POTAMOLOGY INVESTIGATIONS

Report 21-1

SAND-FILLED BAGS AS DIKE MATERIAL

POTAMOLOGY RESEARCH PROJECT 9

by

R. T. Easley

March 1967

Sponsored by

The President, Mississippi River Commission

and

The Division Engineer
Lower Mississippi Valley Division

Conducted by

U. S. Army Engineer District, Memphis
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21-1	Sand-Filled Bags as Dike Material; Potamology Research Project 9	March 1967
21-2	Review of Past Experience with Contraction Works; Potamology Research Project 9	March 1967

* Not of general informational value and hence not distributed.

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Foreword

This report is submitted in connection with Potamology Research Project 9, being conducted by the Memphis District, Corps of Engineers, by direction of the Potamology Board of the Lower Mississippi Valley Division and Mississippi River Commission. The project is a part of continuing investigations with the object of developing new materials for use in river stabilization structures. It consists of the construction and testing of a section of dike in which sand-filled nylon and plastic bags were used as a part of the stone dike. The study was approved by the Mississippi River Commission in first indorsement, LMVGP, dated 16 September 1963, to Memphis District letter, subject: Proposals for Potamology Study.

The study was conducted under the direction of Mr. Robert T. Easley, Chief, Potamology and Maintenance Section, and under the general direction of Mr. C. G. Hutton, Chief, Engineering Division, Memphis District. The field investigation and preparation of material for the report were conducted by Mr. Bobby J. Littlejohn. The report has been reviewed and approved by the Potamology Board in accordance with paragraph 6 of LMVD Special Orders No. 20 dated 12 August 1964.

Col. Edmund Kirby-Smith, CE, was District Engineer and Lt. Col. T. W. Dale was Deputy District Engineer during the field investigation and preparation of this report.

Contents

Summary

As the channel stabilization project on the Lower Mississippi River has progressed, the requirement for materials suitable for placement in deep water and swift currents has increased. Stone has met this demand for dike construction in the past, but other materials which might be better or more economical are being investigated. This report presents a description of field and office investigations of the use of one of these materials, sand-filled nylon and plastic bags, as dike material.

Bags were substituted for stone in a short section of a stone dike being constructed at Forked Deer, Tennessee. The test section was so located that it was subjected to severe current and wave attack during and after placement. Placing was satisfactory, the bags remaining generally where placed in the swift current. There was some breakage of the bag material during mechanical handling, but this could be eliminated by improved handling methods.

Inspection after a high-water period, during which the dike was subjected to fluctuating river stages above and below the top elevation of the dike, revealed that many of both types of bags on the surface of the structure had been ruptured and the fill material lost. This was attributed to drift to which the structure was subjected during the lower river stages. Some of the plastic bags had been moved by the current, but there was no evidence of any appreciable displacement of intact nylon bags.

It was concluded that plastic bags are not suitable for use in dike construction because of the weakness of the material, requiring the use of smaller bags. Results indicated, however, that sand-filled nylon bags are superior to stone for use in making closures or for initial placing in swift currents, but would require an armor of stone or other material where exposed in permanent structures.

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General

Background

1. For many years dikes have been utilized on the principal rivers of the world as important structures in channel stabilization. Design of the structures, the materials used, and their applications to the problems at hand have varied extensively. Pile dikes have been reasonably effective in most areas for channel contraction, while stone or variously shaped concrete blocks have been useful in making closures of secondary channels. As stabilization has progressed on the Mississippi River and tributaries, permeable pile dikes have become less effective for channel contraction due to the lesser amounts of sediment being carried, and are gradually being replaced by stone-fill structures. The increased use of stone as a stabilization material on the Lower Mississippi River resulted in a corresponding increase in transportation facilities and quarry development, and has ultimately reduced costs to the point where stone dikes can now compete economically with pile structures except in extremely deep water. At the same time the search for better and, if possible, cheaper materials has continued. Sand-filled bags of burlap or similar materials have long been used for temporary levee repairs or fills, usually during flood emergencies. However, the lack of strength and durability of the bag material has prevented their use in more permanent structures, or where mechanical handling would be required. Synthetic fibers have now been developed which have these qualities, and a test of the materials under conditions existing in the Lower Mississippi was considered to be worthwhile. Nylon is one of the materials which has found wide usage in hydroengineering. Sand-filled nylon bags of various shapes and sizes have been successfully substituted for stone in many areas, particularly in the lowlands of northern Europe, and plastic materials which might also be useful for this purpose have been developed. This report covers both materials.

Test site

2. It was desired to test the materials as a part of a dike system scheduled for construction during Fiscal Year 1965. The stone dikes proposed at Forked Deer, Tennessee, were selected, and this site was approved at the Potamology Conference of 15 July 1964. Since the dikes at this location were under contract at that time it was necessary to issue a change order to incorporate a test section in one of the dikes. The contractor was Patton-Tully Transportation Company of Memphis, Tennessee. The bag dike section was placed in Dike No. 1 of the two dikes in the system.

Purpose and scope

3. The purpose of the experiment was to determine the durability and permanence of a section of sand-filled bag dike when incorporated in a standard stone dike in the Mississippi River, and also its relative effectiveness as compared to that of the adjacent stone structure. Due to the small volume of work involved and the construction methods necessitated by the experimental nature of the work, a reasonable comparison of costs with stone or other materials was not possible.

Description of dike system

4. Dike No. 1 at Forked Deer, Tennessee, is the upstream of two stone dikes constructed for the purpose of preventing a divided flow and contracting the channel to the right of a middle bar. The general plan of the dike system is shown in plates 2 and 3. Dike No. 1 effects a closure of the secondary channel along the left bank below the Island 25 revetment, and extends across the upper end of the bar for the purpose of deflecting the flow to the right bank. The design cross section of the dike consisted of a 6-ft crown width with side slopes of approximately 1 on 1-1/4, with a stone apron extending 20 ft downstream from the center line. This section is shown in plate 2.

Test section

5. The location selected for the sandbag section is on the right side of the bar, approximately 500 ft from the outer end of the dike where it is subject to direct current attack (see plates 2 and 3). The section was to be placed to an elevation of +8 ALWP (average low water

plane), and the bar elevation at the time of placing was about -5 ALWP. It was determined that test sections approximately 30 ft in length for each type of bag could be constructed with the available supply of bags.

Preparation of Materials

Materials

6. The experimental section of the dike consisted of bags of two types of material: nylon, furnished by Carthage Mills, Inc., of Cincinnati; and plastic purchased from Union Carbide Corporation, Bound Brook, New Jersey.

- a. Nylon. The nylon material is a permeable mesh fabric woven sufficiently tight to prevent the loss of fine materials. A total of 395 bags, 90 by 58 in., with a capacity of about 1 cu yd each, was used in the nylon portion of the test section. The bags were designed to be loaded and picked up with a load of 3,000 lb without exceeding the tensile strength of the material. The bags were furnished in two types: about 40 percent were of continuous weave with no side seams and were gold in color; the remainder were white with one seam down the side. Both types were sewn across the bottom.
- b. Plastic. A total of 3,987 plastic bags was used. These are of a black, impermeable film known as "ZENDEL XT FILM," with a thickness of 0.010 in. The bags are 20 by 40 in. and have a capacity of about 0.10 cu yd each, weighing 200-250 lb when filled with sand.

Bag-filling operation

7. Equipment. Due to the small number of bags involved, the contractor elected to conduct the bag-filling operations at his plant in Memphis rather than mobilize the necessary specialized equipment at a location near the work site as would normally be done. A supply of material classified as silty sand was available on the bank of Wolf River adjacent to the contractor's mooring site. The material was finer than that usually found on sand bars where material would normally be obtained, all passing the No. 16 U. S. Standard Sieve (see plate 1). Barges and other floating equipment for handling and transporting the bags were available at the site. Equipment assembled on the bank for the operation

consisted of a portable belt-type conveyor, a bulldozer for stockpiling the material, and a crane with clamshell bucket for filling the conveyor hopper (see photograph 1). To support the larger nylon bags during filling, a holding device was necessary. This consisted of a rectangular base of 3/4-in. plywood, 24 by 48 in., with sides extending 22 in. above the ground, and two hinged sides which could be raised to a height of 74 in. and clamped by steel angles (see photographs 2, 3, and 6).

8. Filling. The nylon bags were placed in the holding device with the hinged sides closed, and the tops of the bags were fastened to the sides. Bags were filled to approximately 80 percent capacity by means of a chute attached to the conveyor. Average filling time was about 2-1/2 min per bag. The hinged sides were then lowered to permit sewing and removal of the bag. The smaller plastic bags were filled by holding them directly under the chute attached to the conveyor, as shown in photograph 8. No difficulties were experienced.

