UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

HYDRAULIC STUDIES OF FISH COLLECTING FACILITIES - DELTA-MENDOTA INTAKE CANAL CENTRAL VALLEY PROJECT, CALIFORNIA

Hydraulic Laboratory Report Hyd-410

DIVISION ENGINEERING LABORATORIES

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HYDRAULIC STUDIES OF FISH COLLECTING FACILITIES DELTA-MENDOTA INTAKE CANAL--CENTRAL VALLEY PROJECT, CALIFORNIA

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Commissioner's Office--Denver
Division of Engineering Laboratories
Hydraulic Laboratory Branch
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HYDRAULIC STUDIES OF FISH COLLECTING FACILITIES DELTA-MENDOTA INTAKE CANAL--CENTRAL VALLEY PROJECT, CALIFORNIA

PURPOSE OF STUDIES

The purpose of these studies was to evaluate the hydraulic performance of various features of fish collecting facilities in the Delta-Mendota Canal headworks and to improve their operation by modifications wherever called for. The structures involved play a vital part in preventing destruction of large numbers of game fish which otherwise would be drawn into the pumps at Tracy Pumping Plant.

SUMMARY

The purpose of this report is to assemble the results of the studies made in the Hydraulic Laboratory during 1955. The report consists of three main parts: the first deals with a model on 1:20 scale of the intake canal structure at Old River, including trashracks, trashramp, transition sections, and louver and fish bypass sections. Considerable lengths of topography upstream and downstream of the structure were studied for erosion. The second part is concerned with a 1:4 scale model of one fish bypass in the line of guide louvers below the transition section. The third part is devoted to studies of various proposals for sensing velocities at critical points within the collecting facilities.

This report may be considered as supplementary to Hyd-401, "Field and Laboratory Tests to Develop the Design of a Fish Screen Structure--Delta-Mendota Canal Headworks--Central Valley Project, California," in that the tests reported herein were performed on designs developed as an outgrowth of studies described in that earlier report.

CONCLUSIONS

Canal Headworks

Model tests of the canal headworks showed that the preliminary design functioned well. Minor eddies formed upstream of the wing walls when the original topography was in place and erosion of a considerable area took place upstream of the structure. However, after revised topography was installed, the left wing wall replaced by a trash-ramp, and the angle of the right wing wall changed to intercept the flow at a point upstream of the main structure, only a small eddy remained at the ramp and erosion in the approach channel was reduced greatly by the improved alinement. The improved flow condition of the modified design reflects the results of these changes as well as changes in the curves of the transition section.

Fish Bypass

Though the fish bypass model operated satisfactorily without guide vanes, the additon of vanes did work to reduce the range of velocities encountered within the bypass from water surface to channel bottom. Curved vanes have the advantage over angled ones in that fewer areas are susceptible to eddy formation; also, the flow of water was inclined to maintain its new course after traversing the curved vanes whereas with the angled vanes the direction of flow became a compromise between the original path and the desired one.

Velocity Control Device

No recommended velocity-sensing device was developed from the tests conducted. However, important steps toward the elimination of unsatisfactory devices were taken by means of actually testing or through library research and several ideas which are worthy of future consideration were discovered. The background needed for the pursuit of more productive studies was thus gained and is available should the need for a velocity-sensing device be demonstrated by operation of the completed structure.

ACKNOWLEDGMENT

The investigations reported herein were done in cooperation with the Canals and Headworks Section of Canals Branch. Much valuable assistance was rendered in studies of velocity-sensitive control devices by the Hydraulic Machinery and Mechanical Branches.

INTRODUCTION

One of the major features in the Central Valley Project is the Tracy Pumping Plant located some 9 miles northwest of Tracy, California, Figure 1. Here a maximum of 5,400 second-feet of water can be pumped into the Delta-Mendota Canal from an intake canal fed by Old River. Water reaching the pumping plant is supplied from two main sources, the Sacramento River, with Shasta Dam providing storage, and the San Joaquin River. The supply from Shasta Dam flows down the Sacramento River to the Delta Cross channel, a short man-made canal connecting the Sacramento with Mokelumne River. The latter stream flows to the San Joaquin River in a southerly direction and the flow makes its way a short distance up the San Joaquin to the junction with Old River and thence south to the pumping plant. San Joaquin River flow reaches the pumping plant through the junction with Old River north and east of the plant and through Middle River.

The Sacramento and San Joaquin Rivers join some 50 miles east of San Francisco to flow into the Pacific Ocean. They are therefore under the influence of tidal fluctuations, as are the interconnecting channels which thread in all directions through the Delta formed by their confluence. In a lunar day the tide reaches four stages, and at the pumping plant a mean tide range of 4 feet may be expected. Any structure in the intake canal to the pumping plant must be designed to operate satisfactorily with an ever-varying water surface level.

Since both supply streams empty into the ocean the variety of marine life in the Delta directly reflects this connection. Fish are hatched in great numbers in the rivers and migrate toward the ocean when only a few days old. They move in the direction of net transfer of water, i.e., in a complete tidal cycle in which the flow alternately opposes and supplements natural downstream flow, the fish will follow in a direction indicated by the algebraic sum of upstream and downstream flows.

The natural direction of flow in Old River is west from the San Joaquin to the point of diversion near Tracy Pumping Plant, and then north to a junction again with the San Joaquin River. With operation of the plant even at one-quarter capacity, however, the northern flow becomes southern toward the plant while that to the west is unchanged. The result of this reversal is that fish which formerly migrated northward toward the ocean in the north-south leg of Old River now are drawn southward toward the pumping plant, feeling as they apparently do that the flow leads to the ocean.

Hydraulic Laboratory Report No. 401 contains some estimates of the number of fish that become involved. It is estimated that the total number of fish affected by operations of Tracy Pumping Plant is 4,000,000 per year. In this figure are perhaps 10 to 15 percent of the striped bass, a game fish hatched in the upper Delta. During tests in 1954, the number of striped bass alone reaching the pilot fish screen structure at the site for permanent fish collecting facilities was 36,300 on July 5. A greater number may be expected for full capacity of the pumping plant since the above count was obtained during operations at two-thirds capacity. These figures are given here to illustrate the need for providing means to protect the fish and to justify the extensive facilities and tests which are and have been required to accomplish the task.

Certain design criteria based on the natural swimming habits of migratory fish were established by the Fish Advisory Council composed of representatives of the Bureau of Reclamation, Fish and Wildlife Service, and the California Department of Fish and Game. These criteria served as guideposts for the design and hydraulic studies covered in this report.

