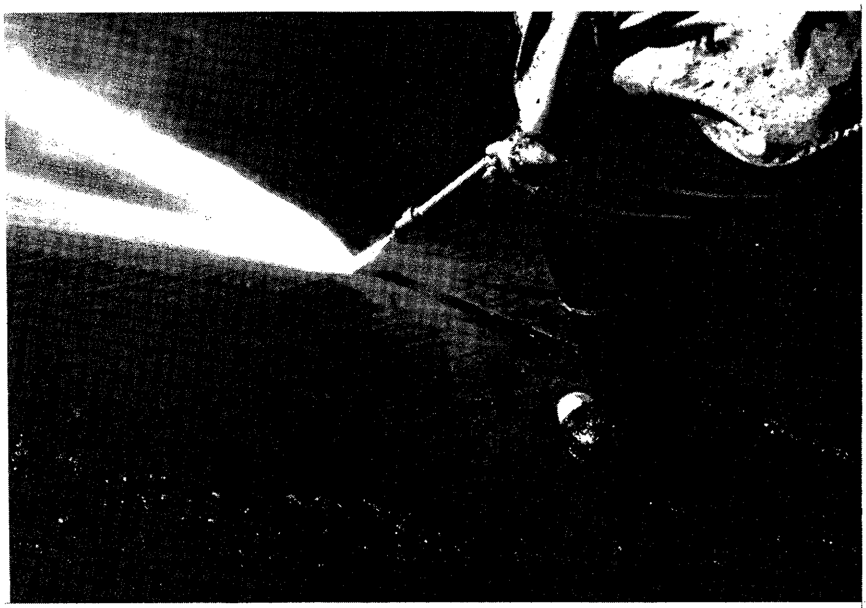


Fig. 2. The jet stream from the hand-held gun blew out the debris and seal materials in the top few inches of an expansion joint.

Houston, Texas. The apparatus basically consisted of an extremely high-pressure water pump (up to 10,000 psi) which supplied flow to a hand-held gun. The gun was equipped with a special nozzle that produced a high-pressure jet stream. The operator made attempts to clean an expansion joint with the jet stream. Typically expansion joints of bridges are three quarters of an inch wide and are from two to three-feet deep. They normally contain an asphaltic impregnated fiber board beneath a shallow asphaltic seal. The apparatus completely removed the shallow asphaltic seal and most of the debris and fiber board within a few inches of the surface (Figure 2). The nozzle was too large for the operator to insert into the joint and thorough cleaning was impossible. Nevertheless, the apparatus appeared to offer considerable promise for debris removal from joints which were at least one-inch wide or only a few inches deep. It was concluded that it would be necessary to design smaller nozzles for narrower joints and that it would be feasible to design them for cleaning joints as narrow as one half inch. In addition it was believed that the overall cleaning operation would be speeded up by employing mechanical methods to remove the larger pieces of material from the upper portion of the joint after they had become partly dislodged by the water jet.

Based upon observations made on in-service pan-formed bridges it became apparent that some joints in need of cleaning would require widening. It was found that many joints in need of cleaning were of the fixed type. This type joint is typically open about one quarter inch at the top and completely closed at the bottom. It was not believed possible to remove the debris lodged in this deep and narrow wedged-shaped cavity between adjacent spans without widening it. Based upon the results of the pilot demonstration of the high-pressure water-jet apparatus it was believed that an effective technique could be devised for using the apparatus to clean pan-formed bridge expansion joints (typically about three quarters of an inch wide). Thus, early in the study it was concluded that two different methods of joint cleaning would be pursued [2], one using the water-jet for joints at least 1/2-inch wide like expansion joints on pan-formed bridges and the other using a widening technique for very narrow or completely closed joints like the fixed joints on pan-formed bridges.

Because of the need for a joint-widening technique, a pilot demonstration of a tractor-mounted cutting wheel was arranged (Figure 3). It was held in January 1973 at the Texas A&M University Research Annex. The equipment used for this demonstration was a Ditch-Witch cutter manufactured by Charles Machine Works, Incorporated, Perry, Oklahoma. The device basically consisted of a 7-foot diameter cutting wheel mounted behind a tractor. The cutting wheel had replaceable hardened cutting teeth and could be used to cut a 4-inch-wide slot up to 31 inches deep. For the demonstration it cut a slot through an 8-inch thick concrete pavement at the rate of 1.5 feet per minute (Figure 4). Considerable cutting-tooth wear was apparent after cutting about 10 feet of the concrete pavement which contained some very hard chert aggregate. It was concluded from this demonstration that the 4-inch-wide cut was undesirably large for most bridge work. In its present configuration the device was directly applicable for construction of pressure relief joints in bridge approach slabs. It appeared feasible to design narrower toothed cutting wheels, or to substitute a narrow

Fig. 3. A tractor-mounted cutting wheel was investigated for joint widening application.

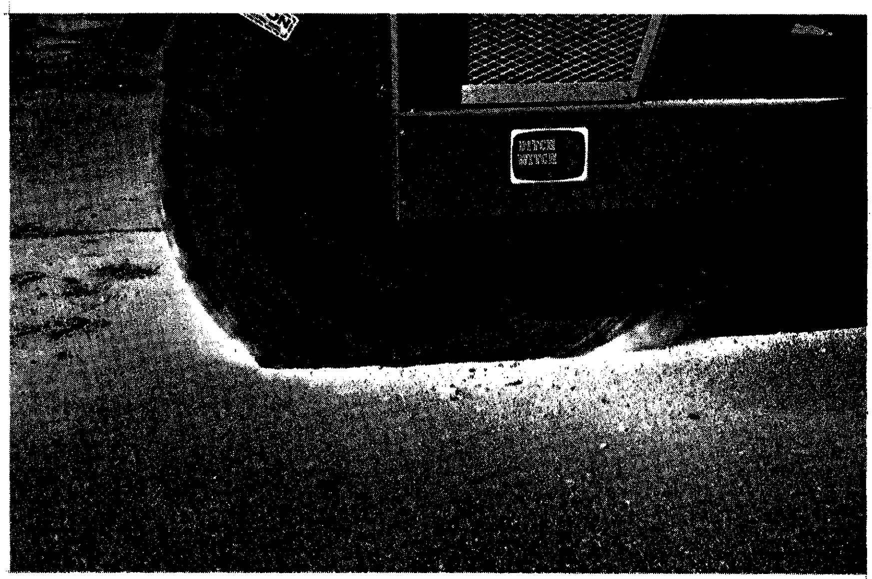


Fig. 4. The apparatus cut a 4-inch-wide slot through 8-inch-thick concrete pavement at the rate of 1.5 feet per minute.

abrasive wheel for the tooth wheel in order to cut a preferred narrower gap between adjacent bridge spans.

Contacts were made with numerous manufacturers of tools and equipment which might be applicable to the problem of widening bridge deck joints. As a result of these contacts many ideas for possible approaches were ruled out. For example, special thin bits for impact tools like a jack hammer cannot be made which will be satisfactory for widening bridge joints. Similarly, long thin routing bits were not feasible. Such bits were considered for operations like a drill rig having sideway movement capability. Present lazer technology offers no hope in slotting concrete. Even an oxygen-iron concrete melting torch was investigated. It appeared applicable to some highway maintenance activities like demolitions and alterations in concrete structures but was not effective for widening deep narrow joints.

During this investigative period two other promising approaches for widening joints were encountered in addition to the tractor-mounted cutter. A rumor was heard of some experimentation in the early 1960's in the vicinity of Chicago, Illinois with a chain saw designed to cut concrete. Also it was learned that a wire-sawing technique is presently used to cut deep narrow slots in granite by the stone quarrying industry. Using a similar type wire saw it should be possible to widen completely closed joints.

In summary the preliminary investigation resulted in finding commercially available equipment that appeared capable of cleaning joints that were at least 1/2 inch wide. A modest developmental effort would be necessary to adapt this equipment to the bridge joint problem. Special long thin nozzles would have to be designed and fabricated, and joint abrasive wheel for the tooth wheel in order to cut a preferred narrower gap between adjacent bridge spans.

Contacts were made with numerous manufacturers of tools and equipment which might be applicable to the problem of widening bridge deck joints. As a result of these contacts many ideas for possible approaches were ruled out. For example, special thin bits for impact tools like a jack hammer cannot be made which will be satisfactory for widening bridge joints. Similarly, long thin routing bits were not feasible. Such bits were considered for operations like a drill rig having sideway movement capability. Present lazer technology offers no hope in slotting concrete. Even an oxygen-iron concrete melting torch was investigated. It appeared applicable to some highway maintenance activities like demolitions and alterations in concrete structures but was not effective for widening deep narrow joints.

During this investigative period two other promising approaches for widening joints were encountered in addition to the tractor-mounted cutter. A rumor was heard of some experimentation in the early 1960's in the vicinity of Chicago, Illinois with a chain saw designed to cut concrete. Also it was learned that a wire-sawing technique is presently used to cut deep narrow slots in granite by the stone quarrying industry. Using a similar type wire saw it should be possible to widen completely closed joints.

In summary the preliminary investigation resulted in finding commercially available equipment that appeared capable of cleaning joints that were at least 1/2 inch wide. A modest developmental effort would be necessary to adapt this equipment to the bridge joint problem. Special long thin nozzles would have to be designed and fabricated, and joint cleaning techniques would have to be developed. During this preliminary investigation it was learned that many fixed-type joints on pan-formed bridges needed cleaning. No promising approaches could be found that were capable of removing the debris from these deep narrow joints. No readily adaptable equipment could be found for widening them; however, three promising approaches to joint widening that appeared to be available were (a) a large diameter tractor-mounted cutter, (b) a concrete chain saw, and (c) a wire saw.

3. Developmental Water-Jet Testing

In order to locate joints in need of cleaning for experimentation, a survey was made of seventy-three in-service pan-formed bridges in the vicinity of Texas A&M University. This survey resulted in findings believed to be significant and therefore was the subject of an interim report in this study [3]. Most of the joints in the surveyed bridges were found to contain debris (Figure 5). The significant distress caused by debris was found to occur more than ten times as frequently at the fixed-type joints than expansion joints (Figure 6).

For developmental testing with the high-pressure water-jet apparatus several bridges were selected that had debris-filled expansion joints. The necessary arrangements were made with the Bryan district to enable the research team to do experimental joint cleaning. Equipment was leased from Tritan Corporation, Houston, Texas who also furnished long nozzles of several small diameters which could be inserted into joints for more thorough cleaning than had been possible in the Houston demonstration.