Fastening of bags

9. Nylon. Fastening of the nylon bags was accomplished with a specially designed electric sewing machine equipped with high strength nylon thread similar to that used in the bags (see photographs 4 and 5). The machine, manufactured in Europe, was furnished on a loan basis by Carthage Mills, Inc. Malfunctioning of the machine resulted in a considerable amount of lost time during the early part of the operation. Repairs and some adjustments were made by a local sewing machine repairman in order to complete the job. When in working order, the machine was satisfactory, and the bags were sewn in about 20 sec each. It is believed that a more reliable machine on the same order could be designed, and that the sewing of the nylon bags would be accomplished satisfactorily.

10. Plastic. The fastening of the plastic bags presented some problems. A device furnished by Union Carbide Corp., consisting of a clamp for holding the open ends of the bags while heat was applied for sealing, proved to be unsatisfactory (see photographs 9 and 10). The method was slow, and many of the seals were not sufficiently strong to withstand normal handling. It was determined that this failure was due to excess dust in the work area which prevented proper sealing. This would preclude

the use of this method except under laboratory conditions. Sewing was tried (see photograph 11) but this was also unsatisfactory. Consequently, a method of tying the bags by hand with treated cord was decided upon, also shown in photograph 11. This resulted in faster operations and satisfactory results. In addition to the 3,987 black plastic bags for use in the test section, 90 clear plastic bags with a capacity of approximately 0.05 cu yd were furnished by Union Carbide Corp., principally to test the self-sealing feature of the bags. This feature consisted of a spout, or flap, which closed after being filled, preventing loss of the material. Filling of these bags with the equipment on hand was difficult due to the small opening provided in the bag.

Handling and transporting bags

11. Nylon. The filled bags were removed from the bank and loaded on barges by means of a floating crane. For handling the nylon bags, a clamshell bucket was altered by welding 6-in. pipes, 6 ft in length, across the teeth on each side of the bucket to prevent direct contact between the bags and the sharp edges of the bucket (see photograph 6). Bags were first picked up near the tops as shown in photograph 7, resulting in some breakage of the fabric from pressure exerted below the point of contact. Picking up from the side of the bags was tried but with no better results. Further damage to the bags from rough edges on the sides of the jaws of the bucket and the jagged ends of the pipes was remedied to some extent by using rubber padding.

12. Plastic. Handling of the small plastic bags by clamshell was not practicable, and the best method was found to be by the use of a "rock bucket," or skip-type bucket (see photograph 16). The bags were loaded into the bucket by hand (about 25 bags per load) and dumped mechanically into the structure. A filled bag could be handled easily by two men, and eight men were used in loading the skip. Damage to the bags in handling was negligible.

Construction

Placement

13. Nylon bags. The specifications for construction of the stone

dike, of which the test section was a part, required that the "base," or lower 4 ft of the dike fill, and the stone apron (see cross section, plate 2) be placed first, and that this portion of the dike fill be placed not less than 400 ft in advance of the placing of the remainder of the fill. This necessitated the placing of the test section in two phases. By the afternoon of 12 August 1964, the stone base had been extended to the landward limit of the proposed test section (see photograph 12). This point was established 30 ft landward of one of the pile clumps driven at 100-ft intervals for alignment control, so that the clump would serve as a marker for the center of the test section (see plate 4). The base of the dike was then continued to the clump using nylon bags. The bags were placed in depths of water varying from 7 to 8 ft by means of a crane with the same bucket used at the loading site. Each bag was spotted at the desired location and released at about the water surface. Soundings were made from a small boat during the progress of the work and it was determined that the bags settled into position approximately where released, with little horizontal displacement, even though the current velocity at the site was estimated to be 8 to 10 fps. Breakage of the bags during the placing operation was extremely high. Twenty-eight of the 100 bags handled were broken or damaged either in transporting or placing in the structure, with the result that a total of 72 bags were placed in the 30-ft base of the dike (see table 1). Placing of the nylon bags required about 4 hr, 10 min. Photographs 13, 14, and 15 show this phase of placing.

14. Plastic bags. Prior to placing the plastic bag portion of the dike base on the morning of 13 August, it was discovered that a scour hole had developed downstream of the nylon bags. This scour was partly the result of a 1-ft fall in the river stage during the night, increasing the velocity of the flow over and around the bags. It was considered advisable to fill this hole before placing the plastic bags, and this was accomplished with stone. The plastic bags were then placed in the dike base to a point 30 ft beyond the pile clump, using the skip-type bucket. The bags were released at the water surface, and soundings indicated that these bags had assumed the approximate position desired. The depth of water in which the bags were placed averaged about the same as for the nylon bags, but the

current velocity was slightly higher. This portion of the base required 1482 plastic bags. Placement of the standard stone base was continued immediately following the completion of the bag base. Placing of plastic bags is shown in photographs 16, 17, and 18.

Final phase of placing

15. By 25 August the stone portion of the dike landward of the test section had been brought up to final grade, and preparations were made for placing the remaining bags to complete the cross section. Prior to resuming the placement of bags in the test section, soundings indicated that the scour hole downstream from the bag section had enlarged and that some of the bags on that side of the dike had been lost or had settled due to having been undermined. Consequently, it was estimated that additional bags would be required to construct the test section to final grade. In order to ensure the longest possible length of bag dike to full grade and cross section with available bags, it was decided to begin placing at the pile clump and proceed landward, thus shortening the test section as necessary. In order to cut off the flow over the test section as soon as possible and also prevent the concentration of flow between the bag dike and the existing completed stone dike, it was further decided to bring the bag and stone fills up in two lifts, the first lift to be sufficient to bring the bags to about the water surface for the entire length of the test section before proceeding with the upper part of the section. As the first lift progressed to the water surface, revised volume computations based on the number of bags remaining on hand indicated the advisability of shortening the nylon portion to 15 ft to assure a full cross section. This was due partly to the settling of the bags and partly to the loss of bags from breakage. Sufficient stone was then placed to complete this lift of the test section. Final placing of nylon bags is shown in photograph 19. Following the same plan, the plastic bags were placed to the same elevation, extending riverward of the center clump for a distance of 25 ft, as determined by calculations. The final lift of placing consisted of bringing the test section to full grade and cross section. Surplus nylon bags were placed over stone at the landward end, resulting in a profile approximately as shown in plate 4. Due to the size and method of placement of the

plastic bags, hand-placing of the bags above the water surface was necessary to provide the proper cross section. Consequently, a more compact fill with some interlocking of the bags was achieved (see photograph 20). During the final phase of construction on the test section, the 90 clear plastic bags, described in paragraph 10, were placed below the water surface on the downstream side of the plastic portion of the test section. Photographs 21 and 22 show completed sections of nylon and plastic bags.

Coating of nylon bags

16. To prevent deterioration of the nylon fabric by exposure to sunlight, it was necessary to protect all surfaces of this portion of the dike which would be exposed during low-water periods. For this purpose the surface of the dike was coated with a coal-tar emulsion developed by the Plastics Division of Allied Chemical and furnished the contractor without cost. The emulsion, which was a mixture of two types designated CP 510, Gr. 105, and CP 528, Gr. 105, was heated to 130 F and sprayed over the bags (see photographs 23 and 24). Approximately 125 gal were required to completely cover all exposed surfaces of the bags. Observations during spraying indicated that a good coating was provided over all surfaces of the bags, and that the material was not affected by wave action immediately after being placed at the water surface. Photograph 25 shows the completed test section with coated nylon bags in the foreground.

Discussion

Methods of operations

17. The decision of the contractor to fill the bags at a location distant from the work site was dictated by the experimental nature and small size of the project. In most cases, a suitable supply of fill material is available in the immediate vicinity of dike locations. For a project involving greater quantities, the filling operation would normally be near the site, and a system for filling and transporting the bags could be worked out which would result in greater production and more efficient operation. The improvised bucket for handling the nylon bags was not satisfactory in spite of the changes made during operations. Much of the

damage to the nylon bags occurred during the handling operation, and a more suitable method of picking up the bags would have to be worked out for efficient operation. Due to the small size of the plastic bags and their susceptibility to damage from sharp edges, handling with a clamshell or other standard type bucket was not feasible. The skip-type bucket was satisfactory and few bags were broken in handling, but the method was expensive due to the hand labor required.