The design problem reduced to its simplest terms is to divert the fish from the intake canal to holding tanks and then to transport them by tank-truck to areas away from the pumping plant from whence they may find their way to the ocean or to safer habitats. The schemes devised to do this are far from simple; they will be briefly described here with the aid of Figure 2. Tests in 1954 led to the decision to use a system of louvers and bypasses to gather the fish for collection in holding tanks. The system is shown downstream of the trashracks and transition.

The louvers consist of steel slats 2-1/2 inches wide, 5/16 inch thick, and 22 feet high, with 2 inches clear spacing. They are placed perpendicular to the flow and extend completely across the channel. The line of louvers is at an angle of 15 degrees with the channel sides. Equally spaced along the line of louvers are four bypasses into which the fish are drawn. The front opening is 6 inches wide for full depth. As the fish approach the louvers they feel the disturbance caused by them and, depending on the velocity of approaching water, the fish orient themselves more or less normal to the line of louvers. In this position they continue downstream along the louvers until being drawn into a bypass in which a velocity somewhat higher than the approach velocity is maintained. Once in the bypass the fish are conveyed by closed conduit to the secondary louver structure. Here the fish are deflected again by louvers toward a bypass which feeds any one of four holding tanks. The maximum rate of flow in the primary bypasses which feed the secondary louver structure is 140 second-feet, while that from the secondary bypass to the holding tanks is 35 second-feet.

CANAL HEADWORKS

Preliminary Design

Description of Model. The first study in this series of investigations was conducted in a large model of the intake canal structures and adjacent river topography on a scale of 1:20. Figure 3 shows the features included in the preliminary tests.

The length of the integral head- and tailbox was approximately 100 feet and the maximum width of any section was 24 feet. Construction of the model departed from the usual method in that no sheet metal was used for bottom or sides. The joists and studs were covered with 3/4-inch plywood sheets. Each sheet was joined on all sides to adjacent ones by splined joints coated with rubber cement. Size of the box was conveniently layed out so that full sheets were used, except for the sides where half sheets were adequate. A wooden fillet was added between floor and side walls. Plywood surfaces were heavily coated with plastic paint. Joints received special attention from a plastic-fiber-glass mixture. The resultant surface was very hard, would not peel off the wood, and could be scuffed badly by sand underfoot without developing leaks. Differential settling produced some cracks and leakage at the fillets; this could have been avoided by using a wide canvas strip or glass cloth saturated with plastic paint over the fillet since canvas would have been flexible enough to withstand movement without tearing.

Boundaries of land masses were constructed of metal lath and mortar, Figure 4. In this view the model is seen before sand contours were placed. The topography was laid out with grease pencil on the floor of the box. Rods of various heights cut from brazing rod material can be seen in the foreground. These were cut for the proper sand depth at the position in which they were mounted. A small block of wood glued to the floor held them in place. About 44 cubic yards of sand were required to represent the topography.

A closeup of the structures portion of the model is shown in Figure 5(A). Here are seen wing walls, trashracks, transition section, the line of louvers, and the training walls. Downstream is the canal section leading to Tracy Pumping Plant. Both the trashracks and the line of louvers were constructed of 1/4-inch hardware cloth. No attempt was made in the use of the cloth to produce head losses to the model scale.

Model Operation. In all tests, maximum discharges of 4,860 and 5,065 second-feet, corresponding to 6-pump operation at Tracy Pumping Plant, were assumed for water stages which varied between elevations +2.0 and +6.0, respectively. These limits represent average tidal fluctuations.

It can be seen in Figure 3 that a line running along the deepest part of the approach channel, in the direction of flow, intersects the structure to the right of center. As might be expected a disproportionate share of the flow travels this route. Evidence of this fact is shown in Figure 5(B) where foam which was following the main body of flow was carried to and through Bays 4 and 5 of the trashracks, at water surface elevation +2.0. Some improvement might be expected for operation at water surface +6.0, but in Figure 5(C) foam collected in Bays 1 and 2 showed little tendency to go through the racks, indicating that there was still a relative concentration of flow in Bays 3, 4, and 5.

The appearance of the upstream water surface for operation at elevations +2.0 and +6.0 is compared in Figure 6(A) and 6(B). Both conditions are good, but smoother flow along the right bank at the higher water surface is obvious in the latter figure. There was little difference in appearance of the water surface for either operating level in the channel downstream, Figure 6(C).

In the vicinity of the wing walls upstream of the trashracks, very slowly rotating eddies were formed. Their presence affected the entrance of water into the trashrack section so that the principal direction of flow at the right of Bay 5 and at the left of Bay 1 was deflected on a small angle toward the center of the channel. Also, boundary flow in the transition section separated from the channel sides just upstream of the points of tangency of the downstream curves, causing components of flow toward the channel centerline. Attempts were made in later studies to improve these conditions.

Erosion. Figures 7(A) and (B) show the sand movement following operation with water surface +2.0. Fresh rake tine marks can be compared with the original ones made during placing of the sand. In 7(A) the greatest sand movement took place along the right side of the main upstream approach channel, which was to be expected from the indications in Figures 6(A) and (B). A view downstream, Figure 7(B), reveals virtually no movement of sand; in fact, throughout the series of tests very little restoring of sand contours was necessary in this reach of the model. The original rake tine marks are still visible here. Erosion at the downstream edge of the apron was negligible.

Of primary importance in the operation of the louvers and fish bypasses is the velocity distribution within the canal headworks. Velocity measurements were taken with a Pygmy current meter at six-tenths of the depth from the water surface at the stations shown in Figure 8. The curves show a reasonable distribution at that depth in spite of the fact that surface inspection, Figures 5(B) and (C), and the pattern of sand movement, Figure 7(A), indicate otherwise. Apparently by the time the water reaches the trashracks all but the surface elements of flow have adjusted to a fairly uniform distribution.

The preliminary design of the canal headworks functioned well even without modifications. Since maps of new river topography had been received which necessitated changes in the model, it was decided to make minor alterations in the headworks structures in an effort to improve flow in the transition section and reduce eddy action at the wing walls.

Modified Design

Description of Modifications. During testing of preliminary designs in the model, a new topographic map of the reach upstream of the headworks was received. Depths in the approach channel were greater and the principal line of flow had shifted to a position more in line with the centerline of the headworks. Both changes were favorable to improvement of flow conditions. When the first structural modifications were made in the model, topographic changes corresponding to the new data were made. Figure 9 shows the modified features and new topography. All downstream topography remained unchanged.