Initial experimentation was conducted with nozzles for the jet-gun that had various sizes and shapes of orifices (Figure 7). It was found that the single circular orifice designed to produce a narrow jet stream had better cutting action for debris removal than orifices designed to produce other shaped streams, for example an elliptically shaped orifice designed to produce a fan-shaped jet stream. It was also found that the most effective debris removal was achieved when the pump was operating at its maximum design flow and pressure, i.e., 10 gallons per minute at 10,000 psi. Thus the pump was operated at nearly full throttle and an orifice was selected which would maintain but not exceed the design

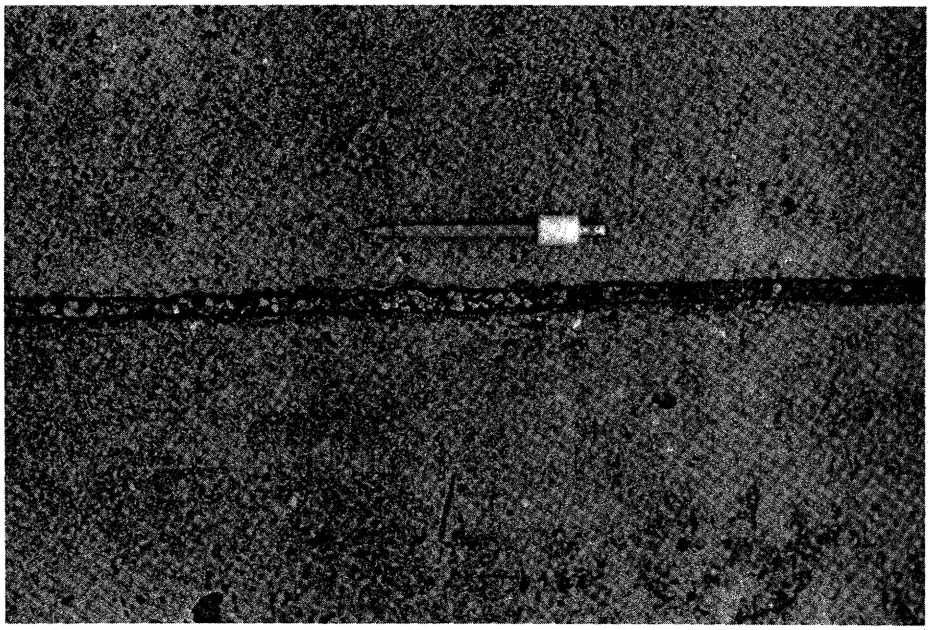


Fig. 5. A survey of in-service pan-formed bridges revealed that most joints contain debris.

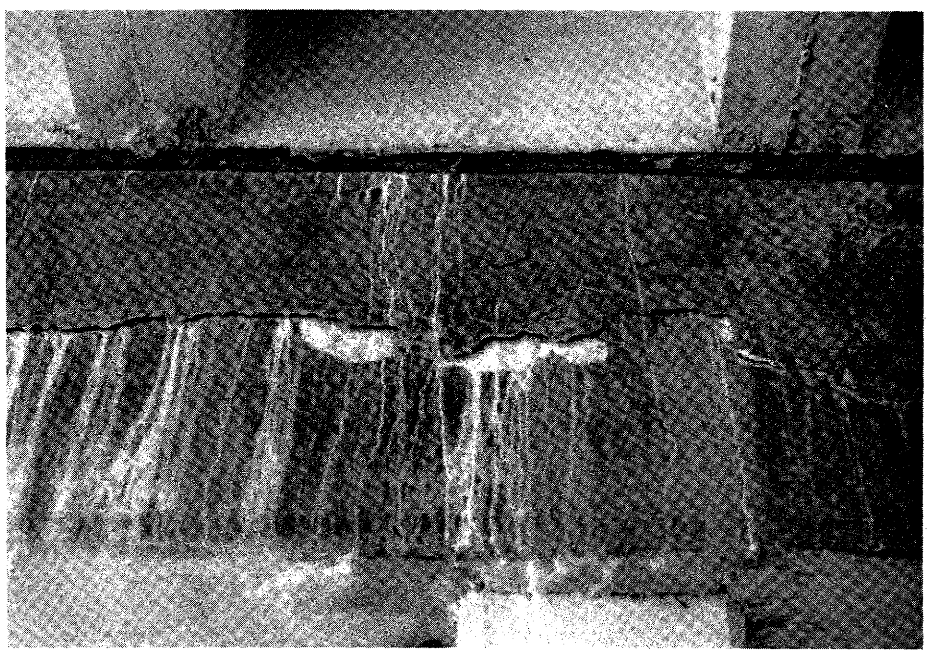


Fig. 6. Significant distress caused by debris was found to occur more than ten times as frequently at the fixed-type joints than at expansion joints.

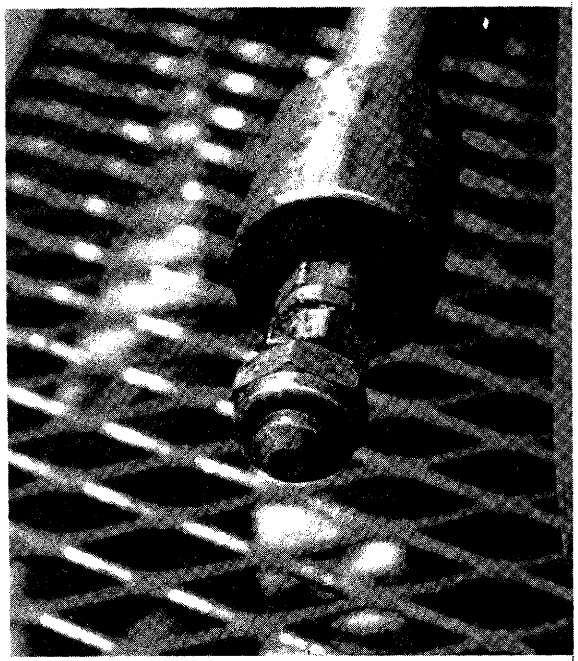


Fig. 7. Various nozzles are available for producing jet streams of different shapes.

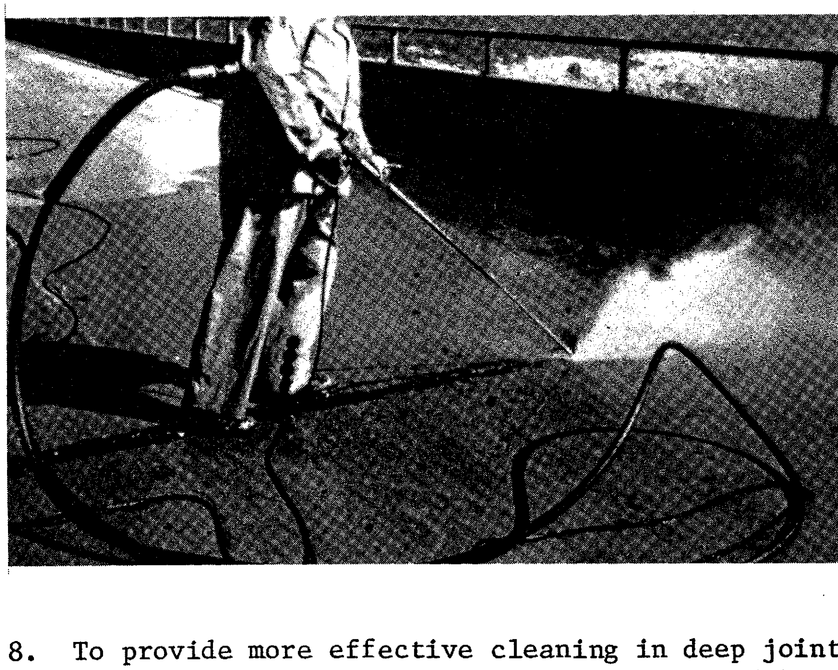


Fig. 8. To provide more effective cleaning in deep joints special long thin nozzles were designed which could be inserted in the joint.

pressure. A 47 mil orifice was found to be most suitable.

Although the long thin nozzles for the hand-held jet gun were found to be much more effective in cleaning out the deep debris, they were also found to be very difficult to handle (Figure 8). The large back pressure of the gun quickly tired the operator and made it difficult for him to insert the nozzle into the joint. Several relief operators reduced the problem somewhat, but did not eliminate it.

A small cart was built to hold the gun to provide relief for the operator (Figure 9). It was found to be quite successful in that the cart was much easier for the operator to handle. It also was found to offer another substantial advantage. The cart held the jet stream steadier which resulted in more thorough cleaning deeper into the joint.

Another problem occurred during these developmental tests. Occasionally there was a back spray of debris and water on the operator causing him substantial inconvenience. It had been found necessary for the operator to wear a slicker suit and a transparent face mask. The face mask would become covered with debris from the back spray and necessitate stopping operations in order to clean it. The cart was modified with a transparent shield to eliminate this back spray (Figure 10). Although the shield was successful in eliminating the back spray, it quickly became covered with debris making it difficult to see how to properly aim the jet spray. After a short trial period the operator removed the shield believing it to produce more inconvenience than the occasional back spray.

Further experimentation resulted in finding that more effective cleaning would result if the operations were begun at the sides of the

Fig. 9. To make operations easier a small cart was built that opposed the thrust of the jet stream.

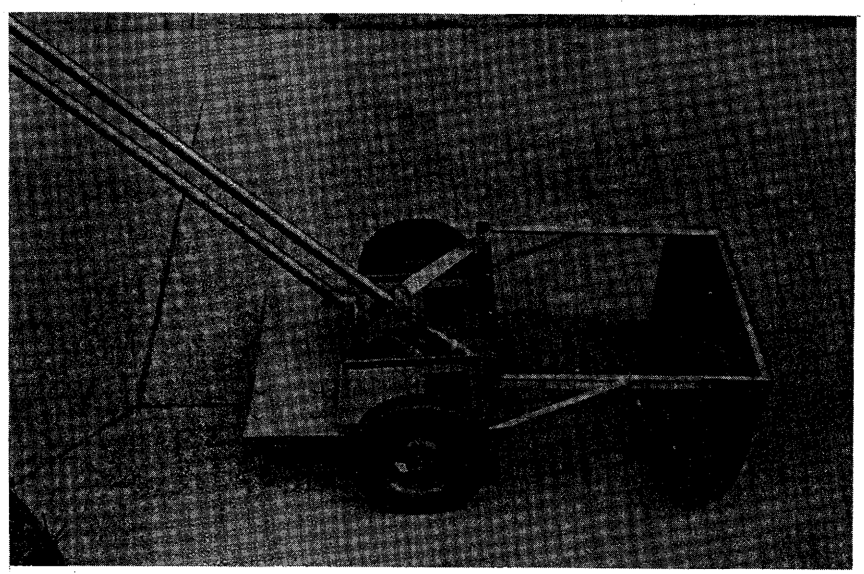


Fig. 10. To eliminate back spray a transparent shield was added; however, it was found to produce more operator inconvenience than the occasional back spray.

bridge. By starting at the sides and working toward the center, a channel was provided for drainage (Figure 11). This made the jet spray much more effective because it did not have to penetrate a thick layer of water before it could get to the debris. In fact, with the pump operating at its design capacity, ten gallons per minute at 10,000 psi, it was possible on many joints to completely remove the fiber board filler and debris all the way to the top of the pier cap without insertion of a long nozzle into the joint. In addition this technique was found to greatly reduce the frequency of back spray.

At this point in the study it was concluded that sufficient developmental testing of the high-pressure water-jet apparatus had been accomplished. The device was capable of removing all debris from bridge joints which were at least one half-inch wide (Figure 12). It was ready for pilot implementation and field testing by maintenance personnel.

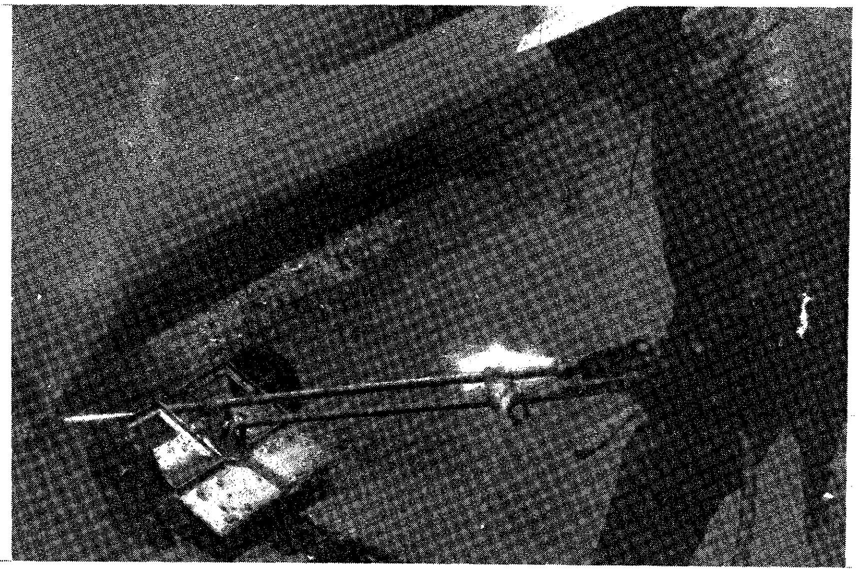


Fig. 11. Cleaning operations are more effective if work begins at the sides so that drainage is provided.