Materials

18. Nylon. Of the two types of nylon bags used, the seamless bags appeared to be the most satisfactory. In addition to the weakness at the seams in the other bags, the material stretched under stress, resulting in elongated bags improperly filled and difficult to place. Even with the very fine material used for filling there was no evidence of loss of material through the fabric. With proper handling equipment, the seamless bags would be satisfactory from the standpoint of strength. However, for use in dikes or similar structures, the bags should be redesigned both as to size and shape. A smaller bag would handle better and provide a more compact fill. The ratio of length to width should also be increased to permit placing in an interlocking pattern.

19. Plastic. Due to the small size of the bags and the method of handling and placing, a determination of the tensile strength of the plastic bag material was not possible. The material appeared to be easily snagged or broken and its durability under direct machine-handling is questionable.

Time and cost

20. Time. A summary of the bag-placing operation, including the number of bags broken, time required to place, gage readings, depths of water, and other pertinent data is given in table 1. Typical times required for the separate operations involved are indicated below:

Nylon Bags

Place in box and fill	2 min, 30 sec
Prepare and sew	1 min, 30 sec
Remove from box and place on barge	1 min, 30 sec
Total time	5 min, 30 sec

(Continued)

Plastic Bags

Filling, tying, loading 86 bags/ hr

21. Cost. The principal items of cost involved in the experiment were the lump sum payment to the contractor of $14,065, and $1,000 for the cost of the plastic bags. All other materials were furnished without charge by the manufacturers. Had all materials been purchased at current prices, the total cost would have been $17,137, resulting in costs per cubic yard of dike constructed of $6.37 for materials and $29.71 for filling, transporting, and placing the bags; or a total of $36.08 per cu yd of dike. A comparison between this and the $4.73-per-cu-yd cost of stone under the contract is not valid because of the small size and experimental nature of the project. Analysis of the operational costs indicates that 70 percent of this cost was attributed to filling and fastening the bags, an item which could be drastically reduced on a large project involving quantities which would justify the development of special filling and handling techniques. These have been demonstrated on similar projects in Europe. The exclusive use of nylon bags, which proved to be easier to fill, would further reduce operational costs. Information furnished by the manufacturers indicates that quantity production of nylon bags would permit price reductions, possibly up to 40 percent. These cost reductions would result in a more reasonable comparison between sand-filled bags and stone on larger projects. It is not likely, however, that the use of bags could be justified on the Mississippi River on the basis of cost alone.

Results, Conclusions, and Recommendations

Results

22. Condition of test section. Between the time of completion of construction in September 1964 and the survey of August 1965, the experimental bag section was subjected to fluctuating river stages above and below the top elevation of the dike, as indicated by the hydrograph in plate 7. Comparisons of conditions before and after the high-water period are shown in plates 5 and 6. The elevation of the crest of Dike No. 1 was slightly lower throughout its entire length following the high-water period,

and the profile over the bag section showed an additional lowering of from 1 to 4 ft below the adjacent stone section. The survey also revealed a large failure in the stone portion of the dike 400 ft riverward of the bag section. In addition to the loss in elevation of the bag section, most of the plastic bags in the top portion of the dike, as well as about 20 ft of the adjacent stone dike, had been moved about 10 ft downstream by current action. Both plastic and nylon bags which had been exposed to the current were badly damaged, and fill material had been washed out. However, there had been little apparent movement of any of the undamaged nylon bags. Photographs 26-31 show the general condition of the test section after one high-water period.

23. Durability of bags. Although some of the smaller and lighter plastic bags were moved by the current, the principal cause of failure of both types of bags was the loss of fill material due to rupture of the bags. This was evidently caused by drift or other floating objects during stages at or near the dike elevation. During the period of stage fluctuations, as indicated on the hydrograph (plate 7), the bag section was alternately submerged and exposed a total of six times, during which extensive damage could have occurred from drift or even boats.

24. Coating of nylon bags. The coal tar emulsion used in coating the nylon bags did not provide the desired protection for the fabric. The coating on many of the bags appeared to have been washed off by the current.

Conclusions

25. The durability of sand-filled bags is not sufficient for use in a permanent structure in the Mississippi River when exposed to normal rising and falling river stages. This is due primarily to their vulnerability to damage from drift and other floating objects.

26. Sand-filled bags would probably be more effective than stone or other materials in making channel closures or for placing in deep water since they usually remain approximately as placed, and are not easily moved by current action. This is probably due to their smooth, rounded surfaces, and to their shape and pliability which results in some interlocking during placement. If used for these purposes, the bags could remain as a part of a permanent structure provided an armor of stone was added.

27. Of the types of bags tested, nylon was far superior to plastic. The plastic bags were too small to withstand the current velocities encountered, and the strength of the plastic material was not sufficient for use in larger bags.

28. Another problem in the use of plastic bags was in fastening. Heat sealing was not satisfactory, and the tying resorted to would not be practical with larger bags.

29. The tensile strength of the larger nylon bags appears to be sufficient for handling in any size desired, although a redesign with respect to shape and size is desirable. Slightly smaller bags with a greater length-width ratio could be filled and handled better and would result in a more compact fill with fewer voids.

30. The method used in handling nylon bags could be improved upon, possibly by using a hook or tong-type device. Only seamless bags with continuous weave, however, should be used unless a stronger seam can be developed. A redesign of the sewing machine used in the experiment to improve its durability would provide a satisfactory means of fastening the nylon bags.

31. The weave of the nylon bags was sufficiently close to prevent the loss of material as fine as silty sand.

32. For an operation on a large scale, an efficient loading and handling plan could be worked out using equipment similar to that used in the experiment, or with a hopper-type filling device.

33. The coal-tar emulsion coating, while easy to apply and quick-setting, could not withstand the action of the current, and was washed off during the first high-water period.

34. Due to the size and shape of nylon bags available, they would be superior to burlap for making emergency repairs or during floods.

35. It is not likely that the use of nylon or plastic bags could be economically justified on the Mississippi River. However, their effectiveness under some conditions could offset the added cost.

Recommendations

36. It is recommended that:

a. The use of sand-filled bags as permanent structures not be considered in dike design on the Mississippi River.

b. Further experimentation with sand-filled nylon bags be confined to channel closures or placing in swift currents, with the view of determining the optimum shape and size of the bags for use under these conditions.

c. If sand-filled bags are found to be superior to stone or other materials for placing in areas subject to severe current attack, consideration be given to their use during flood emergencies.