The trashrack piers were lengthened to accommodate a roadway for vehicles and a crane, Figure 10(A). The right wing wall was extended upstream at an angle of 30 degrees with the direction of flow. On the left, the original wing wall was replaced by a large pier and a trashramp. The ramp is at an angle of 35 degrees with the direction of flow. In the transition section, the radius of the downstream curve was increased from 1.9 feet to 4.25 feet model, corresponding to 38 and 85 feet prototype, while the upstream radius remained at 1.9 feet. No alterations were made in the section containing the line of louvers.

Model Operation. Operation of the modified model is shown in Figure 10(B) for water surface elevation +6.0. This view should be compared with that in Figure 6(B). The improvement in flow conditions is the result of topographic changes which allow the water to approach the structure over a wider front more nearly in line with the structure and at a greater depth. Improvement of like magnitude occurred for water surface elevation +2.0. Flow conditions downstream of the structure remained excellent.

The eddy formation noted in tests of the preliminary design was not seen in tests of the modified structure. The flow along the right wing wall was directed toward the trashracks and though the velocity was somewhat slower than that in the main channel it was still of sufficient magnitude to prevent any counterflow characteristic of an eddy upstream along the wall. On the left side of the trashrack structure a small eddy formed over the ramp. It rotated slowly and should not be a source of trouble if one also forms in the prototype.

Some deflection of the surface flow toward the centerline of the structures at the entrance to the trashrack section was still present in the modified design, though to a lesser extent. Also, despite the more gradual curves in the transition section a slight separation remained at the points of tangency of the downstream curves. The increased radius did improve flow conditions at the transition, and no difficulties should be experienced in these areas.

Velocity distribution measurements were made upstream of the line of louvers at six-tenths of the depth from the water surface for two water surface levels, +2.0 and +6.0, Figure 11. The distribution for water surface +6.0 shows that more water travels in the right side of the structure than in the left. The same is true for water surface +2.0 though not to the same extent.

In both the preliminary and modified designs there was evidence of a component of flow along the line of louvers. The use of dye showed the effect most pronounced near the surface but also detectable at some depth. The amount of such flow seemed to be very small.

Erosion. Following tests at water surfaces +2.0 and +6.0, the upstream sand contours were as seen in Figure 10(C). This figure should be compared with Figure 7(A). Note the rake tine marks are still quite prominent. There was some evidence of sand movement midway to the rock baffle at the upstream end of the model and also immediately downstream of the baffle. This washing is more the result of initial flow across the sand in filling the model than erosion caused by operation at either of the test water surface elevations. The model was backfilled in an attempt to eliminate the false erosion pattern with the result that no movement of sand occurred anywhere except immediately downstream of the rock baffle.

It would be quite difficult to predict the location and amount of sand scour or deposition from the model tests. Two areas, however, appear to offer possibilities for such action, and they are mentioned here more in the realm of speculation than as established fact. In the area at the left of the trashracks and immediately upstream of the ramp the flow divides between two courses, one to the pumping plant and the other into a slough. Depending on the divisions of flow, during flood and ebb tides, a bar may deposit at the entrance to the slough. The other area is along the end of the apron downstream of the line of louvers. Here the water will be decreasing in velocity because of the increased section, and any material carried through the structure may tend to settle to the channel bottom.

Eddy action in the modified design was eliminated at the right wing wall and reduced slightly on the left side of the structure. In the transition section deflection of surface flow toward the centerline was reduced somewhat. Credit for much of the improvement in the modified design must go to changes in flow distribution brought about by the new topography. It should be kept in mind that channel characteristics will be continually varying because of tidal action and pumping load, but such variations will probably not be of sufficient magnitude to seriously upset the satisfactory operation present in the modified design.

FISH BYPASS

Description of Model

The second study in this series of investigations dealt with a model of a fish bypass constructed on a 1:4 scale, Figure 12. The rock baffle reduced turbulence and helped insure a good velocity distribution at the entrance of the bypass. The entrance was built a short distance inside the headbox instead of flush with the endwall in an attempt to simulate an intermediate bypass; thus there was water on the left and right sides of the entrance. Flow designated as Q_1, in the figure proceeded into the bypass, through the transitions to circular pipe, and then to the tailbox where a 90-degree V-notch weir was installed for measurement of the rate of flow. Flow shown as Q_2 was able to pass to the left of the bypass entrance through the line of louvers and over a tailgate and return to the supply sump. A similar discharge should also pass on the right of the entrance if there were to be true representation of an intermediate bypass; however, it was desirable to view the flow in the bypass through a plexiglas window which formed part of the right side wall, and such flow would have made visual observation impossible. Since a steel baffle extended a considerable distance upstream from the right edge of the entrance, it was felt that the entrance conditions were not too dissimilar from those in an intermediate bypass. The baffle was made in two vertical sections to enable varying the length upstream of the entrance.

Discharges at the two operating limits of water surface elevation +2.0 and +6.0, were supplemented by the amount Q_2 which passed to the left of the bypass. Figure 13A is a general view of the model test sections. In part B of this figure can be seen the transitions at the outlet of the bypass and in part (C) the 90-degree V-notch measuring weir. Within the tailbox on the circular pipe outlet a slide gate was used to create back pressure on the system; by this means the water surface elevation was adjusted to agree with the attendant discharge. Minor adjustments were made at the tailgate controlling Q_2.

Figure 12 shows the location of the ports through which a pitot cylinder was entered for velocity measurements. The cylinder utilized was a standard two-hole instrument, the angle between the holes being 78-1/2 degrees. Each hole was connected by tubing to a glass manometer. When the cylinder is turned so that the heads in the manometers are equal, then the direction of flow must bisect the angle between holes, and the static head is indicated. Turning the cylinder to obtain a maximum rise in one or the other of the manometers gives the stagnation point pressure. The difference in the respective heads is the velocity head.

A dye injection system was installed just upstream of the bypass entrance. The elevations of the dye outlets corresponded directly to the elevations of the pitot cylinder ports numbered 1 through 7. A manifold supplied the aqueous dye to each outlet through plastic tubing. Each tube was clamped so that one or more could be opened at any time. Congo red dye gave the best results for photographic purposes.

Model Operation

Two principal means were employed in evaluating the performance of the bypass structure and modifications thereof: determination of velocity distribution with the pitot cylinder, and Pygmy current meter and visual comparison of flow patterns with the use of dye.