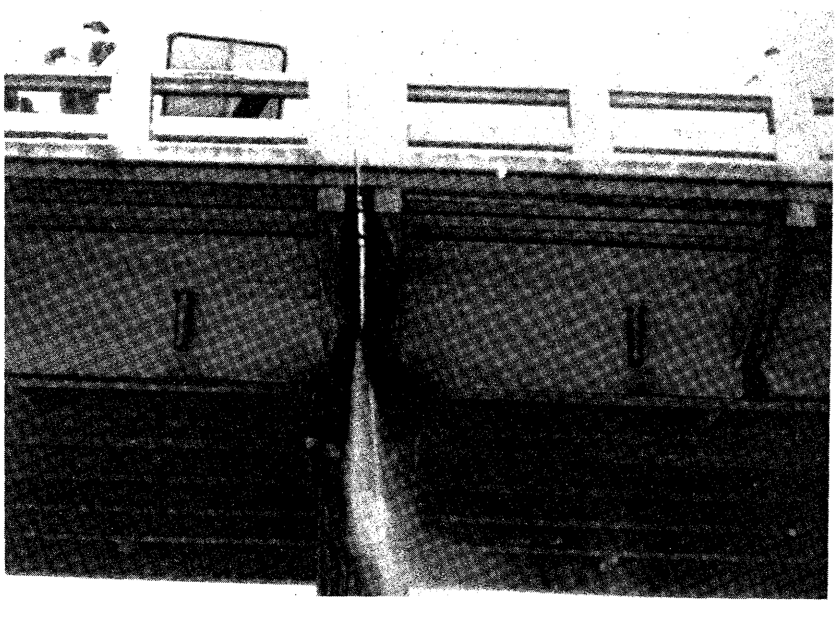


Fig. 12. It is possible to remove all debris from bridge joints which are at least one half-inch wide.

4. Joint Widening Investigation

Concurrently with the developmental testing of the water-jet equipment, further investigation of joint widening was made. Based upon the results of the preliminary investigation the three promising approaches that appeared to be available were (a) a large diameter tractor-mounted cutter, (b) a concrete chain saw, and (c) a wire saw.

After the pilot demonstration of the tractor-mounted cutting wheel, contacts were made with the two known manufacturers of such devices, Charles Machine Works, Incorporated, Perry, Oklahoma and Vermeer Manufacturing Company, Pella, Iowa. They were asked if a narrower cutting wheel could be made. It was found that three inches is about the narrowest possible width for the toothed-type cutter used in the pilot demonstration. However, it was also learned that a large diameter diamond saw manufactured for use in the building stone industry could be substituted for the toothed wheel. This substitution would necessitate the addition of a water supply for saw cooling. Thus, a cut narrower than one half inch and as deep as 32 inches would be possible with the current device, provided a diamond saw was substituted for the toothed wheel.

Based upon these findings it appears possible to design and build a diamond saw cutter which would be effective for bridge joint widening. The cutting wheel should not be mounted behind a tractor because of the excessive length. The current device is much too long to widen joints on a two-lane bridge and would necessitate closing at least two lanes on multi-lane structures.

All efforts to find additional details about any type of concrete chain saw were fruitless. Although several people had heard of the existance of one in the early 1960's, no one could be found that had been directly involved. It was believed that the development had been abandoned by the cutting tool industry. Further development along this line appears to be impractical.

In the fall of 1973 arrangements were made to visit the Texas Granite Company, Marble Falls, Texas. This company was using a wire saw in its stone quarrying and finish cutting operations. The sawing technique being used involved an extremely long grooved steel wire and a slurry of corundum grit. A substantial portion of the corundum grit was recovered and recycled in the cutting operation. A continuous wire about 1500 feet long was used to distribute the wear and thereby reduce the frequency of wire replacement. This technique appeared unattractive for bridge joint application. However, it was learned that diamond impregnated wires also were being used for similar cutting operations by other stone companies. Although the cost of the diamond impregnated wires was much greater, their wear was said to be greatly reduced so that shorter wires were practical.

Based upon these findings it appears possible to design a diamond impregnated wire cutting device which would be effective for bridge joint widening. It would basically consist of a band-type saw with apparatus for guiding and positioning the wire in the joint. It is believed that the guiding apparatus would require a major developmental effort to make it adaptable to the many types of in-service bridges which have various width and depth of cut requirements.

At this point in the study the results of the joint widening investigation were not very promising. Although two readily adaptable techniques had been found, a major development effort would be required to adapt either to the problem of widening joints of in-service bridges. The tractor-mounted cutting wheel with a diamond saw seemed to be the most practical approach and the next logical step was to conduct a pilot test as follows: (a) purchase suitable diamond saw, (b) lease tractor-mounted cutting device, (c) substitute diamond saw, (d) rig up water supply, and (e) conduct pilot test on multi-lane bridge. It was clear that this test would not result in a practical technique that would be applicable to in-service two-lane bridges. It would merely demonstrate technical feasibility, whereby an effective device could be developed. Further development (i.e., the design and fabrication of a shorter device) would require an effort several times larger than had been planned for this entire study.

Preliminary plans were made to conduct the pilot test at a cost of about $3,000; however, findings in the field test with the high-pressure water-jet apparatus indicated that the water jet might remove enough debris to relieve the compressive stresses at the fixed joints. Although joint widening was an ideal solution in relieving joint stress, it was believed that the water jet might provide a satisfactory solution. Because of the pressing need to eliminate distress at fixed joints and the possibility of finding a practical solution with the water jet rather quickly in this study, research efforts were shifted in that direction and the pilot test with the diamond saw was not made.

5. Field Test

In the fall of 1973 arrangements were made for the maintenance personnel in the Fort Worth district to perform two weeks of experimental joint cleaning. The district was asked to furnish the following:

a) water truck and driver to provide 600 gallons per hour of cleaning

b) pickup and driver for towing high-pressure water pump

c) necessary flagmen for closing one lane of a bridge

The drivers of the water truck and pickup were to serve as operators for the jet gun. The researchers were to provide the apparatus and instructions for its use and to remain in the district for as long as needed.

The equipment was taken to Fort Worth in November 1973. At the district headquarters the researchers explained and demonstrated its operation and described the necessary safety precautions. After the necessary hose and connections were obtained and assembled so that the water truck could be connected to the water pump, the equipment was ready for use on a bridge. These preliminaries at the district headquarters required about two hours.

Although the researchers remained in the district for two days they were not needed. Within an hour of initiating joint cleaning on the first bridge, operations by district personnel were running smoothly. Normally the water truck was backed onto the bridge following the pickup with the equipment. The vehicles were stopped so that the joint to be cleaned was between them (Figure 13). A hose of sufficient size to

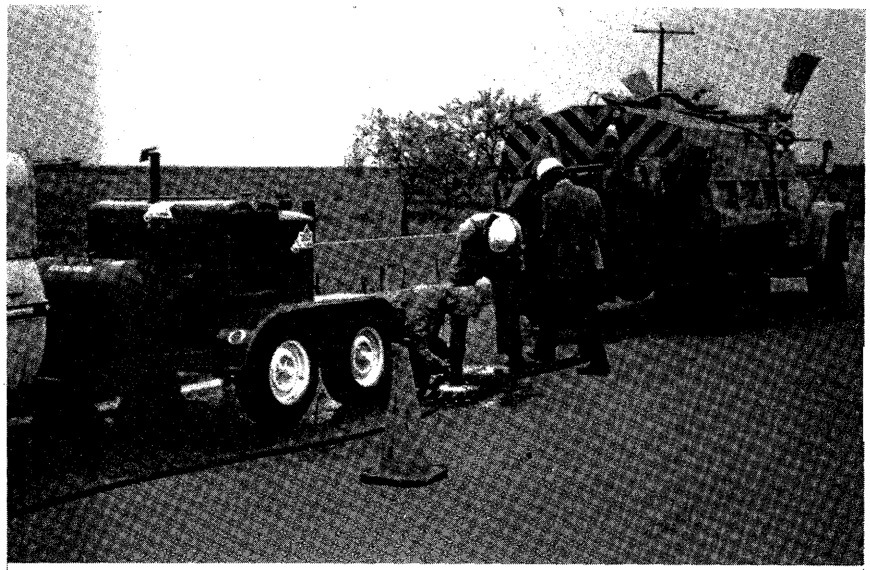


Fig. 13. Normally the water truck and high-pressure pump are positioned so that the joint to be cleaned is between them.

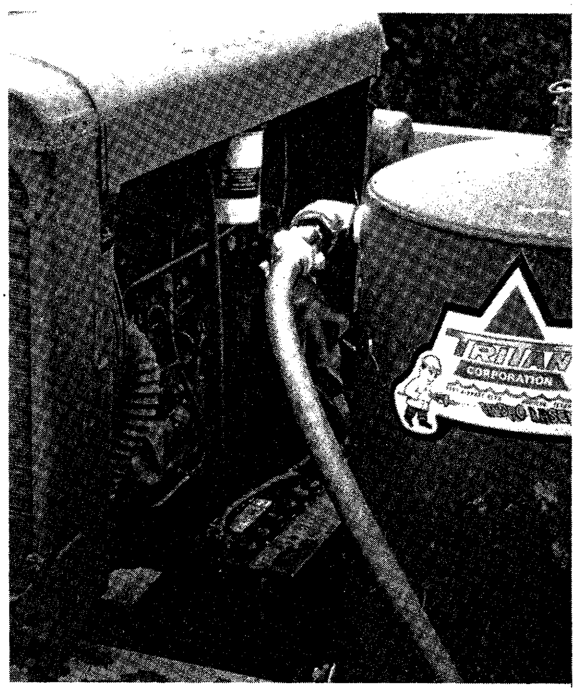


Fig. 14. The water supply hose must deliver at least 10 gallons per minute to the high-pressure pump.

deliver at least ten gallons per minute was connected to the water pump (Figure 14). In the field tests made in most districts the tank of the water truck was high enough to gravity feed the water. However, in one district it was necessary to use a small pump. Normally the high-pressure line was left connected and the jet gun that was attached to the cart was carried on the pump trailer. Therefore, after the water supply connection was made the pump could be started and the cleaning operations could begin immediately.

In December arrangements were made with the Beaumont district to conduct similar experimental joint cleaning. The experimental field tests were successful in both the Fort Worth and Beaumont districts. Neither district had any major problems. Both felt that the joint cleaning technique was far superior than any other that they had tried. In fact the maintenance personnel in the Beaumont district subsequently leased similar equipment and accomplished a major joint cleaning program (Figure 15). Letters from these districts describing their tests are contained in Appendix B.

Based upon the results of the developmental testing in the Bryan district as well as the experimental testing in the Fort Worth and Beaumont districts, joint cleaning with the water jet turned out much better than had been originally anticipated. Using a sufficiently powerful jet stream held right at the top of the joint it was possible to remove all of the debris from expansion joints. It was not necessary to insert long thin nozzles into the joints. It appeared that the effectiveness of this technique should be investigated for the cleaning of fixed joints, particularly since almost all of the distress found in pan-formed

Fig. 15. After conducting limited experimental joint cleaning in this study the Beaumont district accomplished a major joint cleaning program.

Fig. 16. Almost all detectable debris can be removed from fixed joints in pan-formed bridges.

bridges was at the fixed joints and this distress was apparently caused by joint debris [3].