Table 1

Summary of Bag-Placing Operations

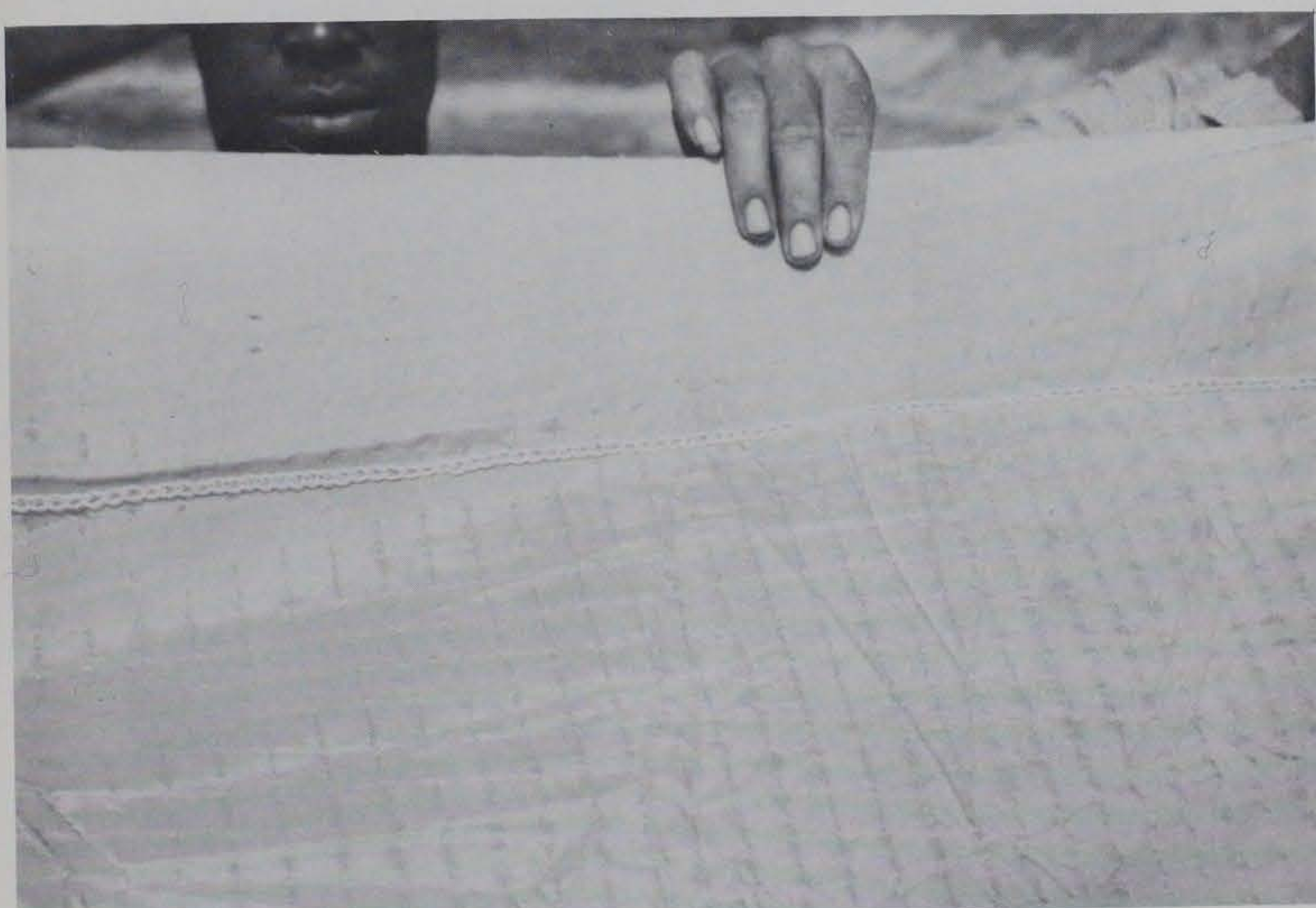
Broken in Filling and Handling	Available for Placing	1964 Date	Phase of Placing	Broken or Lost in Placing	Total in Place	Gage (ALWP)	Approximate Water Depth, ft	Placing Time hr:min
			Nylon Bags					
2	100	12 Aug	Base	28	72	+2.6	6.9	4:10
1	105	25 Aug	To above water	21	84	+2.6	6.9	3:35
2	185	28 Aug	Topping	13	172	+2.7	7.0	5:20
Total 5	390			62	328			
			Plastic Bags					
8	1500	13 Aug	Base	18	1482	+1.7	5.9	3:25
9	1475	27 Aug	To above water	10	1465	+2.5	6.7	2:30
8	1012	28 Aug	Topping	9	1003	+2.7	6.9	1:30
Total 25	3987			37	3950			

Photograph 1. Overall view of borrow area showing equipment used in filling nylon and plastic bags

Photograph 2. Plywood box used to support nylon bags being filled with sand

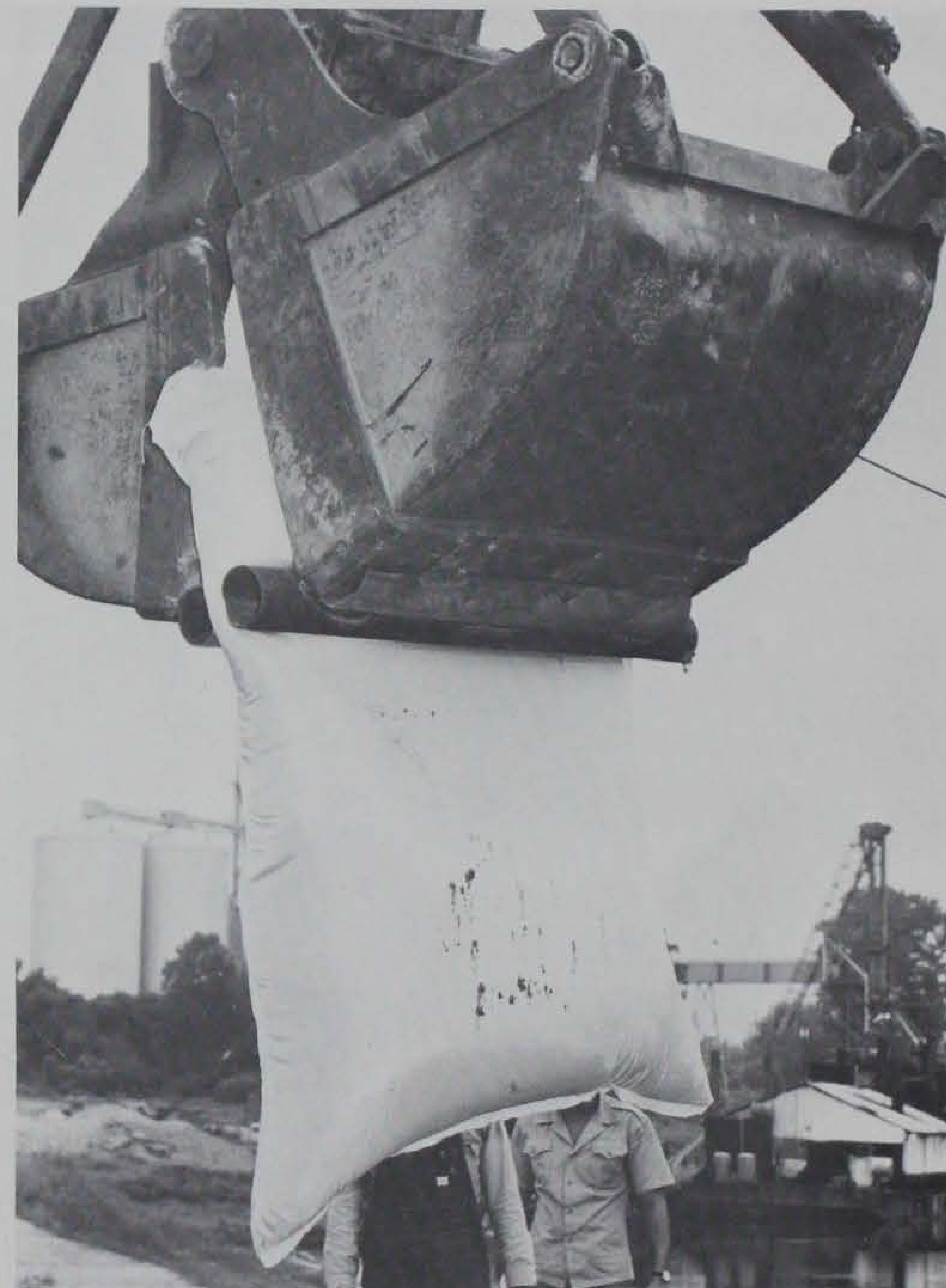
Photograph 3. Plywood box supporting nylon bags being filled with sand from conveyor belt equipped with chute

Photograph 4. Sewing nylon bag with special portable sewing machine



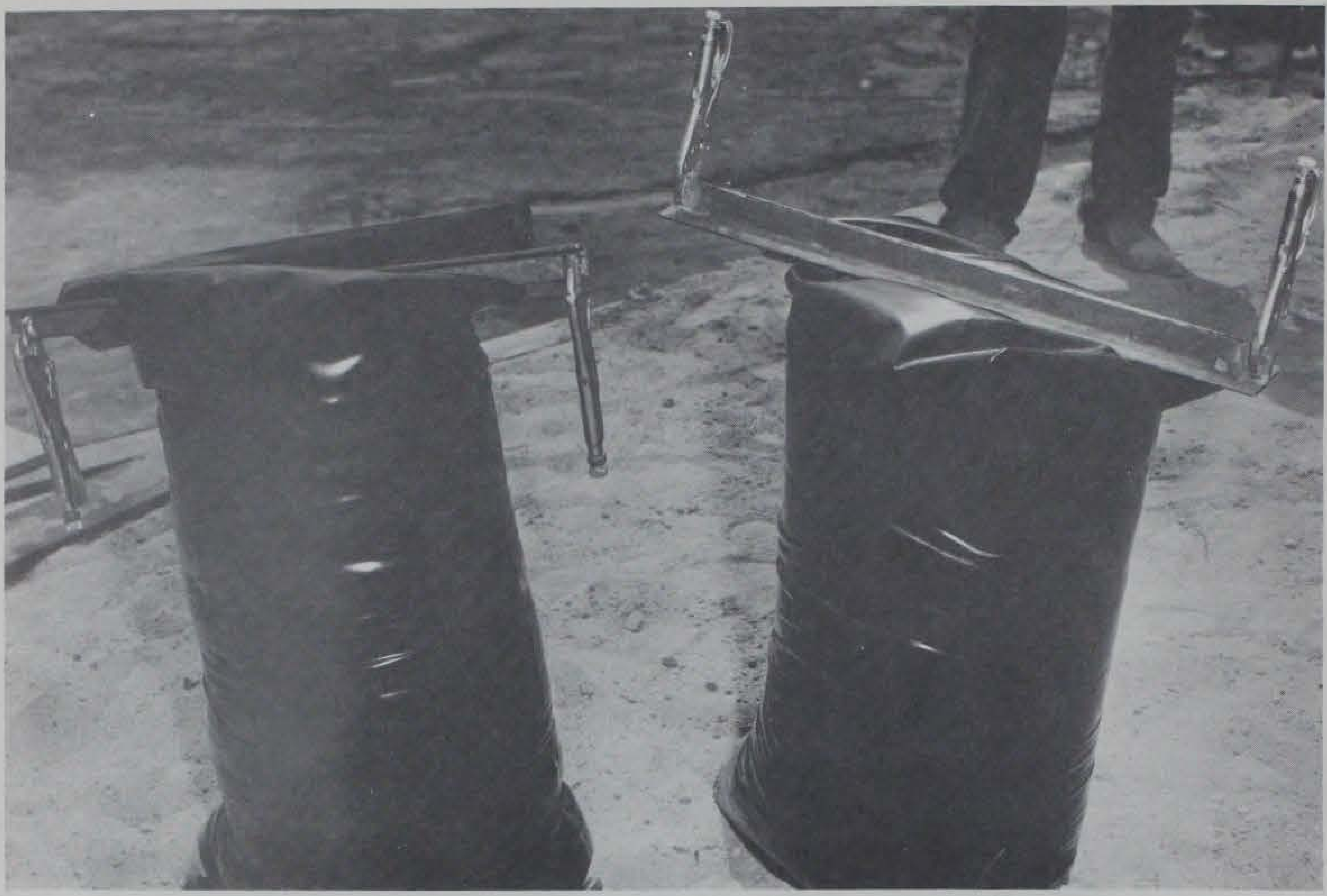
Photograph 5. Stitching done by special portable sewing machine