The ideal velocity distribution would prevail when velocities at pitot stations 1-7 were equal and a similar uniformity existed at pitot station 10-14. Dye clouds would then show a gradual change in flow direction at all sections of the bypass from vertical to horizontal. Such conditions are virtually impossible to attain from any other than a theoretical standpoint; an approximation may be gained but only after extensive tests on guide vane shapes and spacings.

The results of these studies are best described with the numerous plots of velocity distribution and photographs which follow. In all tests the velocity of flow in the bypass was maintained higher than the approach velocity, in accordance with findings in Hyd-401.

Flow Conditions Without Vanes

The first series of tests was made with no flow guide vanes within the bypass. The preliminary design included vanes, but in order to have an operating base with which to compare vane designs, none were used initially. Velocity distribution without regard to directions of flow are shown in Figure 14 for water surface +1.9 and +6.0. For simplicity, velocities at Ports 8 and 9, Figure 12, are not shown. The range of velocities is about 1 to 2.5 feet per second for pitot Stations 1-7. As the flow is guided toward the transition sections, the distribution pattern changes to that shown by pitot Stations 10-14. For Stations 11-14, velocities are reasonably uniform, but at Station 10 the velocity is much below the average of the others. The components of flow along the floor of the bypass apparently do not change direction as rapidly as necessary to raise the velocity at Station 10 to a value comparable to those at the other stations. In other words, the higher velocity water shoots across the region of Station 10, changing direction in the vicinity of Station 11.

Dye patterns indicating flow direction are shown in Figure 15 for a water surface +6.0. In (B), (C), and (D) the direction of flow has begun to change upstream of the pitot stations. In (D) the flow seems directed principally toward Stations 12 or 13, thus lending support to the indications from the velocity measurements referred to above. There is an appreciable pocket of slow moving, eddying water which is shown in (A) by the dye cloud. The cloud tends to cling to the downstream sloping boundary in passing toward the transitions which form the outlet to the bypass. The dye eventually clears out of this region but only after considerable delay and mixing with water in the adjacent zone.

Model head losses were measured between the water surface upstream of the bypass and a point just downstream of the transition to the circular pipe where a water manometer was installed. The difference between the water surface elevation upstream of the bypass and the total head (velocity plus pressure) at the manometer indicated a head loss of 0.145 foot for water surface elevation +2.0, discharge of 0.82 second-feet, and 0.15 foot for water surface elevation +6.0, discharge of 0.91 second-feet.

Because of the undesirable eddy formation within the bypass and the unequal velocity distribution in the transition, the investigation continued toward improvement of the flow conditions by the use of vanes.

Flow Conditions With Angled Guide Vanes

Three styles of guide vanes were studied in the tests that followed, Figure 16. The angled vanes were used at six positions in one series of tests. Both curved designs were used in the next series, in groups of three, to shorten testing time.

Distribution of velocity with angled guide vanes in place is shown in Figure 17 for a station 1 foot upstream of the bypass entrance, and for Pitot Stations 1 to 7 and 10 to 14. The velocities upstream of the entrance were measured with a Pygmy current meter. Curves for both water surface elevations were quite similar. In a comparatively short distance the velocity pattern changed to that shown for Pitot Stations 1 to 7. If the velocity at Station 1 for water surface +6.0 is momentarily ignored, the range of velocities for Station 2 to 7 was 1.4 to 1.9 feet per second. This is quite an improvement over the range of 1 to 2.5 feet per second prevailing when no guide vanes were used. The relatively high velocity at Station 1 is thought to be caused by the vane shape and arrangement in this particular setup; the vanes probably have a backwater influence on those elements of flow beneath the top vane but exercise little restraint on the flow above that vane. Some support of this contention is found in the distribution shown for water surface +2.0.

The velocity distribution for Pitot Stations 10 to 14 has also been altered by the vanes, Figure 17. The lowest vane forces the water in the floor region to change direction while accelerating to Station 10. The acceleration is caused by the restricted area between the floor and vane. Guiding the water has resulted in a decrease in the quantity flowing along the downstream sloping boundary, as seen by the velocity at Pitot Station 14; the range of velocities at Stations 12 and 13, however, was somewhat greater than those which prevailed without vanes.

Dye patterns for flow through the angled guide vanes are shown in Figures 18 and 19, for water surface +6.0 and +2.0, respectively. In both figures the main body of the dye seemed to travel much the same route as when no vanes were used; however, there was a downward dispersion of the dye from the point of the break in the vane which was not apparent before. Note that the lower tip of the vane did not extend down to the elevation of the horizontal portion of the vane beneath it, Figure 12. Comparing Figure 15(A) with Figure 18(A), in the region above and downstream of the top vane, the zones of eddying were about the same size; in terms of persistence, though, the dye cloud disappeared quicker in the setup with angled vanes.

The model head loss for discharges of 0.82 and 0.91 cfs corresponding to water surface elevations +2.0 and +6.0, was 0.17 feet.

This being only about 0.02 feet higher than that when no vanes were in place, the increment represents the loss chargeable to the vanes alone.

The use of angled guide vanes brought about sufficient improvement in flow distribution to suggest one further step, curved guide vanes. Distribution around Pitot Stations 10 and 11 was noticeably better and a gradual change in flow direction was accomplished, although it did not remain stable after passing beyond the vanes. A curve in the vane design would eliminate an eddy area created at the break point in the angled guide vanes and seemed to promise a more stable, maintained direction of flow.

Flow Conditions With Curved Guide Vanes

Distribution of velocity with curved guide vanes, Figure 16, is shown in Figure 20 for a station 1 foot upstream of the bypass entrance, and for Pitot Stations 1 to 7 and 10 to 14. The upstream distribution was not appreciably different from that obtained with angled guide vanes. The patterns for Pitot Stations 1 to 7 and 10 to 14 improved over those when angled guide vanes were used. The range of velocities for Stations 1 to 7 and water surface +6.0, 1.8 to 2.7 feet per second, was somewhat greater than with angled guide vanes; velocity at Station 5 was the offender in making the range as great as it was, but considering the trend as indicated by Stations 1 to 4, it was accepted.