Arrangements were made to conduct further field tests with the water-jet apparatus in the Pharr, Wichita Falls, Dallas and Waco districts. The districts were asked to furnish the same equipment and personnel provided by the first two test districts. However, in these tests the districts were asked to attempt the cleaning of several fixed-type joints on pan-formed bridges. The results were most encouraging. The districts generally found that the technique satisfactorily cleaned both the fixed and expansion joints and that the method of cleaning was far superior to any other that they had tried. Letters from these districts describing their tests are also contained in Appendix B.

The researchers were present at some of the fixed-joint cleaning experiments in several of the districts. Almost all of the debris that could be detected in the joint was removed (Figure 16). Some tightly wedged pebbles could not be removed. Although it was impossible to determine how much debris actually remained in a fixed joint after cleaning, it was clear that a significant quantity had been removed. It is believed that the removal of almost all detectable debris will reduce and possibly eliminate future distress at these joints.

6. Conclusions and Recommendations

A commercially available high-pressure water-jet apparatus (see specifications in Appendix C) is a practical and effective means for cleaning joints in concrete bridge decks. For effective operations the apparatus should supply a narrow jet stream of at least ten gallons per minute using a line pressure of at least 10,000 psi. A small cart (see description in Appendix D) facilitates operator control and steadies the jet stream for more effective debris removal.

Although an extensive search was made, no readily implemental equipment appears to be available for widening the deep narrow joints like those on pan-formed bridges. However, two different stone sawing techniques could be applied to the problem. Either of them will require extensive apparatus development which is not believed to be warranted at this time.

Almost all of the pier-cap distress on pan-formed bridges is apparently caused by debris in the fixed joints. Therefore, it is recommended that these joints be cleaned and sealed on a routine basis to prevent additional pier-cap fractures. If after a few years of implementation this does not substantially eliminate further joint distress, it is recommended that the joint widening research begun in this study be continued.

If a pan-formed deck span is fixed at both ends and one of the ends has cracked its pier-cap--a typical type of distress--it is recommended that the dowels between the deck and the cap be cut with a welding torch prior to the cap repair.

7. References

1. Personal communication with Al J. Dunn, Bridge Maintenance, State of Louisiana Department of Highways.

2. "Concrete Bridge Joint Cleaning Methods--Preliminary Findings," Informal Report of Research Study 2-18-73-12, Texas Transportation Institute, Texas A&M University, College Station, Texas, March 1973.

3. Moore, William M., Swift, Gilbert and Furr, Howard L., "A Survey of Distress and Debris in Joints of Pan-Formed Concrete Bridges," Research Report 12-1, Texas Transportation Institute, Texas A&M University, College Station, Texas, January 1974.

APPENDIX A

REPAIR OF JOINTS OF CONCRETE BRIDGE DECKS

This Appendix contains an annotated bibliography on repair of joints of concrete bridge decks. It was compiled by Mr. Frederick S. White, Research Librarian, of the Texas Transportation Institute.

1. Casbeer, Dick. OPEN JOINT REPAIR. Texas Highways (Editorial Office, Travel and Information Division, Texas Highway Dept., Austin, Texas 78701), Vol. 14, No. 12, p. 25, Dec. 1967. HR Abstracts, May 1968.

   A new method of handling open joints on bridges overlaid with asphaltic concrete has been developed. The work is done by maintenance forces after the overlay has been completed. The hot mix is scored 1/2 inch deep with a masonry saw 3 inches either side of the open joint to give a neat break line. The 6-inch wide strip of hot mix is then removed from half the width of the bridge with a jackhammer. Next, the exposed concrete is cleaned by sandblasting. The concrete surface is then painted with THD type B-102 epoxy. After this, the premolded joint material is installed and the epoxy grout, which consists of 40 pounds of dry sand mixed with one 3/4-gallon unit of THD type B-102 epoxy, is placed on the strip. The epoxy joint is finished off to the top of the hot mix. After approximately one hour, the premolded expansion joint material is trimmed or removed from the joint. Traffic is routed over the finished half which the procedure is repeated for the other half of the bridge. The first epoxy joint was installed about two years ago and is still in good condition.

2. Ivy, Raymond J., California Div. of Highways. CALIFORNIA'S BRIDGE EXPANSION PROBLEMS. HR Abstracts, December 1955.

   Some of the most troublesome problems in connection with bridge maintenance concerns the expansion details of a structure. Deck expansion joints, bridge bearing assemblies and hinges are used to provide for expansion difficulties while the hinge is comparatively trouble free.

   A defective deck expansion joint is not only a structural problem but is a serious hazard to traffic. An improperly functioning bridge bearing assembly can result in extensive structural damage to a bridge. The repairs required to correct such faulty expansion details taxes the ability and ingenuity of the bridge maintenance engineer.

   Most problems encountered with deck expansion joints are caused by the armor. It is either too light, inadequately anchored to the concrete or a cover plate is used that will not function properly. The repairs required to remedy these defects are difficult to make. Deck expansion joints have been improved by the simple expedient of eliminating the armor. This is done where the width of the deck joint is less than 1-1/4 inches. For joints over 1-1/4 inches, heavy armor is used and particular attention is given to the anchorage and cover plates.

   Two types of bridge bearing assemblies are in general use to provide for expansion in bridge superstructures. One is the roller type which makes use of the rocker or segmental roller either singly or in nests. Very little trouble has developed when this type of expansion bearing has been used. The other type that was commonly used is the friction or sliding plate type. This has been a prolific source of trouble. The numerous ruptured bridge seats with the resulting maintenance trouble all testify to its inefficiency. This type has practically been abandoned in favor of the rocker or roller type of bridge bearing assembly.

The hinge is an expansion assembly that has come into use with the continuous span structures. Types have been developed for the steel beam and girder, the concrete tee beam and box girder, and the flat slab bridge. These hinges have all proved to be quite satisfactory.

The paper discusses the maintenance problems experienced with deck expansion joints, bridge bearing assemblies and hinges; outlines the methods of repairing defective expansion details; and describes the improvements that have been made in deck expansion joints and bearing assemblies.

3. Bishop, Earl D. CONTINUITY CONNECTION FOR PRECAST PRESTRESSED CONCRETE BRIDGES. Journal, American Concrete Inst. (P. O. Box 4754, Redford Sta., Detroit 19, Mich.), No. 4 (Proc., Vol. 59), pp. 585-599, April 1962. HR Abstracts, June 1962.

A method is proposed by which precast prestressed concrete bridge members may be connected to bring about continuous action under dead loads as well as live loads. The proposed connection consists of steel plates cast into the ends of the precast members and welded together at the supports. The longitudinal slab steel over the supports is designed to resist the live load moments.

In conclusion, it appears that the largest problem involved here as compared against simple span design and construction is the location of the tendons and the final prestress force at the end of the beams. Solution of the strand placement for best stress results may require a little more time in the design room, but the method of splicing should allow the designer to either decrease the size of beam used, or increase the center-to-center spacing of the beams. It may be that for longer spans the use of smaller (or fewer) beams would result in savings which might offset the cost of additional erection time and materials required; additional savings would result if the beam depth were decreased due to lower fill areas and possible shortening of the bridge length. In all cases a more efficient structure would result and the maintenance problem offered by expansion joints in the deck would be eliminated.

4. GLUED JOINTS IN REINFORCED CONCRETE BRIDGES. Engineering Developments in the U.S.S.R. Civil Engineering and Public Works Review (8 Buckingham St., London, W. C. 2), Vol. 60, No. 709, p. 1151, Aug. 1965. HR Abstracts, April 1966.

The use of epoxy resin for jointing precast concrete elements is being adopted for a number of bridges at present under construction in the U.S.S.R. This method **is** described in Beton i Zhelezobeton, No. 6, 1965.

Experience gained during bridge construction in Moscow and Rostov showed that the technique of glued joints presents no special problems on site. Good watertight joints can be easily obtained and good contact surfaces insure uniform distribution of compressive stresses.

Since the viscosity of the glue varies with temperature, the amount of prestress and the thickness of the glue layer in the joint are affected. This problem was overcome at both sides by adjustments of the adhesive mixture where the amount of filler was regulated according to conditions.

Cold-setting epoxy resin adhesive were used in both cases. The mixtures by weight were as follows (the Moscow bridge quoted first): ED-5 epoxy resin: 100, 100; plasticizer (dibutyl phtalate): 10 to 20, 2.5 to 10; hardener (polyethylenepolyamine): 10, 10; filler (cement): 200 to 250, 75 to 125.

At present, research is being carried out on glued joints cured in cold weather conditions with the possibility of developing new types of adhesives suitable for all weather conditions. During the winter of 1964-65, a number of bridges were under construction where the glued joints were heated during the curing period.

5. Goldberger, Harold W., Engineer of Maintenance, Garden State Parkway, N. J. CORRECTIVE MEASURES EMPLOYING EPOXY RESINS ON CONCRETE BRIDGE DECKS. HR Abstracts, Dec. 1960.

This paper describes the application of an epoxy polysulfide sealer to the concrete bridge decks of the Bass and Mullica River bridges on the Garden State Parkway operated by the New Jersey Highway authority. The Garden State Parkway extends 173 mi south from the New York State line to Cape May, New Jersey. There are 240 bridges on the Parkway, varying in length from 50 to approximately 6,200 ft. Most of the bridges have been in use since 1954. The average number of toll transactions on the Parkway during the peak summer months in 1960 was 320,000.

The main problem on these bridges is deterioration of the concrete decks and curbs from the action of salt penetrating cracks and causing scaled and spalled areas to develop. Corrective measures to date, such as crack sealing and filling spalled areas with asphaltic compounds, have been unsuccessful. Past experience with epoxy compounds led to seeking improved compounds and methods of application to repair and seal the bridge decks from further crack penetration and deterioration in one complete operation. The patching and sealing material used in the operation was a proven formulated epoxy polysulfide compound sold in bulk by the raw material suppliers. Prior to the application of the sealer, 12,000 sq yd of the concrete bridge decks of the Bass and Mullica River bridges were sandblasted to remove foreign materials. Spalled areas were patched and cracks filled with an epoxy polysulfide compound using stone sand as the aggregate. Use of bulk materials in experimentation with various application methods gave a fully automated operation using a troweling compound mixer and a two-component epoxy spray unit plus accessories. Application of the non-skid emery aggregate to the freshly applied sealer was accomplished using a sandblaster and an open-end hose. The general result of this automated operation was a skid resistant road surface. The concrete decks were sealed from the damaging effects of salt and the life of these bridges was extended by this preventive maintenance program.

Other benefits include low cost of application through the training of Parkway maintenance personnel and purchase of material in bulk from the raw material suppliers.

The general consultants for the New Jersey Highway Authority have recommended that all bridge decks on the Parkway be sealed within the next five years as a preventive maintenance measure. Based on the performance of the materials used and the experience gained by the maintenance personnel, it is intended to use material similar or equal to those used on the Mullica and Bass River bridges to accomplish this program.

6. Dillon, R. M. and Edwards, P. H. D. THE INSPECTION, REPAIR AND MAINTENANCE OF HIGHWAY BRIDGES IN LONDON, ONTARIO. Engineering Journal (2050 Mansfield St., Montreal 2, Quebec), Vol. 44, No. 11, pp. 39-48, November 1961. HR Abstracts, Feb. 1962.

In the fall of 1959, a section of deck collapsed on the Dundas Street Bridge in the City of London, Ontario. The investigations described in this paper revealed that the condition of many of the bridges was worse than might have been expected. The cause in part is attributed to the increasing use of de-icing chemicals.

These investigations and the planning and supervision of the remedial work served to bring out several lessons. There is nothing particularly new contained in them, but their importance was brought into sharp focus.

The more important ones are worthwhile repeating.

The design of abutments and piers should make adequate provision for friction forces developed in expansion bearings. This is particularly important for structures using sliding plate bearings which tend to freeze.