Photograph 6. Clamshell used in handling nylon bags. Note 6-in. pipe welded to jaws of bucket to protect nylon bag from damage



Photograph 7. Clamshell removing nylon bag from plywood box

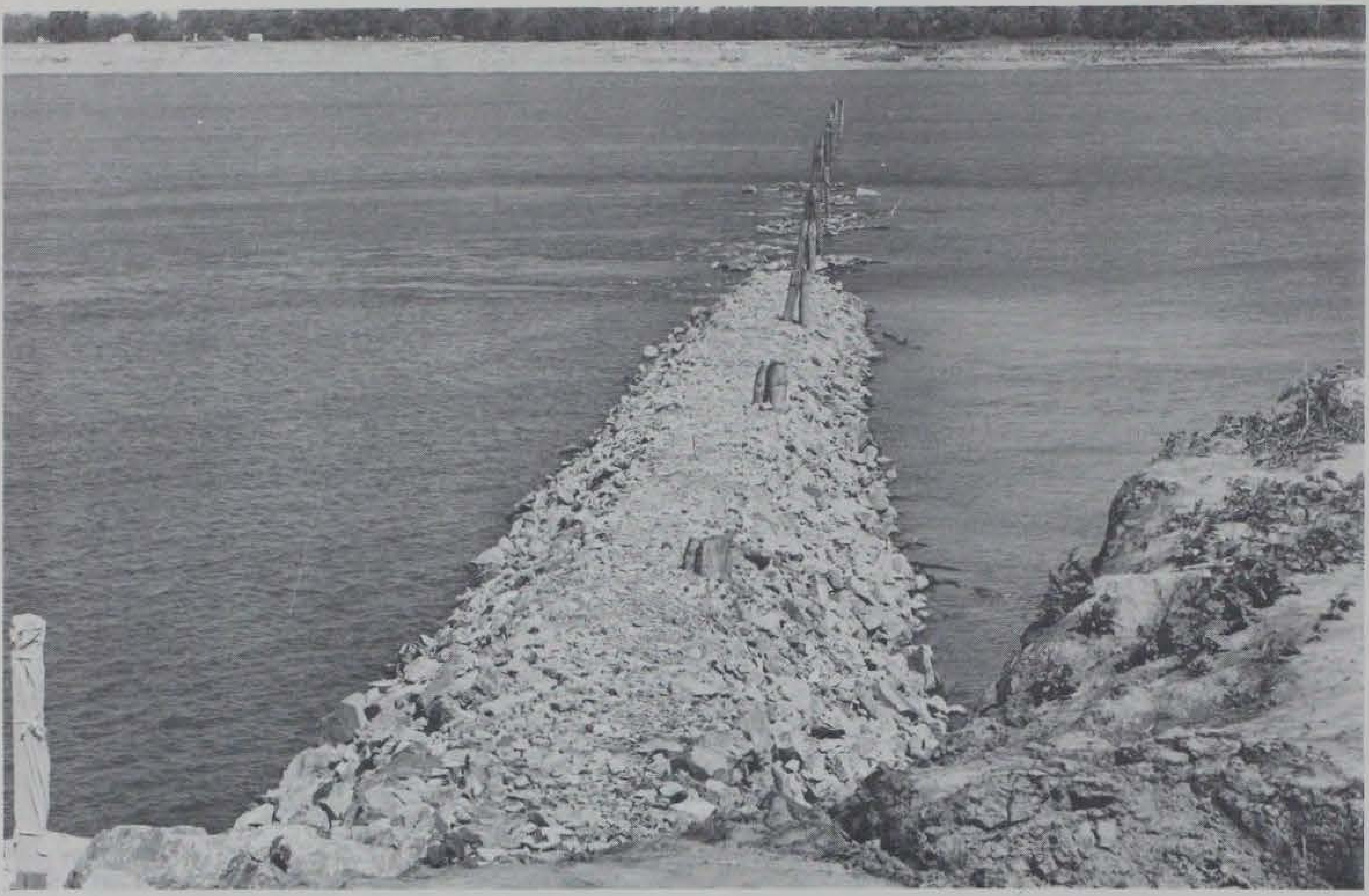
Photograph 8. Plastic bag being filled with sand from conveyor belt. Filled bags are being prepared for sealing



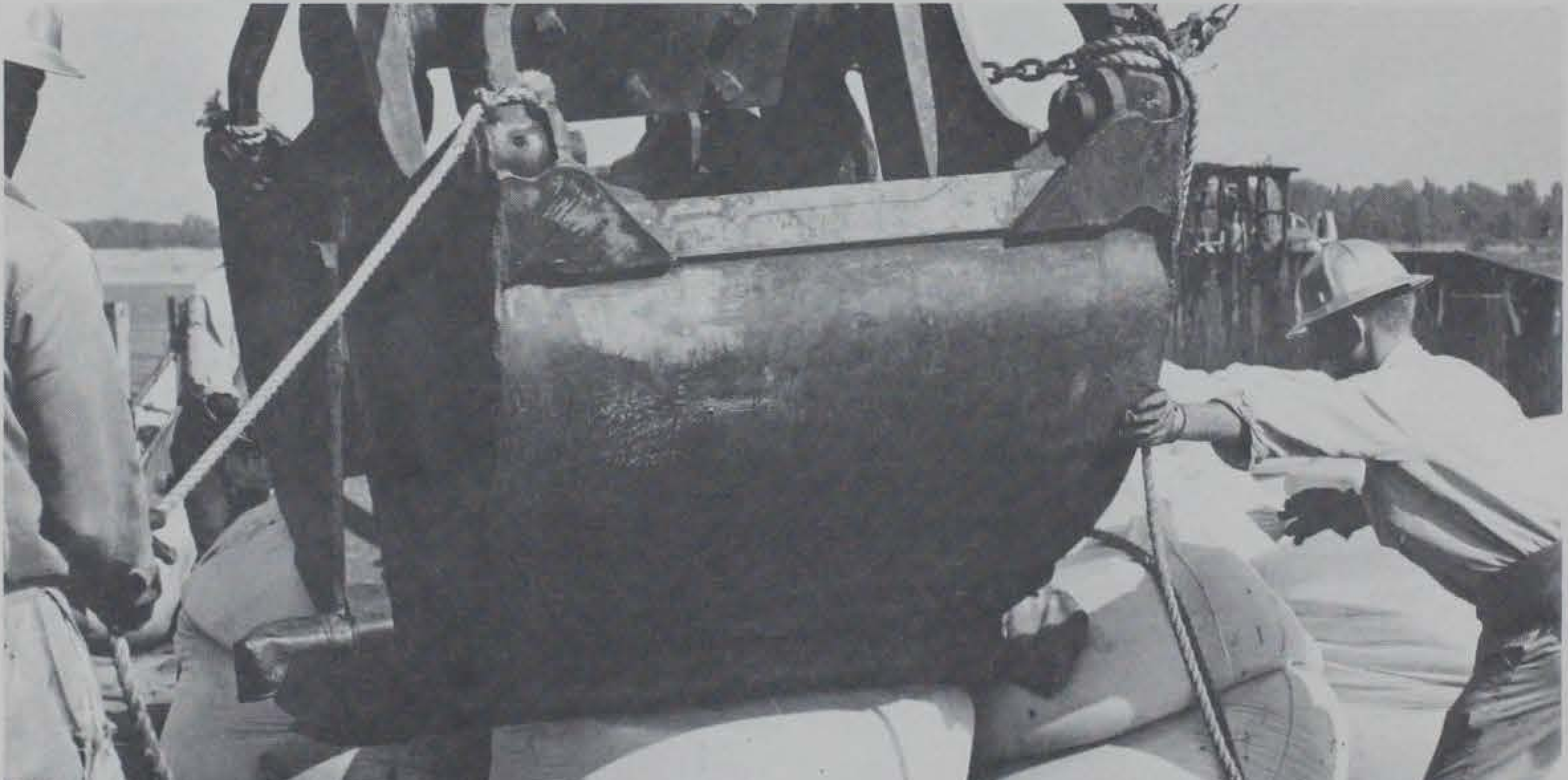
Photograph 9. Two methods used in applying clamping device for heat sealing of plastic bags