The velocity distribution for Stations 10 to 14 was somewhat better with the curved vanes than the angled ones in that variations from point to point were less pronounced. In both curved designs the downstream tip was at least low enough to equal the top elevation of the vane below, and in the case of the lower trio of vanes, the tip was extended slightly below that elevation, Figures 16 and 21. So constructing them prevented a horizontal component of flow from passing in a near-straight path between the vanes, as happened with the angled vanes. The ability of the curved vanes to change the direction of flow gradually to a new maintained course is principally responsible for the pattern at Stations 10 to 14. This is particularly evident at water surface +2.0, Figure 20.

The effect of making the flow in the vicinity of the sloping boundary slower than that near the vanes is accentuated by curved vanes, following a trend first seen with the angled vanes. As the ideal situation the pattern at Stations 10 to 14 would show a uniform velocity at all points, but such a distribution cannot be obtained from vanes set at equal spacing in this bypass. The benefits to be derived from properly spaced vanes were not considered worth the necessary research cost, nor would time permit such studies.

Dye patterns for flow through the curved guide vanes are shown in Figures 21 and 22, for water surfaces +6.0 and +2.0, respectively. The performance differs from that with the angled vanes because the redirected flow continues to travel in the direction given it by vanes. This was partly due to a more gradual change in direction, but it was also helped by placing the tip of one vane at or below the elevation of the top of the vane below. No difference in performance between the two curved designs could be detected nor did it appear that reversing the positions of the two trios of vanes would make any operational difference.

In Figures 21(A) and 22(A) the dye clouds continue to show eddies of slowly moving water. The rate at which the clouds disappear with the curved vanes was somewhat higher than in the model without vanes and about the same as with angled guide vanes. The time required was less at water surface +6.0 than at water surface +2.0. Figure 23 shows the clouds that remain shortly after dye injection was stopped, for operation with angled and curved vanes, water surface +2.0.

The model head loss of 0.17 foot for the curved vanes was equal to that for the angled vanes for water surface elevations +2.0 and +6.0.

The use of curved guide vanes showed distinct advantages over angled guide vanes. Eddy action was reduced and the velocity distribution at the entrance to the transitions was more nearly that desired. Spacing the vanes equally should be satisfactory for this installation.

VELOCITY-SENSING CONTROL DEVICES

Operating Criteria

The system of gates, valves, and pumps required to operate the fish collecting facilities is complex. Figure 24 is a simplified drawing of the principal features of this system. Slide gates at A operate the inlet to the secondary louver structure, and a pump and butterfly valve at B control the amount of water in the screened water bypasses. Six pumps in combination with two butterfly valves in the pumping plant, C, at the end of the secondary louver structure, maintain the operating water level within the structure and also the differential level on the slide gates at the entrance.

As stated previously, the velocity of water in the bypasses should be higher than that in the approach channel. This is just as true in the secondary louver structure as in the primary one. To create a differential head and thereby induce the required higher velocity in the single bypass of the secondary louver structure, two additional pumps and a butterfly valve at D work to lower the water level in the holding tanks. As the level in the tanks drops, the velocity in the influent pipeline increases and a velocity conducive to the entrance of fish into the bypass is realized.

Preliminary design criteria called for a completely automatic control system to activate the gates, valves, and pumps. It was felt that only automatic controls could cope with the number of variables involved, such as varying tide stages, changing approach velocities, velocity differentials in all bypasses, and almost innumberable combinations of pumps, and gate and valve openings. The control system which evolved from the above requirements is shown outlined in Figure 25. In this figure the points at which velocity-sensing control devices were required are indicated by (V.C.D.). This generalization was used because the form of the devices was unknown at the time.

The reason for the investigations reported in this part is thus apparent: to devise a means of sensing velocities.

The reader should be made aware at this point that analyses made subsequent to issuance of specifications covering the structures in the fish collecting facilities, showed that the elaborate control system, at first thought absolutely necessary, might be considerably simplified. In fact, in the light of studies made in models at the pilot structure indicating the difference in canal and bypass velocities could be much greater than originally set, it now seems possible that manual operation of pumps, gates, and valves by trained personnel may prove to be adequate. Of the two main sections of the facilities, the primary and the secondary louver structures, the need for controls will probably arise in the secondary louver structure only, if indeed it arises at all. This part of the facilities can be dewatered easily at the close of an irrigation season for installation of velocity-sensing devices.

The conclusion reached from the analyses was to operate the facilities for 1 year without automatic controls. Then, after judging the effectiveness of manual control, an automatic system could be installed to compensate for any deficiencies noted. It is important in the understanding of the material in this part of the report, however, to remember that an automatic system of controls was sought throughout the period of investigations.

To fully understand the functions of a system of controls, let us follow an imaginary fish through the facilities to a holding tank. The velocity of the water approaching the line of louvers may vary from 0.5 to 4.0 feet per second. A fish approaches the line of louvers with his head upstream, and though he appears to be swimming away from the louvers, his resultant motion is downstream with a velocity equal on the average to the algebraic sum of swimming and water velocities. The louvers cause a disturbance which the fish senses, and his reaction causes him to move along the line of louvers while still continuing downstream. Eventually the fish finds himself at the inlet to a bypass, and because of a baffle wall on the right side of the bypass entrance which extends upstream parallel to the direction of flow, his progress along the line of louvers is stopped. If the velocity just inside the bypass is somewhat higher than that in the approach channel--tests show the range of incremental velocities can vary from 0.5 to 2.5 feet per second--the fish will voluntarily enter the bypass and be carried through a closed conduit to the gate valves at the upstream end of the secondary louver structure.

The opening of three of the slide gates at A, Figure 24, would be controlled by velocity-sensing devices in each of three bypasses in conjunction with a fourth such device in the approach channel. The fourth slide gate would be motor operated by manual control.

Velocity of water at the slide gates is a function of water depth in the approach channel, losses in the bypasses, gates and conduits to the gates, and the water depth on the downstream side of the gates. Gate opening and water level in the secondary louver structure can be varied, but only pumping demand and tidal activity influence approach channel water level. Two velocity-sensing devices would be installed at the fourth bypass, one inside and one upstream in the approach channel. These devices would be relied upon to operate the six pumps and two butterfly valves in the pumping plant sump, C. The combination of pumps and valve openings would adjust the water level in the secondary louver structure, thereby setting the velocity across the secondary lines of louvers and, indirectly, in the primary bypasses.