Design of foundations should take full account of the possibility of scour and bank erosion.

There is need for development of a satisfactory non-leaking type of expansion joint suitable for longer spans.

Gage marks on expansion joints and on bearing plates are useful in early detection of abutment movement.

Control of concrete production at all stages is more important than ever where structures are exposed to de-icing agents. This is of prime importance in modern concrete bridges where the deck acts as a structural element of the superstructure. Asphalt pavement will not protect concrete from salt attack. An efficient sealer is necessary.

Steel painting specifications must be prepared with care, particular attention being given to steel surface preparation and paint application. Field control is important.

Most of the serious damage observed occurred in structures which were constructed between the two wars. With relatively little maintenance they have stood up well for about 25 yr, but under heavier and heavier loads, more and more traffic and finally under increasing attack from de-icing chemicals, they are deteriorating at a rapid rate.

7. NEW TECHNIQUE FOR REPAIRING SPALLED JOINTS. Public Works, Vol. 85, No. 11, pp. 68-69, November 1954. HR Abstracts, Feb. 1955.

These spalled joints were repaired using an unusual technique: removing the spalled portions, thoroughly cleaning the area to be patched, and filling with a concrete patching mixture.

In removing the damaged area at the joints, a concrete saw was used to make a vertical cut 1-1/2 to 2 inches deep, approximately 6 inches in back of the contraction joint, and extending transversely for the length of damaged section. This not only made it easier to break out the concrete with an air hammer, the next operation, but also produced a straight vertical edge to patch against.

After removing from 1-1/2 to 3 inches of broken concrete with an air hammer, the area was meticulously cleaned of all loose material, and a final dust-free surface was obtained by blowing with compressed air. In order to remove the film of slime left by the sawing operation, the vertical face of the saw cut was wet-scrubbed.

The area was ready then to receive the patch which was applied in three steps. First the entire area to be patched was lightly moistened with a whitewash brush to give a damp appearance. A grout mixture was then prepared using one part of cement and one part of sand with sufficient water to give a consistency of "thick paint." This mixture was thoroughly brushed into the surface and sides of the area to be patched. A joint cap then was inserted over the contraction plate at the proper location. The patching mixture was placed and vigorously tamped to insure proper density of the material and positive contact with the slab being patched. The tamping process was also necessary to bring sufficient mortar to the surface to permit satisfactory finishing.

Success of this type of patching depends to a large degree on the mixture. Proportions were 1 to 5, 40 percent coarse pea gravel and 60 percent sand. Water was added to give a dry consistency. An air-entraining agent and 2 percent (by weight of cement) of calcium chloride strength was added to the mixing water for high early strength.

After the finishing and edging was completed, the surface of the patch was broomed to give a surface texture similar to that in the existing concrete. When the concrete had gained sufficient strength, the joint cap was removed and the opened joint cleaned. This procedure was followed in order to assure that when the pavement expands, compressive stresses will act on the vertical faces of the existing pavement and not on any part of the vertical face of the patch. The patched areas were cured by wet burlap for three days, after which the joints were filled with joint filler and the roadway opened to traffic.

These patches were inspected after being subject to 15 months of heavy traffic and exposure to one winter of freezing and thawing. The excellent condition of the patches at that time demonstrates that construction defects of this type can be corrected.

8. GUIDE TO JOINT SEALANTS FOR CONCRETE STRUCTURES. Reported by ACI Committee 504. Journal of American Concrete Institute (Box 4754, Redford Sta., Detroit, Mich. 48219), Proc. Vol. 67, No. 7, pp. 489-536, July 1970. HR Abstracts, Jan. 1971.

This report is a guide to better understanding of the properties of joint sealants and to where and how they are used in present practice. Described and illustrated are the functioning of joint sealants; required properties, available materials and applicable specifications for field-molded sealants and preformed sealants such as waterstops, gaskets, or compression seals; determination of joint movements, widths, and depths; outline details of joints and sealants used in general structures, fluid containers, and pavements; methods and equipment for sealant installation including preparatory work; performance of sealants; and methods of repairing defective work or maintenance resealing.

9. POLYETHYLENE JOINT RELIEF FILLER PROTECTS AGAINST BLOWUPS. Public Works, Vol. 102, No. 1, Jan. 1971, pp 56-58.

This article describes a method devised by the Illinois Division of Highways to use a new type of pavement joint relief filler made of foam. They devised a method that incorporates the use of jack hammers and a new saw cut to break out the old concrete so that the new filler could be applied. While this is basically a discussion of the polyethylene foam, there are photos showing the cleaning of the joints and the installation of the new material. They feel this is the best method they have devised to relieve pavement stress in bridge decks.

10. RESTORATION OF JOINT AND SPALL FAILURES. Public Works, Vol. 95, No. 11, Nov. 1966, pp 82-83.

Describes work done by the North Dakota State Highway Department. The following steps were found successful in the repair of failures of concrete pavements: Jack hammers were used to break up the concrete that was found to be in poor condition by a sounding method. They learned that by tapping the concrete with hammers they could determine the sections in poor condition by the emission of a hollow sound. Each depression was cleaned of all dust and loose particles by brooming and then by vacuum cleaning. Every joint was carefully checked after resawing and cleaning to be sure it was completely dry. A neoprene joint seal was then used. They have found that seal joints functioned perfectly even when temperatures dropped to -31° F.

APPENDIX B

DISTRICT EXPERIMENTATION

This appendix contains letters from six Highway Department districts. In each of these districts the maintenance personnel operated the high-pressure water-jet apparatus for a period of approximately two weeks. Prior to turning the equipment over to the district, brief instructions were given concerning its operation, maintenance and safety requirements. The letters contained herein describe their experience during this period. Although primary emphasis was placed on joint cleaning, many of the districts tried the equipment in other applications, for example to clean equipment and various types of structures.

COMMISSION

REAGAN HOUSTON, CHAIRMAN
DEWITT C. GREER
CHARLES E. SIMONS

TEXAS HIGHWAY DEPARTMENT

STATE HIGHWAY ENGINEER
B. L. DEBERRY

P. O. Box 6868
Fort Worth, Texas 76115
December 5, 1973

IN REPLY REFER TO
FILE NO.

Mr. Gilbert Swift
Instrumentation Engineer
Pavement Design Department
Texas Transportation Institute
Texas A & M University
College Station, Texas 77843

Dear Mr. Swift:

We used the Triton Hydro-Laser the weeks of November 19-23 and November 26-30. We lost about two days of operation time because of a holiday and transportation time.

This device was very efficient for cleaning expansion joints on pan girder bridges compared to methods used previously by the Highway Department. Previously we had spent a full day cleaning one joint on FM 51 at the Brazos River with hand tools and compressed air. We spent about three days cleaning with the Triton Hydro-Laser and cleaned 21 identical joints on the same bridge. Traffic control personnel and the number of personnel used in the hand-cleaning operation and the Hydro-Laser project were about equal.

The device designed by your organization to hold the gun and nozzle was, we believe, a safety feature and also made it less tiring for an operator of the gun and nozzle. A larger radius on the small set of wheels would probably make it easier for it to maneuver over aggregate and other particles on the deck.

We cleaned joints on four bridges during the two weeks we used this equipment.

We tried cleaning asphalt materials from trucks and tanks and found that it easily removed asphalt and also the paint beneath the asphalt. We plan to do a bit more of this type of cleaning next time we have the equipment for further evaluation of the equipment cleaning function.

We appreciated the opportunity to work with you on this project. We shall accumulate a list of projects that will utilize this equipment for another two weeks and call you then.

Yours very truly,

J. R. Stone

J. R. Stone
District Engineer

CRC:rc

TEXAS HIGHWAY DEPARTMENT

P. O. Box 3468
Beaumont, Texas 77704
December 14, 1973

IN REPLY REFER TO
FILE NO.

Mr. Gilbert Swift
Texas Transportation Institute
College Station, Texas 77843

Dear Sir:

We wish to thank you for allowing us the use of the Hdro-lazer pressure pump for cleaning our bridge joints. We found this to be a very useful piece of equipment. It cleaned these joints quicker and better than anything we have previously tried.

Since we have this experience, we propose to lease one of these machines, and rework the joints in the bridges on a district wide basis this winter.

Yours very truly,

F. C. Young
District Engineer

CHB:cf
cc: C. H. Brown

COMMISSION

REAGAN HOUSTON, CHAIRMAN
DEWITT C. GREER
CHARLES E. SIMONS

TEXAS HIGHWAY DEPARTMENT
Pharr, Texas
February 7, 1974

STATE HIGHWAY ENGINEER
B. L. DEBERRY

District 21

IN REPLY REFER TO
FILE NO.

Texas Transportation Institute
Texas A & M University
College Station, Texas 77843

Attention: Mr. Gilbert Swift

Gentlemen:

Reference is made to the hydro-laser machine which was used in this District for a variety of experiments. We found that the machine was very effective in cleaning fixed joints on bridge structures and, although we did not clean to the bottom of the fixed joint with the machine, we see no problem relating to this type cleaning operation except that of time required to do the job. The fixed joints that we were interested in cleaning had no aggregate in them and we wanted to clean them only to a depth of about three inches in order that we could pour a crack-sealing compound into the joint to cut off intrusion of moisture. The machine worked very well for this purpose and no difficulties were experienced in its operation.

Additionally, the machine was used to clean roadside rest area arbors and the water blast was quite effective in removing grease and food stains from tables, floors, and for cleaning the barbecue pit and removing mildew from the painted surfaces where the mildew had grown. We also used the machine to remove loose paint from a structure that we were preparing to paint and it was used to do a thorough clean-up job on a vertical lift span structure across the Arroyo Colorado in the town of Rio Hondo. We tried to use it to improve the color matching between two different concrete pours on a riprap surface on one of our expressway overpasses. Due to the color difference being primarily caused by difference in color of cement, we were unable to match the two colors using the machine.

We believe that the machine or one of this general type has a place in routine maintenance and preventative maintenance and are considering the possibility of trying to interest two other districts into sharing one of these. We believe that we could keep a machine like this busy on a steady basis about one-third of the time.

We appreciate your considering us as you were looking for districts to try the machine. If we can provide any other information that would help you, please advise.

Sincerely,

R. E. Stotzer, Jr.
District Engineer

S. G. Cox, Jr.

By: S. G. Cox, Jr.
District Maintenance Engineer

SGC:p

TEXAS HIGHWAY DEPARTMENT
Wichita Falls, Texas 76307
June 7, 1974

IN REPLY REFER TO
FILE NO.

Mr. William M. Moore
Texas Transportation Institute
Texas A&M University
College Station, Texas 77843

Dear Mr. Moore:

Reference is made to our use of the high pressure water jet apparatus during the month of March 1974. We used this water jetting machine to clean fixed and expansion joints of pan girder bridges and concrete girder structures with good results.

We found that as long as the water pressure could be maintained above 10,000 p.s.i. the machine did an excellent job in cleaning expansion joints. Fixed joints that had begun to open at the top, yet still closed at the bottom of the diaphragms, were more difficult to clean because of the compaction, but the machine did a good job. We cleaned 24 joints during a 40 hour working period. With this method, we cleaned the joints safer, quicker, and cheaper than with any other method known to personnel in District 3. We used three men to perform the work for a total of 120 man hours, which averaged 5 man hours per joint. The high pressure jet streams of water were successful when used to wash bridge rails and flex beam guard fence. Other uses for the machine, such as cleaning paint from a corrugated metal building and removal of asphalt from a distributor were not successful.

We encountered only one mechanical problem with the machine. The high pressure hose fittings did not hold. Also, when we first received the machine, it had water in the fuel.

If one were available, we feel the high pressure water jet apparatus is a good tool and could be used to clean joints in other structures. It is our recommendation that the Highway Department consider purchasing a machine to be used in the District 3 Region.