Photograph 10. Top of plastic bag being sealed by heat from a small propane torch

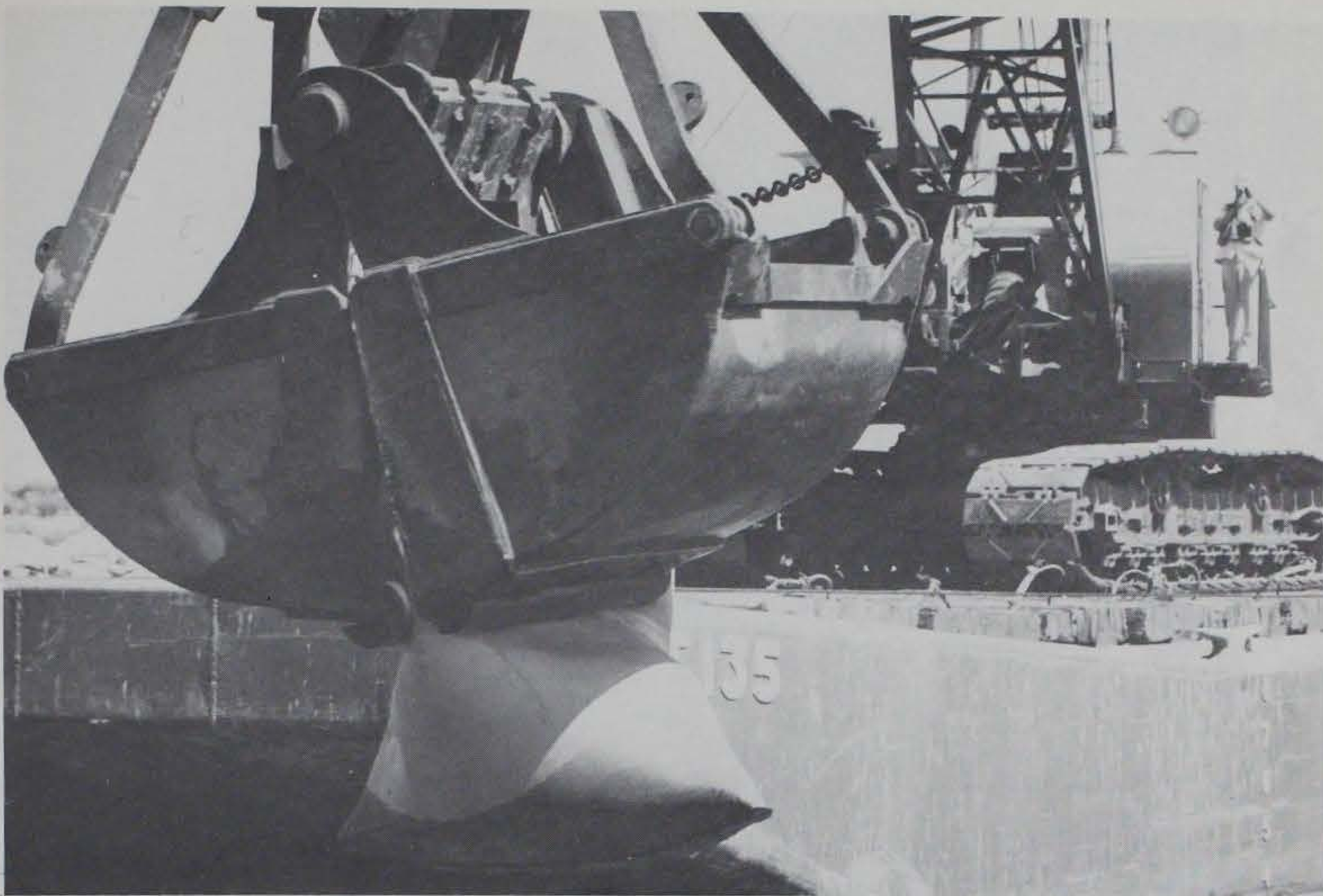
Photograph 11. View showing method used in unsuccessful attempt to sew plastic bags.
Also method of tying bags



Photograph 12. Dike No. 1 looking riverward along dike line to section where nylon and plastic bags are to be placed. Note stone base extending 400 ft beyond completed portion of dike to experimental section



Photograph 13. Bucket being positioned for picking up nylon bag from barge



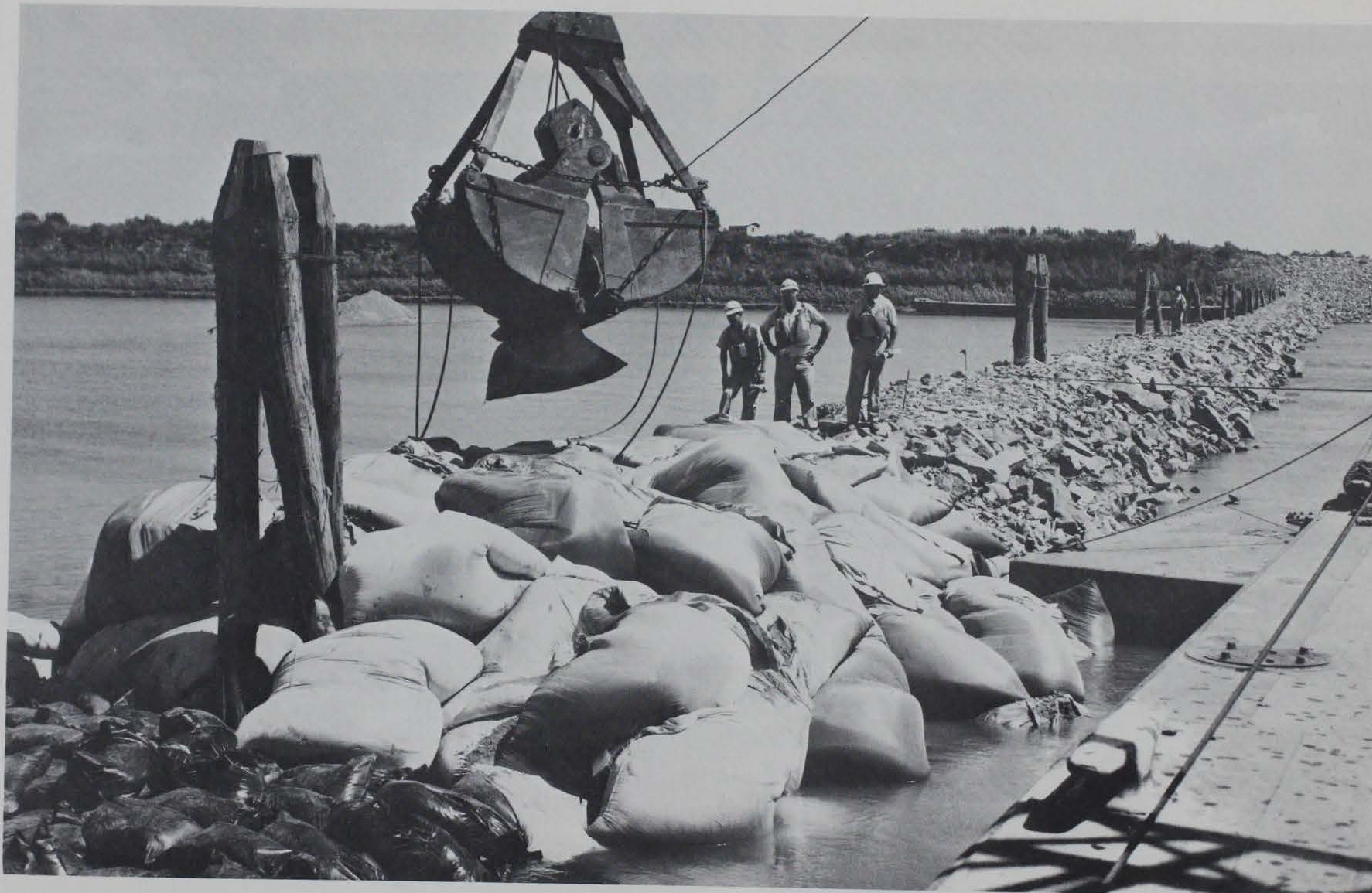
Photograph 14. Clamshell preparing to place nylon bag underwater during placing of 4-ft-thick base of dike