Having entered the secondary louver structure the fish is confronted with two secondary lines of louvers in series, and he is directed along one of those lines of louvers to a secondary bypass. This rectangular bypass, located on the side of the main channel, performs the same function as the primary bypasses, but in construction it is quite different since access may be had at two points, the downstream ends of both lines of louvers. Flow of water at the first point of entrance is forced by screened water supplied 5-1/2 feet upstream at a velocity higher than that in the secondary approach channel. The screened water carries into the first entrance, taking with it some unscreened water and the fish from the first secondary line of louvers. The mixture is conveyed about 19 feet to the area which serves as access from the second line of louvers. Here water and fish must carry across 5-1/2 feet of open channel to the second point of entrance. The latter entrance leads through closed conduits to the holding tanks. The velocity of screened water has gradually decreased as it traversed the route to the second entrance so that an additional aid to assure a favorable velocity differential is desirable. This is provided by pumping water from the holding tanks, creating a differential head between tanks and the second bypass entrance.

Once in a holding tank the fish remains there until transported by tank-truck to safer areas in the Delta.

In the secondary louver structure velocity-sensing devices are required at four points. The velocity at the outlet of the screened water supply, upstream from the first bypass entrance, must be measured together with the velocity in the adjacent main channel. Intelligence from these two units controls the pump and butterfly valve at B, Figure 24. Two additional devices are needed to operate the pump and butterfly valve at D to lower the head in the holding tanks. One would be installed in the bypass just upstream of the second point of entrance, and the other would be positioned opposite the first in the main channel.

All of the controls in the system would act automatically to compensate for any of the variables. To keep them from "hunting" for the most satisfactory combinations of pumps and gate and valve openings, changes would be accomplished in a stepwise manner.

Test Facilities

The initial stage of the velocity control investigations consisted of several meetings to discuss possible solutions to the problem. Some library research preceded the meetings, and at two such gatherings representatives from commercial firms marketing velocity equipment were invited to participate.

Three devices received primary consideration, and they will be discussed in succeeding paragraphs.

The testing facilities, Figure 26, were designed to accommodate velocity-sensing devices which the design branches might submit. Water entered the headbox on the left, Figure 26(A), flowed into the bypass test channel at center, and continued into the tailbox at right where the depth of flow was varied by a tailgate. The test channel was of prototype width, or 6 inches, and was 5 feet high. The setup could pass a maximum of 12 second-feet.

Velocities in the test channel were measured at a station 3.0 feet upstream from the position in which all velocity-sensing devices were mounted. Distributions for two discharges are shown in Figure 27. They are nearly ideal for the purposes of the tests in this investigation.

Buoyant Vane

The design of the buoyant vane shown in Figure 28 was submitted by the Hydraulic Machinery Branch. The vane was rectangular in section, 36 inches high, approximately 16 inches wide, and had a maximum thickness of 3 inches. A small sealed tank in the upper half acts to reduce the frictional force at the bearings. Except for the tank, water had free access to the interior. The vane was pivoted about an axis to permit a maximum projection into the flow of 1 inch at a 15-inch radius. When there was no deflection the front surface was flush with the side of the channel. Trim plates on four sides of the vane box were within 1/16-inch of all edges of the front surface when the vane was flush with the channel side, and upon full 1-inch deflection, this clearance increases but slightly at the downstream vertical edge.

The vane assembly tested was dimensionally the same as that shown on the drawing. To ease fabrication, however, a section of brass tubing was used to form the curve around the axis of rotation, instead of forming 16-gage iron at the proper radius along the upper and lower bearings. This change added some weight to the assembly, but percentagewise the increment was small. Weight of the vane in air was 36 pounds, while the weight in water was 27 pounds, giving a buoyant force equivalent to 9 pounds. Figure 29 shows the vane before assembly. A deflection indicator arm 20 inches long was added to the shaft for the purpose of making torque measurement at various velocities and deflections, Figure 26(B). Along the arm, 14 inches from the axis of rotation, very small flexible wires were attached; these wires ran across the two pulleys shown to two cans below them which held gram-weights used to balance and deflect the vane. A pointer at the end of the arm gave the deflection in fractional parts of an inch as marked on a plate immediately below it. Early tests showed that the arm gave inconsistent readings of deflection, though it could be used as a loading medium. The indicator in Figure 26(C) was then attached through the vane box to the back side of the vane. No. further difficulty was experienced.

With the trim plates in place the voluntary movement of the vane was into the bypass flow, counter to the direction desired. As the bypass velocity increased above 1 foot per second, the vane deflected the full inch allowed, and being restrained, remained at that deflection for all higher velocities. Piezometric pressures measured within the vane box behind the vane showed a slightly higher head than that which prevailed on the front side of the vane in the bypass flow. This is shown in Figure 30 for a velocity of 3.11 feet per second and three vane positions. There apparently was a recovery of some part of the velocity head which produced a pressure differential forcing the vane out of the box. Torque characteristics could not be measured with all trim in place because the differential forces on the vane up to 4 feet per second were less than frictional forces in practical measuring devices.

With the downstream trim plate removed to expose the volume behind the vane to the lower pressure downstream of the vane projection, the device deflected into the box with increasing water velocity, in the more conventional manner. Torque characteristics were measured with this setup. It was discovered that the vane was insensitive to velocities lower than 1.46 feet per second at 1-inch deflection. Consistency in deflections was poor below 2.25 feet per second. The mass of the vane and the enclosed water volume have quite an influence on its ability to react to small changes in velocity as well as to low velocities. The large size calls for rather substantial bearing surfaces; therefore, static frictional resistance to movement at low velocities, or for slight increases or decreases in velocity, is considerable. The mass and the water cushion behind the vane served to damp out flutter which could be produced by turbulence in the bypass.

Figure 31 is a summary of tests to determine torque characteristics of the vane with downstream trim removed. The rapid convergence of the family of curves may be taken as an indication of the lower practicable limit of velocity of this device.

No provisions were made in the preliminary design for any loading mechanism to hold the vane at full deflection for zero velocity since it was not needed for the contemplated tests. Were this design or a similar one to be used at any installation, some means of loading would be required. When the vane is fully deflected, no force from the mechanism can be exerted on it, while at maximum velocity the force must be just great enough to limit vane movement to a position flush with the channel side.