Sincerely yours,

Robert H. Schleider, Jr.
District Engineer

By: Frank L Ragland

Frank L. Ragland
District Maintenance Engineer

BL/lb
cc: D-18

TEXAS HIGHWAY DEPARTMENT

P. O. Box 3067
Dallas, Texas 75221

April 22, 1974

IN REPLY REFER TO
FILE NO.

Hydro-Laser

Mr. Mike Moore
Texas Transportation Institute
Texas A & M University
College Station, Texas 77843

Dear Mr. Moore:

The Hydro-Laser was used in District 18 for approximately two weeks. During this time it was used for removing painted traffic stripes, removing graffiti from concrete structures and cleaning joints in pan girder bridges.

While the machine did a good job of removing stripes from concrete pavement, we feel that there are better ways of doing it. The best rate of progress we could attain on an eight inch stripe was about one foot per minute. Stripes removed on asphalt pavement was impractical in that the water jet cut too deep into the surface.

Graffiti spray-painted on concrete structures was rapidly and effectively removed with the Hydro-Laser. The only limitations to this use for the machine are the obvious ones of accessibility and overspray or drainage onto passing vehicles.

Several joints in pan girder bridges were cleaned with very good results. These joints were ones where the girder ends on both sides of the bent were fixed. The opening in the joints varied from 1/8 inch to 3/8 inch at the surface of the deck to zero to 1/8 inch at the cap. Where the joint was open as much as 1/8 inch at the cap and 1/4 inch at the deck, we were able to remove most of the foreign matter and we feel that at least we removed enough to relieve any stress which the matter may have caused.

Yours very truly,

John G. Keller
District Engineer

COMMISSION

REAGAN HOUSTON, CHAIRMAN
DEWITT C. GREER
CHARLES E. SIMONS

TEXAS HIGHWAY DEPARTMENT
P. O. Drawer 1579
Waco, Texas 76703
June 5, 1974

STATE HIGHWAY ENGINEER
B. L. DEBERRY

IN REPLY REFER TO
FILE NO.

Mr. William T. Moore
Texas Transportation Institute
Texas A & M University
College Station, Texas 77843

Dear Mr. Moore:

We have completed use of the "Hydro Laser" high pressure water cleaning machine manufactured by the Tri Tan Corporation.

We were satisfied with the effectiveness of the machine in cleaning construction joints in bridges, particularly where there existed only an accumulation of dirt and debris from the road surface. The machine was not as effective where joints contained premolded joint or asphaltic materials.

On one bridge made up of 40 foot pan girder spans with a 30 foot roadway width, eleven fixed joints and four expansion joints were cleaned for a cost of $210 exclusive of the cleaning machine rental. Resealing these joints cost approximately $100.

The machine was used in this district approximately two weeks. During this time minor repair was required consisting of replacement of a seal and one cylinder. The operation could be improved by the addition of a transparent shield near the nozzle which would prevent splatter against the operator's mask which impaired visibility.

We feel that the high water pressure cleaning machine is an effective tool; however, we do not feel that cleaning bridge joints is justified except in exceptional cases.

Yours very truly,

Elton B. Evans

Elton B. Evans
District Engineer
District No. 9

ELH:gm

APPENDIX C

SPECIFICATIONS FOR HIGH-PRESSURE WATER-JET EQUIPMENT

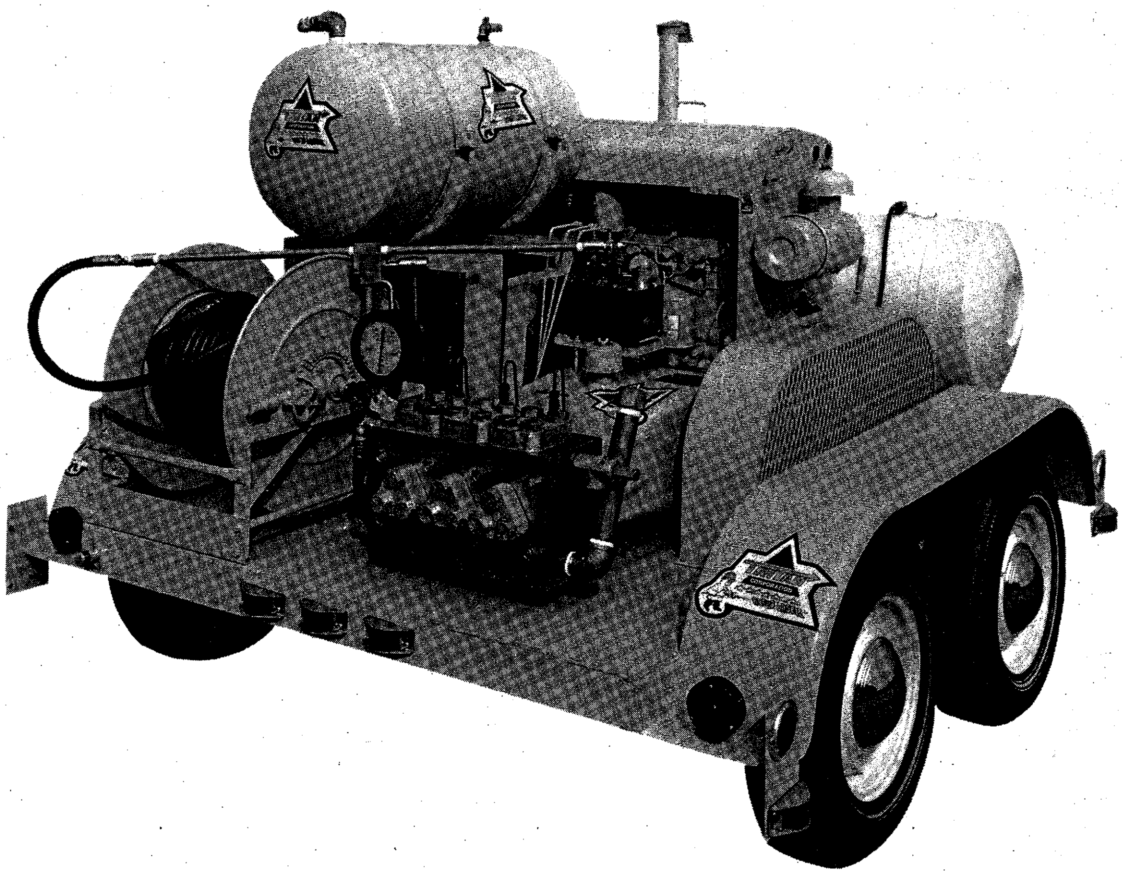
High-pressure water-jet equipment suitable for joint cleaning is manufactured by several different companies. The equipment manufactured by Tritan Corporation, Houston, Texas and American Water Blaster Company, Houston, Texas have been used for this purpose by maintenance personnel of the Texas Highway Department. Both were found satisfactory. Manufacturer's specification sheets describing the particular models of equipment that have been used are included in this appendix.

The equipment should be reasonably maintenance free and be furnished with the necessary supplies (pump packings, etc.) for several months of continuous operation. A maintenance and trouble shooting manual should be provided that is detailed enough for use by skilled mechanics.

The high-pressure pump should be diesel powered and trailer mounted. It should have a discharge capacity of at least ten gallons per minute at a working pressure of 10,000 psi. It should have a water-supply surge tank with a suitable filter for removing any dirt particles that would produce damage in the pump.

The jet gun should be equipped with a nozzle that provides a narrow jet stream. It should have a single lever for operator control of the jet stream which when released will immediately reduce the jet stream flow to a safe level. Fifty feet of suitable high-pressure hose should be provided for jet gun operation.

TRITAN CORPORATION
P. O. BOX 12333
9006 AIRPORT BLVD.
HOUSTON, TEXAS 77017



TRITAN HYDRO-LASER MODEL 3101SS

Allis-Chalmers D262 Diesel Engine (Could be a GMC Detroit Diesel, 3-53N). 15-5 PH Stainless Steel Forged Block Fluid End. (10,000 PSI-10 GPM). Forced Feed Plunger Oilers, Pressurized 40 Gal. Water, 40 Gal. Diesel Fuel Tank, Hose Reel, Pistol Grip Gun, Trailer w/Hydraulic Brakes and Running Lights. Can be Painted Highway Safety Yellow.

P.O. Box 12333 / 9006 Airport Blvd. / Houston, Texas 77017 / (713) 941-8941

PUMP SPECIFICATIONS

MODEL 3310SS HORIZONTAL, TRIPLEX, SINGLE-ACTING RECIPROCATING PLUNGER PUMP

FLUID END

15-5 PH Forged Stainless Steel Fluid Body

- 5% Nickel, 15% Chrome
- Wet fatigue strength value 45,000 - 50,000 PSI
- Tensile strength 145,000 PSI Yield strength 125,000 PSI
- Hardness 28 Rockwell C, minimum
- IZOD impact 60 ft. lbs.
- Forged 15-5 PH stainless steel has a 50% greater elongation value than E4340 carbon steel and 21% greater than cast or machined 15-5 PH stainless steel
- Integral stuffing box assures correct alignment with the power end, and quick packing changeout without removing the fluid block.
- Colmonoy coated no. 304L stainless steel plungers
- No. 431 hardened stainless steel valves and seats (50-55 Rockwell C hardness) and inconel springs. In addition, the valves and polyurethane o'rings to afford double sealing - metal to metal and polyurethane to metal.
- Non-adjustable high pressure plunger packing. This style packing is superior to self-adjusting spring loaded packing which contributes to free travel of the packing when the springs break and/or become weak, which results in short packing life and pump cavitation.

POWER END

- Moly-iron oil-tight power frame
- Integral scoop-gravity feed lubrication system providing lubrication to connecting rod bearings and wrist pin bearings
- Lube oil filter
- Offset steel crankshaft mounted in anti-friction tapered end bearings. By offsetting the crankshaft below the horizontal plane to the crossheads, the vertical thrust of the crossheads on the frame has been decreased over 40%.
- H-beam connecting rods with shell bearings
- Bronze wrist pin bearing, hardened steel wrist pin and alloy iron crossheads
- Multiple seal wiper box, steel crankcase cover, oil level sight gauge, breather cap and steel plunger access cover

PUMP WEIGHT: 920 Lbs. (less piping)

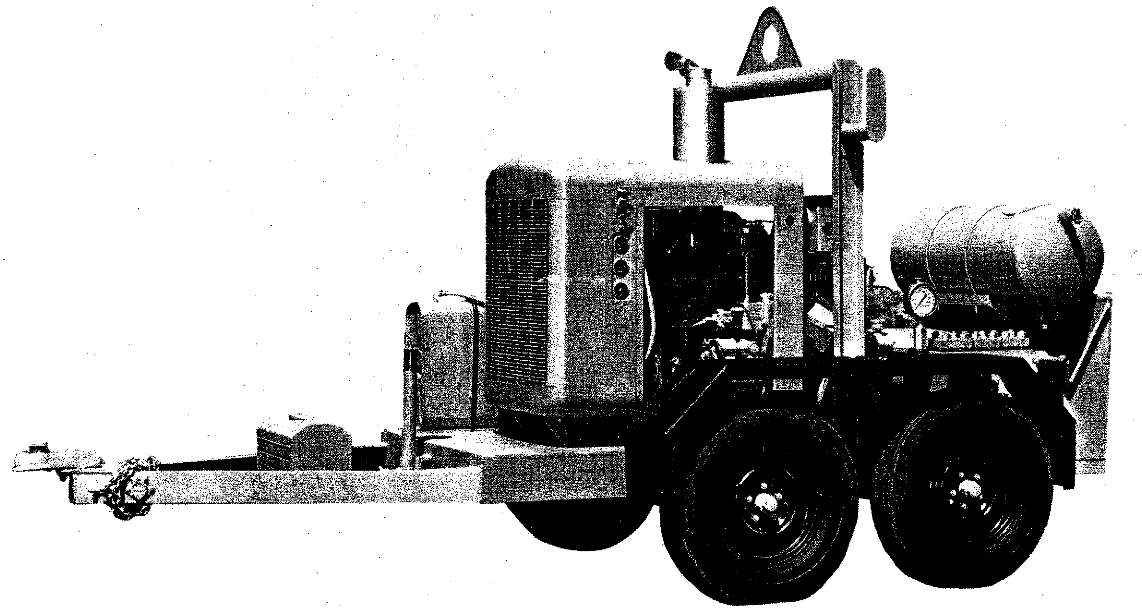
PIPING

All high pressure piping is stainless steel, in accordance with good piping practices and has burst pressure ratings up to 4 times designed working pressure.