Photograph 15. Looking riverward, nylon bag being released into water during placing of base of dike

Photograph 16. Workers loading plastic bags into skip bucket

Photograph 17. Skip-bucket load of plastic bags being lifted from barge by dragline. About 25 bags per load

Photograph 18. Load of plastic bags being dumped in base of dike



Photograph 19. Looking landward, from below dike line. Nylon bag test section nearing completion

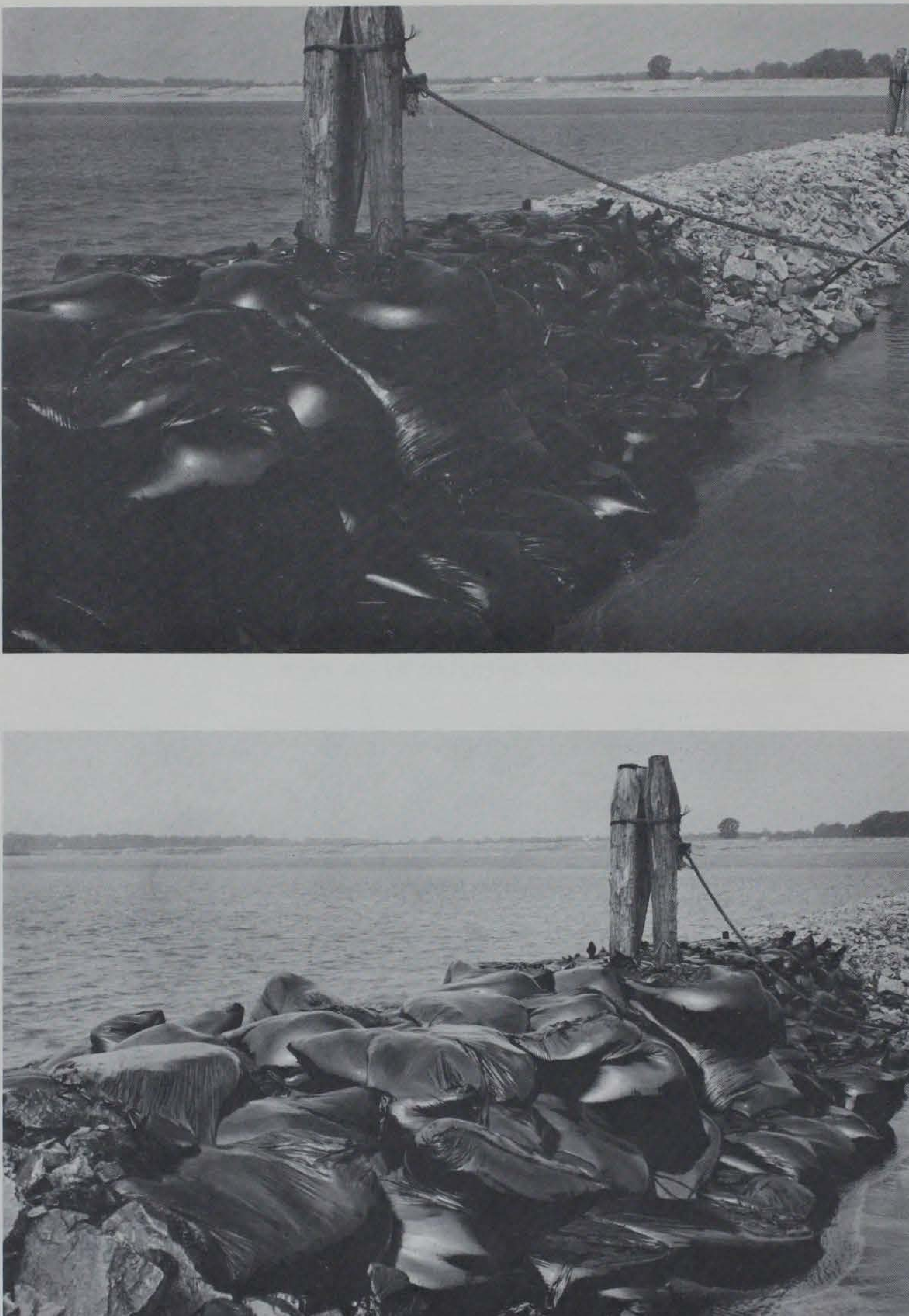
Photograph 20. View looking landward from below dike line. Workmen are hand-placing plastic bags

Photograph 21. Nylon bag portion complete to final grade (+8 ALWP)

Photograph 22. Looking landward from below dike line. Test section complete except for coating of nylon bags

Photograph 23. View showing tank, compressor, and flexible hose to be used for spraying nylon bags

Photograph 24. Spraying nylon bags with coal-tar emulsion



Photograph 25. Downstream views of completed nylon and plastic bag section

Photograph 26. Looking upstream, showing profile of damaged bag dike

Photograph 27. Looking landward, showing damaged crown of bag dike

Photograph 28. Looking riverward, showing damage to both nylon and plastic bags. Note how plastic bags have shifted downstream

Photograph 29. Upstream profile of damaged nylon bags

Photograph 30. Damaged nylon bags from which fill material has been lost

Photograph 31. Damaged plastic bags from which fill material has been lost

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1		Silty Sand		D_{10}= 0.014		
		Density = 89 Lb per Cubic	Foot			

Project Forked Deer Dikes

Dike No. 1

Area Material Out of Borrow Pit on Wolf River

Boring No.

Date

GRADATION CURVES

PLATE I

ENG FORM 1 MAY 63 2087 REPLACES WES FORM NO. 1241, SEP 1962, WHICH IS OBSOLETE. (TRANSLUCENT)

C 0436


CORPS OF ENGINEERS
U.S. ARMY
OPEN LAKE
T E N N E S S E E
L A U D E R D A L E C O U N T Y
LOWER FORKED DEER RIVER
1962 A.L.W.P. = 217.0 M.S.L.
DIKE NO. 1 AZ. 143° 15'
DIKE NO. 2 AZ. 143° 15'
FORKED DEER DIKES
NOTE: EXPERIMENTAL NYLON AND PLASTIC BAG DIKE SECTION
TOP BANK 22 MAY 1964
ISLAND
25
REVET.
Sounded May 1964
Sounded May 1964
ISLAND
26 & 27
CURRENT
20'
6'
1 on 1 1/4 Slope
1 on 1 1/4 Slope
18" THICK
TYPICAL STONE DIKE SECTION
NOTE: Contours are referred to Average Low Water Plane.
L A U D E R D A L E C O U N T Y
T E N N.
A R K.
M I S S I S S I P P I C O U N T Y
ISLAND NO. 25
CANADIAN REACH
LAUDERDALE COUNTY
MISSISSIPPI COUNTY
FORKED DEER ISLANDS NO. 26 & 27
VICINITY MAP
SCALE OF MILES
TENNESSEE
ARKANSAS
LOCATION OF DIKES
LAUDERDALE COUNTY
TIPTON COUNTY
MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT-MEMPHIS
POTAMOLOGY STUDY
GENERAL MAP
FORKED DEER, TENN.
MAY 1965
SERIAL 60567
FILE 60/288