Simple Vane

Hydraulic Laboratory Branch designed the simple vane shown in Figure 32. The vane was 18 inches high, 5.2 inches wide, and was made of 12-gage galvanized iron. The blade was attached to a 1/2-inch diameter shaft. At maximum deflection the plate extended 4 inches across the 6-inch channel, perpendicular to the flow. At minimum deflection the vane lies parallel to the channel side. The lower bearing was a simple pivot and cup unit which could be inverted to prevent collection of water borne debris; the upper bearing consisted of a flat brass plate 1/16 inch thick with a hole for the shaft machined to a diameter about 0.002 inch greater than that of the shaft. The latter bearing is provided as a guide bearing only, therefore the thinness of the plate. A 3- by 3-inch housing, 20 inches high, enclosed the shaft and bearings. Corners of the blade were well rounded to minimize turbulence in those regions. The same deflection indicator arm used on the buoyant vane was rigidly attached to the vane shaft. Rotation in degrees was indicated on a calibrated plate below the pointer. Figure 33(A) shows the simple vane before assembly; Figure 33(B) is a view of the vane assembled with the blade positioned perpendicular to the direction of flow.

In trial runs it became apparent that there was a flow of water through the housing around the shaft. A differential pressure induced water to flow from a region of higher pressure near the upstream face of the vane to a region of lower pressure on the downstream face. Trim plates were installed as close to the vane as possible, Figure 34(A), to reduce flow through the box; so doing limited deflection of the blade from a position perpendicular to flow to that 45 degrees to the flow.

Initial tests showed the vane sensitive to slight changes in velocity and quite consistent in repeating angular deflections for velocities above 1 foot per second. At 4 feet per second the vane was consistent in repeating angular deflections within $\pm 1/2$ degree. From 1 to 1.5 feet per second the vane was consistent within ± 1 degree. It was also remarkably free of flutter, even at higher velocities.

Since preliminary tests gave evidence the simple vane should be explored further, efforts were then directed toward fitting the device with electrical means of indicating vane deflection. To do this an impedance bridge circuit was constructed. Two legs of the bridge were variable potentiometers, while the other two consisted of air-core coils wound on 1-inch outside diameter plexiglas tubing. One of these coils had a straight axis; the other was curved to a 19-inch radius so that an iron core of the same radius and fastened to the indicating arm on the vane shaft could travel into the coil as the vane deflected. A light coil spring was attached to the arm to provide a force in limiting the rotation of the arm. Figure 34(B) shows the assembly so constructed.

As the core penetrated the coil in reaction to vane deflection the bridge became unbalanced, causing a current to flow. Calibration of this current flow in terms of velocity thus was possible. A curve of velocity versus current flow is given in Figure 35. The intersection with the y-axis, together with the average slope of the curve, was taken as the lowest velocity this device was capable of measuring.

Analysis of a computed curve of projected area versus angular displacement for this vane, Figure 36 showed that operating in the 45- to 90-degree range imposed a restriction on the sensitivity of the device at low velocities. Deflection from 90 to 75 degrees would result in a much smaller decrease in projected area than say a deflection from 60 to 45 degrees. In other words, for the same incremental forces applied to the vane at 55 degrees and at 85 degrees, there would be a much greater decremental change in projected area at 55 degrees than at 85 degrees. This fact indicated that the sensitivity of the vane could be improved by working between 30 and 60 degrees instead of 45 and 90 degrees. Doing so would result in a decrease in projected area and force, but a compensating increase in vane size would be possible so as to produce the same area at 60 degrees as was available beforehand at 90 degrees.

As with the buoyant vane no mechanism was designed for loading the simple vane. The spring that was used served only to confine rotation of the arm between limits imposed by the experimental setup. Were the vane to be operated in the 30- to 60-degree range, as suggested above, two opposing springs would probably be called for: one to hold the vane near 60 degrees, no velocity, the tension decreasing as velocity increases; and a second to limit deflection to 30 degrees for the upper limit of velocity, the tension increasing with velocity increase.

The effect on the force of increasing vane size for a velocity of 2 feet per second is shown by the computed curves in Figure 37. Curve A is for the vane tested, curve B is for a vane with a 4- by 8-inch projected area when deflected to 60 degrees, and curve C for one the same width as that tested, but 24 inches long. Comparing curves A and B, there is about a 15-percent difference in forces for any given angular deflection; in the case of curves B and C, an approximate difference of 16 percent. As vane size increases in either dimension, the slope of the curve decreases so that for the same increment of angular deflection there is a correspondingly greater increase in available force.

Magnetic Flowmeter

The Mechanical Branch suggested the use of a magnetic flowmeter. Operation of a magnetic flowmeter is based on Faraday's law of electromagnetic induction; the voltage induced in a conductor moving through a magnetic field is proportional to the velocity of the conductor. In this case the conductor is the water. Designed for pipe flow, the meter tube becomes a short length of pipe in the line through which the fluid to be measured passes. A magnetic field is created with lines of flux perpendicular to the direction of flow. Electrodes are placed on the periphery of the tube with their mutual axis at right angles to both the direction of flow and the flux path. As water flows through the tube lines of flux are cut and a current flow is induced across the electrodes. The flow of current can be calibrated in terms of velocity.

In the field installation, flowmeters would be placed both in the approach channel and in the bypasses. The axis of the tube would be parallel to the flow. By modifying the standard flowmeter in regard to entrance and outlet, a small portion of the total flow would pass through the tube. Head losses would reduce the velocity in the tube to a lower value, than the approach channel or bypass velocities, requiring the meter to be calibrated in place.

Evaluation of the merits of this device was based on several discussions with representatives of the manufacturer and studies with members of the design branches. No laboratory tests were conducted because loan of a device for test purposes could not be arranged. The manufacturing company felt that the instrument was not in the developmental stage nor did it require tests for special uses. Also, even if purchase of one unit had been made, delivery would have come too late to meet certain design schedules.

The flowmeter has a rather bulky shape, Figure 38, and to install it in a bypass would mean bulging the sides considerably. In addition, its form was not conducive to smooth flow so that auxilliary stream lining would be needed to avoid undue disturbance.

Since the water in which it would be used is saline, platinum electrodes would be called for. Even so, frequent cleaning might be required to remove deposits on them. Our experience in the Sacramento-San Joaquin Delta with conductivity cells has proved that even platinum does not withstand chemical attack of saline water for very long. The manufacturer claims there will be no interference with electrode operation as long as the deposit on them is of the same conductivity as the flowing medium. It is hard to imagine when this would be the case. The design of the meter does not lend itself to easy or frequent removal for maintenance.

Magnetic flowmeters are available commercially in sizes from 2 to 24 inches in tube diameter. For our purpose the 4-inch diameter meter was considered the maximum size adaptable. How well this size would sample the flow in a depth of 22 feet is an open question. How susceptible a 4-inch opening is to fouling by moss, twigs, etc., is also a point for concern.