THE AMERICAN

The Original and Nation's Largest
Manufacturers of Water Blaster Equipment

Model WBD-85 Diesel



SPECIFICATIONS:

Capacity: Choice of 5,000 psi @ 18 GPM; 7,000 psi @ 14 GPM; 10,000 psi @ 10 GPM.
Pump: T-50 Triplex specially designed and manufactured for water blasting service. Equipped with chrome plated or *Diamacote* coated plungers *(Diamacote* plungers standard on 10,000 psi models); stainless steel valves, seats & springs; forged steel fluid end; special water blaster pump packing; 20,000 psi liquid filled stainless steel pressure gauge with snubber; patented stainless steel snap action safety relief valve.
Pump Drive: Super "V" Belt with tensioning system & completely enclosed splash proof belt guard.
Water Supply Tank: Hot dipped galvanized 30 gallon capacity with automatic water control valve & water filter.
Machine Base: 6" x 44" x 96" structural steel, box type.
Tool Box: Contains packing wrenches, packing removal tool, grease gun & service manuals.
Power Unit: Engine GMC-3-53 Diesel with power take off, radiator, starter, muffler with rain cap, oil bath air filter, battery, instrument panel & 8-hour fuel tank.
Dimensions: Width 44", Length 96", Height 48". Weight approximately 3,500 lbs.

ACCESSORIES:

Trailer: Model 4T Tandem, 4,000 lb. capacity (with jack stand) for highway use. Model 6W four wheel steerable for in-plant use.
Skid: Heavy structural beam type.
Lifting Bail: Heavy structural steel, 5,000 lb. capacity.
Control Systems: Patented Saf-Trol "E" (electric engine throttle control). Saf-Trol "H" (hydraulic engine throttle control). Also single operator control gun P-10-M & multiple operator control gun P-10-MM.
High-Pressure Hose: 20,000 & 30,000 psi burst in 50' lengths.

American Water Blaster has the most complete line of water blaster accessories to help solve your problems.

AMERICAN WATER BLASTER, DIVISION OF

AMERICAN AERO INC.

10950 Old Katy Rd. • P.O. Box 55343 • Houston, Texas 77055 • Phone A/C 713 461-3630

ANOTHER Dixel INDUSTRY

SOLD AND DISTRIBUTED BY

APPENDIX D

JET-GUN MOUNTING CART

This appendix contains the parts list and drawings to fabricate a jet- un mounting cart for use in joint cleaning operations. Slight modifications may be necessary in the mounting brackets to fit a different type of jet un than that shown in the drawings.