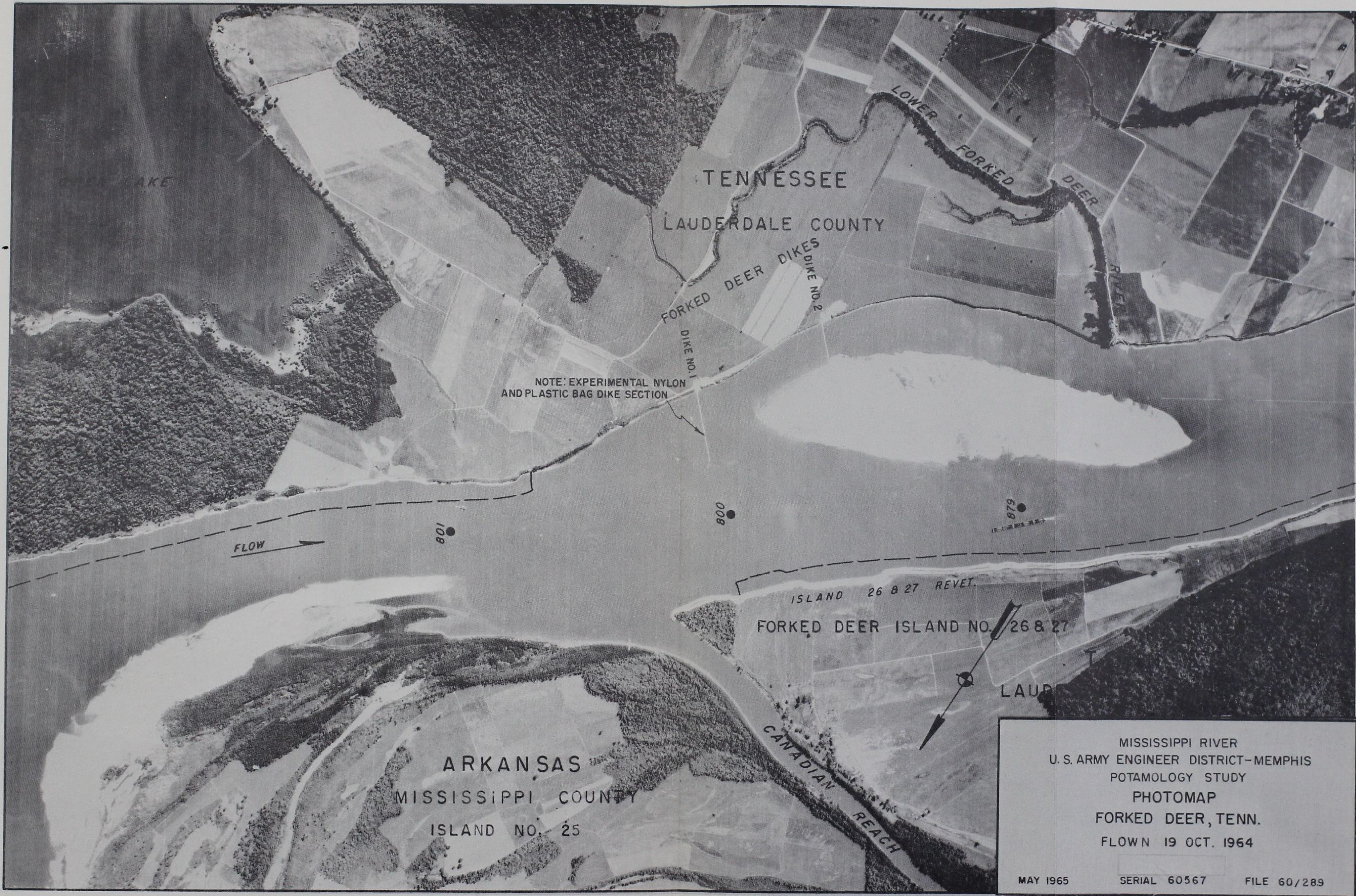

TENNESSEE
LAUDERDALE COUNTY
LOWER FORKED DEER RIVER
FORKED DEER DIKES
DIKE NO. 2
DIKE NO. 1
NOTE: EXPERIMENTAL NYLON
AND PLASTIC BAG DIKE SECTION
801
800
879
FLOW
ISLAND 26 & 27 REVET.
FORKED DEER ISLAND NO. 26 & 27
LAUD
ARKANSAS
MISSISSIPPI COUNTY
ISLAND NO. 25
CANADIAN REACH
MISSISSIPPI RIVER
U. S. ARMY ENGINEER DISTRICT-MEMPHIS
POTAMOLOGY STUDY
PHOTOMAP
FORKED DEER, TENN.
FLOWN 19 OCT. 1964
MAY 1965
SERIAL 60567
FILE 60/289

PLATE 3

PROFILE OF BAG DIKE SECTION

NOTE: (1) CAPACITY OF NYLON BAG - 1.0 CU. YD. (APPROX)
(2) CAPACITY OF PLASTIC BAG - 0.1 CU. YD. (APPROX.)

MISSISSIPPI RIVER
U. S. ARMY ENGINEER DISTRICT - MEMPHIS
POTAMOLOGY STUDY
PROFILE OF BAG DIKE SECTION
FORKED DEER, TENN.

MILE 800-L
MAY 1965 SERIAL 60567 FILE 60/290

CORPS OF ENGINEERS U. S.

MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT — MEMPHIS
POTAMOLOGY STUDIES
PROFILE & CROSS SECTION
FORKED DEER, TENN.
MILE 800 L

JAN. 1966 SERIAL 60567 FILE 60/29

PL

OF ENGINEERS U. S. ARMY

MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT — MEMPHIS

POTAMOLOGY STUDIES

PROFILE & CROSS SECTION
FORKED DEER, TENN.
MILE 800 L

JAN. 1966 SERIAL 60567 FILE 60/291

LEGEND

- --5-- Survey of Oct. 1964 (After Construction)
- ~5~ Contours Indicating Changes as of Survey of Aug. 1965

Notes: Elevations are referred to Mean Sea Level.
Contours are referred to Average Low Water Plane.

MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT — MEMPHIS

POTAMOLOGY STUDIES
DIKE PLAN
FORKED DEER, TENN.
MILE 800 L

JAN. 1966 SERIAL 60567 FILE 60/292

LEGEND

—5— Survey of Oct. 1964 (After Construction)

—5— Contours Indicating Changes as of Survey of Aug. 1965

Notes: Elevations are referred to Mean Sea Level.
Contours are referred to Average Low Water Plane.

MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT—MEMPHIS

POTAMOLOGY STUDIES
DIKE PLAN
FORKED DEER, TENN.
MILE 800 L

JAN. 1966 SERIAL 60567 FILE 60/292

CORPS OF ENGINEERS

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MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT MEMPHIS

POTAMOLOGY STUDIES

STAGE HYDROGRAPH
FOR H. W. GAGE 152
MILE 783.5

JAN. 1966 SERIAL 60567 FILE 60/293

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Study of Materials in Suspension, Mississippi River; T. M. No. 122-1	February 1939
Study of Materials in Transport, Passes of the Mississippi River; T. M. No. 158-1	September 1939
Geological Investigation of the Alluvial Valley of the Lower Mississippi River; Mississippi River Commission	December 1944
A Laboratory Study of the Meandering of Alluvial Rivers	May 1945
Fine-grained Alluvial Deposits and Their Effects on Mississippi River Activity	July 1947
Report of Conference on Sand-asphalt Revetment, 12 August 1948	August 1948
Geological Investigation of Mississippi River Activity, Memphis, Tenn., to Mouth of Arkansas River; T. M. No. 3-288	June 1949
Bank Caving Investigations, Morville Revetment, Mississippi River; T. M. No.3-318	September 1950
Investigation of Free Nigger Point Crevasse, Mississippi River; Mississippi River Commission	December 1950
Mississippi River Revetment Studies; St. Anthony Falls Hydraulic Laboratory Project Report No. 21	June 1951
Investigation of Mass Placement of Sand Asphalt for Underwater Protection of River Banks; T. M. No. 3-329	August 1951
Mississippi River Revetment Studies - Tests on a Double Layer Articulated Concrete Mattress; St. Anthony Falls Hydraulic Laboratory Project Report No. 28	May 1952
Potamology Barrel Samples; Miscellaneous Paper No. 3-9	August 1952
Torsion Shear Study; Miscellaneous Paper No. 3-10	August 1952
Study of Variability of Sand Deposits; Miscellaneous Paper No. 3-12	August 1952
Flume Investigation of Prototype Revetment; Miscellaneous Paper No. 2-35	September 1952
Investigation of Bituminous Cold Mixes for the Protection of Upper River Banks; T. M. No. 3-362	April 1953
Feasibility Study of Improved Methods for Riverbank Stabilization; Contract Report No. 3-81 by Harza Engineering Co.	November 1964

* Unless otherwise noted, all reports listed are publications of the Waterways Experiment Station.