List of Drawings

D-1. Complete cart

D-2. Chassis plate and axles

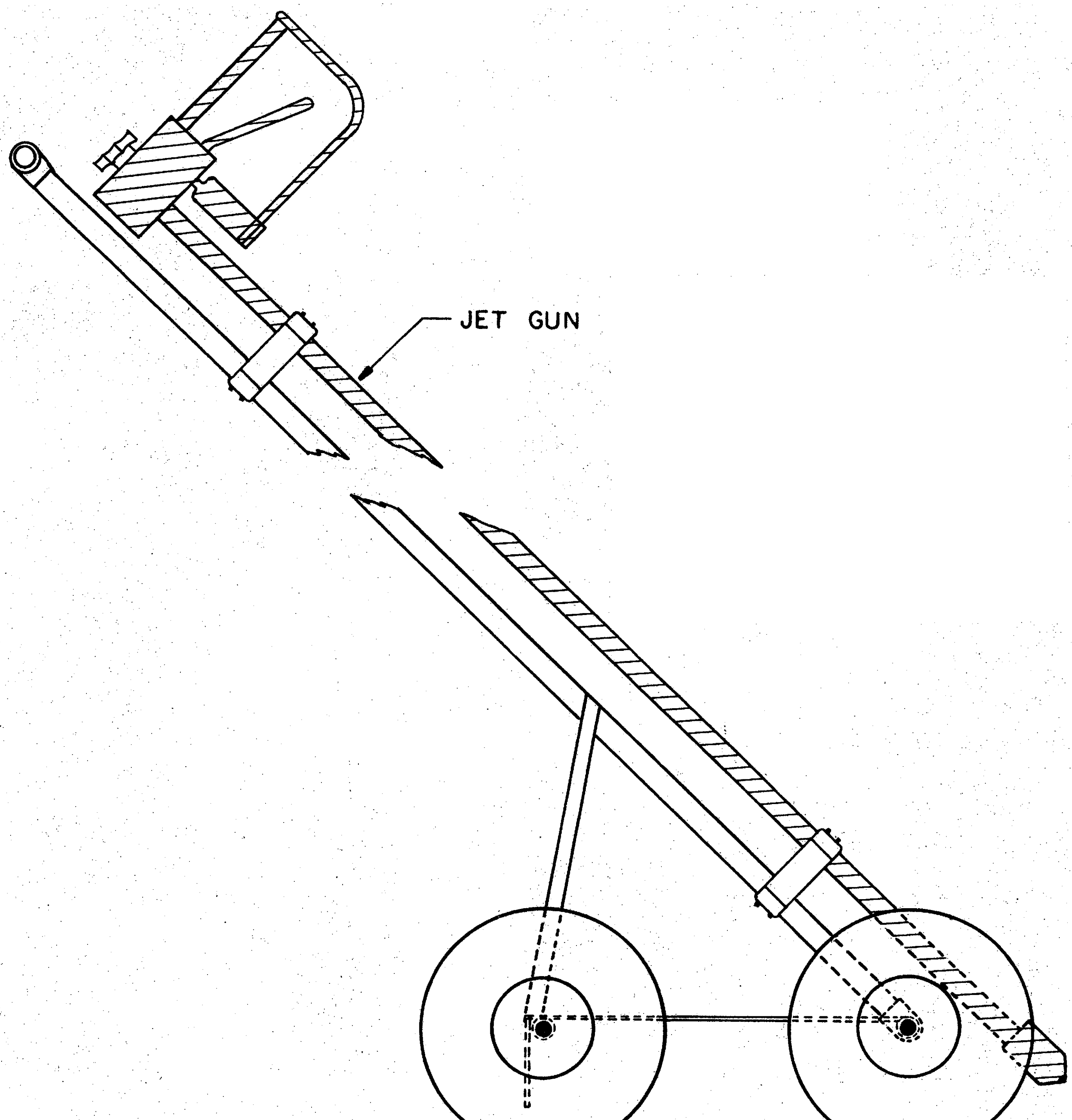
D-3. Handle-axle assembly

D-4. Handle support brace

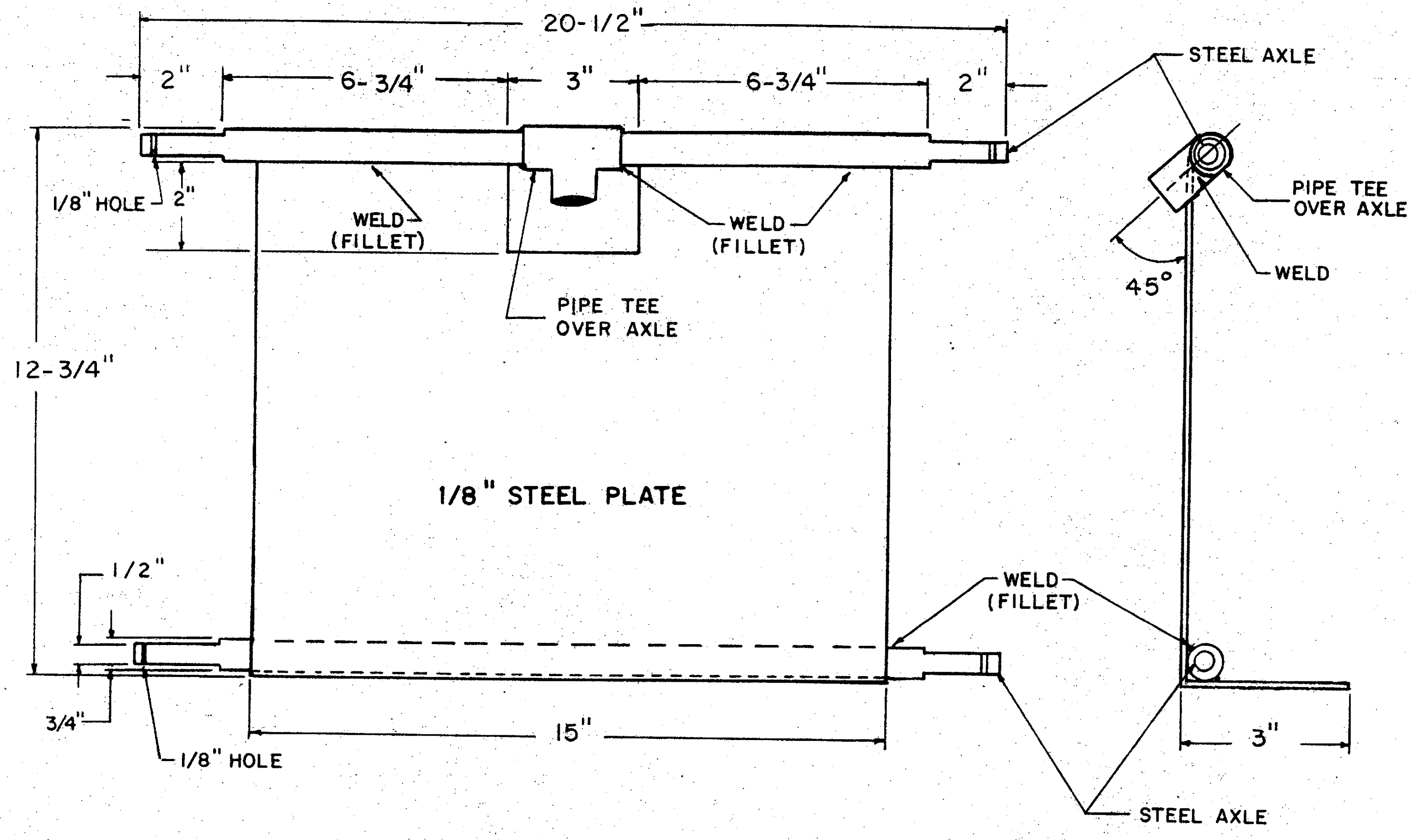
D-5. Jet-gun mounting bracket

Parts List

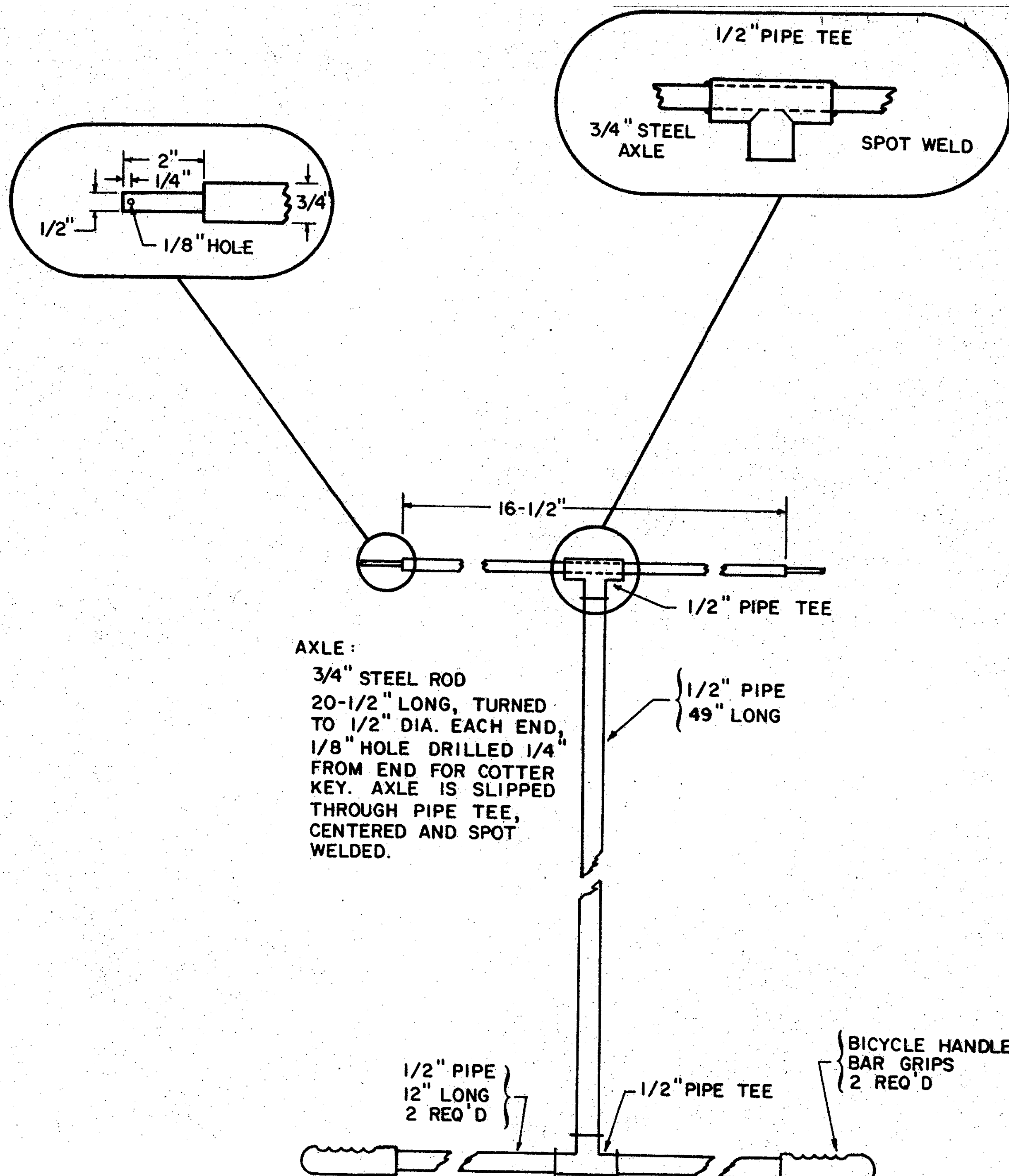
Quantity	Item
4	8" x 1 3/4" with 1/2" bearing lawnmower wheels
4	1/2" flat washers
4	1/8" x 1" cotter keys
2	1/2" pipe tees
2	3/4" i.d. bicycle handlebar grips
2	1/2" x 12" steel pipe (threaded at one end)
1	1/2" x 49" steel pipe (threaded at both ends)
2	Jet-gun mounting brackets (custom made)
2	3/4" x 20 1/2" steel axles
1	13" x 15" x 1/8" steel chassis plate
2	1/2" x 1/2" x 1 1/2" handle support brace (angle iron)
8	1/4-20 x 1 1/2" steel hex head bolts
8	1/4" lock washers



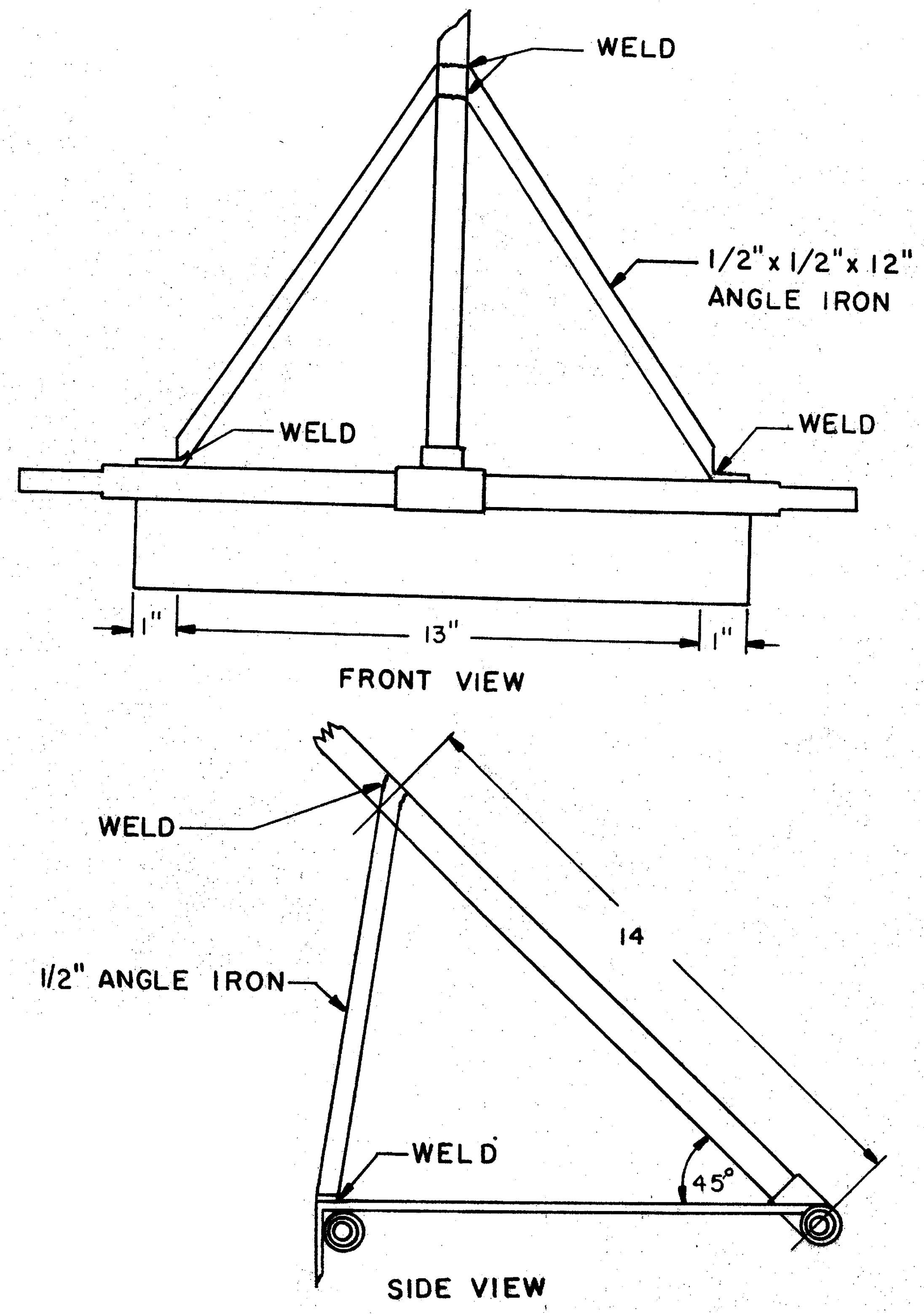
Drawing D-1. Complete cart.



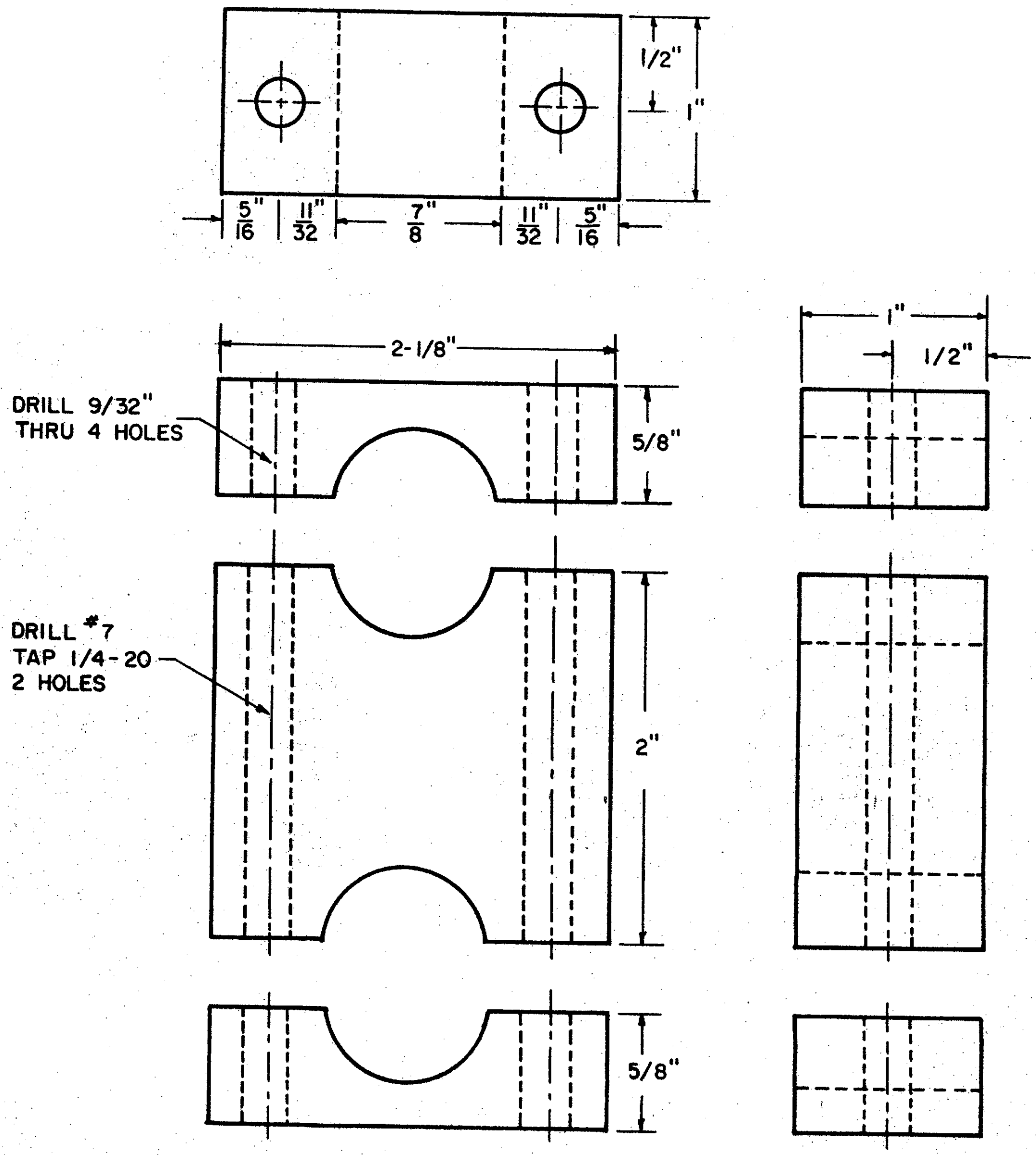
Drawing D-2. Chassis plate and axles.



Drawing D-3. Handle-axle assembly.



Drawing D-4. Handle support brace.



Drawing D-5. Jet-gun mounting bracket.