Other Velocity-sensing Devices

The Hydraulic Laboratory has modified a Price Type A current meter for use with a recorder. The electrical pulse produced by the "whisker" in the contact chamber coming in contact with the axle of the meter cups, was fed into a "memory" circuit capable of translating low frequency pulses into a steady output current for a recording milliameter. The output current was easily calibrated in terms of velocity.

The Price Type A meter will operate well over the required range of 0.5 to 4.0 feet per second. It is believed that standard discriminator circuits can be built which would take the inputs from two meters, one in the main channel and one in a bypass, and convert them to a single output which would represent the velocity differential existing between the meters. This output could in turn be the input to a constant-relationship controller.

Installation of this device would probably be the simplest of any considerered. The meter is an accepted means for water measurement, and replacement parts are easily obtained and installed. Experience with it supports the assertion that meter cups and pivots can show considerable wear before the calibration is seriously affected.

Principal objection to its use lies in the belief that it will foul rather easily with the foreign material always present near the pumping plant. The trashracks would eliminate much debris, but concern was felt, with justification, more in regard to moss and tule shoots, which even in short lengths might become entwined on the meter.

One device discussed would make use of twin, opposite torque propellers, of the design used singly on propeller-type open-flowmeters. The pair would work through a gear arrangement so that the resultant torque at the output shaft would represent the velocity differential. To avoid gear friction it was also proposed to investigate the use of the magnetic drive principle of some new propeller meters.

After the close of these investigations, a new means of measuring velocities by the same principle as that utilized in the magnetic flowmeter, came to our attention. The device shows definite possibilities of being adaptable to measuring velocities in restricted areas. As presently envisioned, it consists of an electromagnet and a pair of electrodes mounted coplanar with a channel surface. The flow of water, or the conductor, cuts lines of flux from the magnet, thereby inducing a current flow across the electrodes.

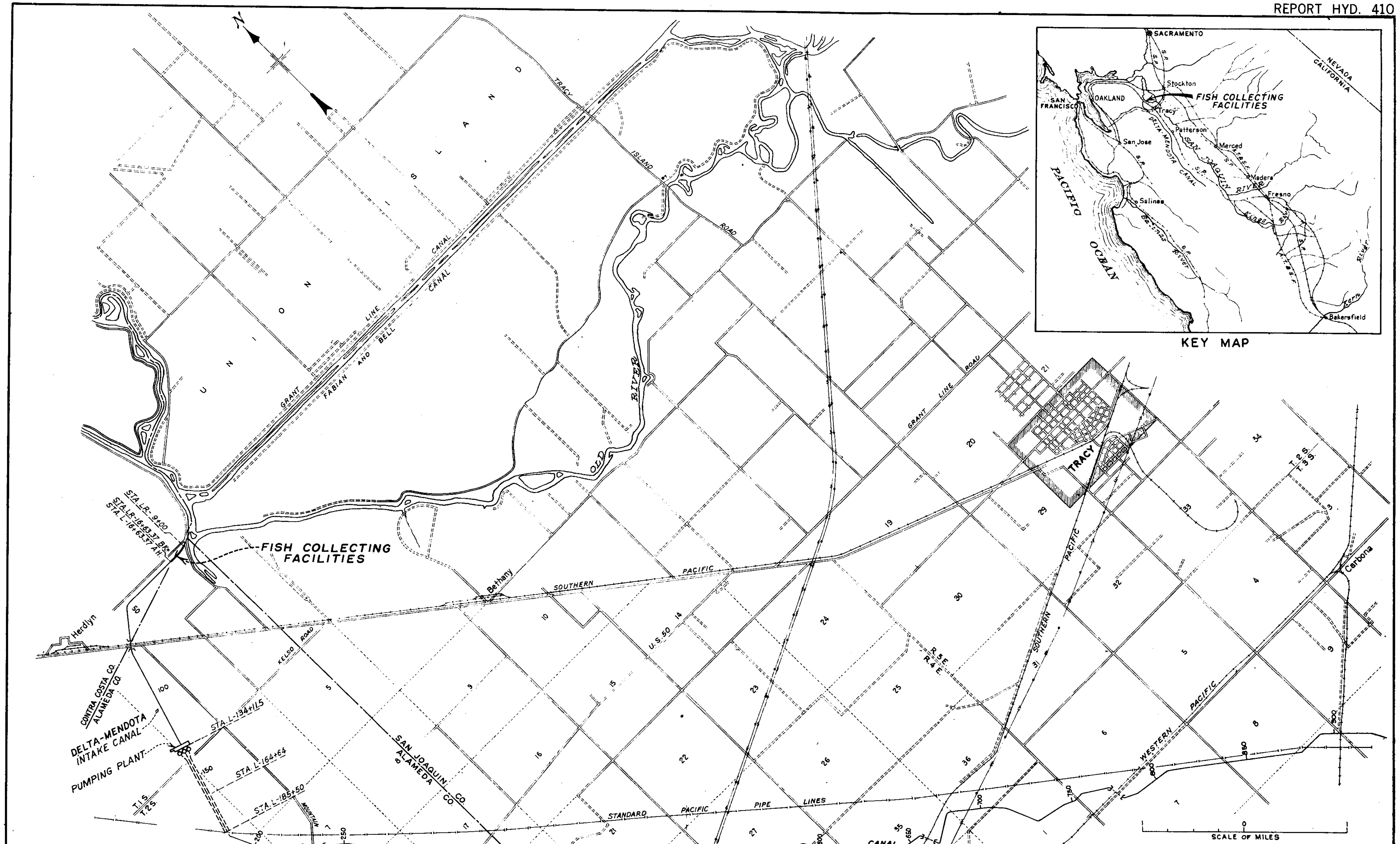
Future Studies

Should a need for velocity control devices develop after a year of trial operation of the fish collecting facilities, several courses of action suggest themselves for future studies.

1. On the basis of experience gained from tests on both the buoyant and simple vanes, a new vane device could be designed which, it is felt, would function satisfactorily below 1 foot per second. Notes on such a design have been recorded.

2. Use of the modified Price Type A current meter for the secondary louver structure could be investigated to determine the probability of fouling in that structure. Its adaptation through appropriate circuits to standard controllers and recorders should also be studied.

3. By the time any need for a device would be known, studies of the new flush-type magnetic measuring device will be underway. Its applicability to the control problem in either the primary or secondary louver structure should be determined.



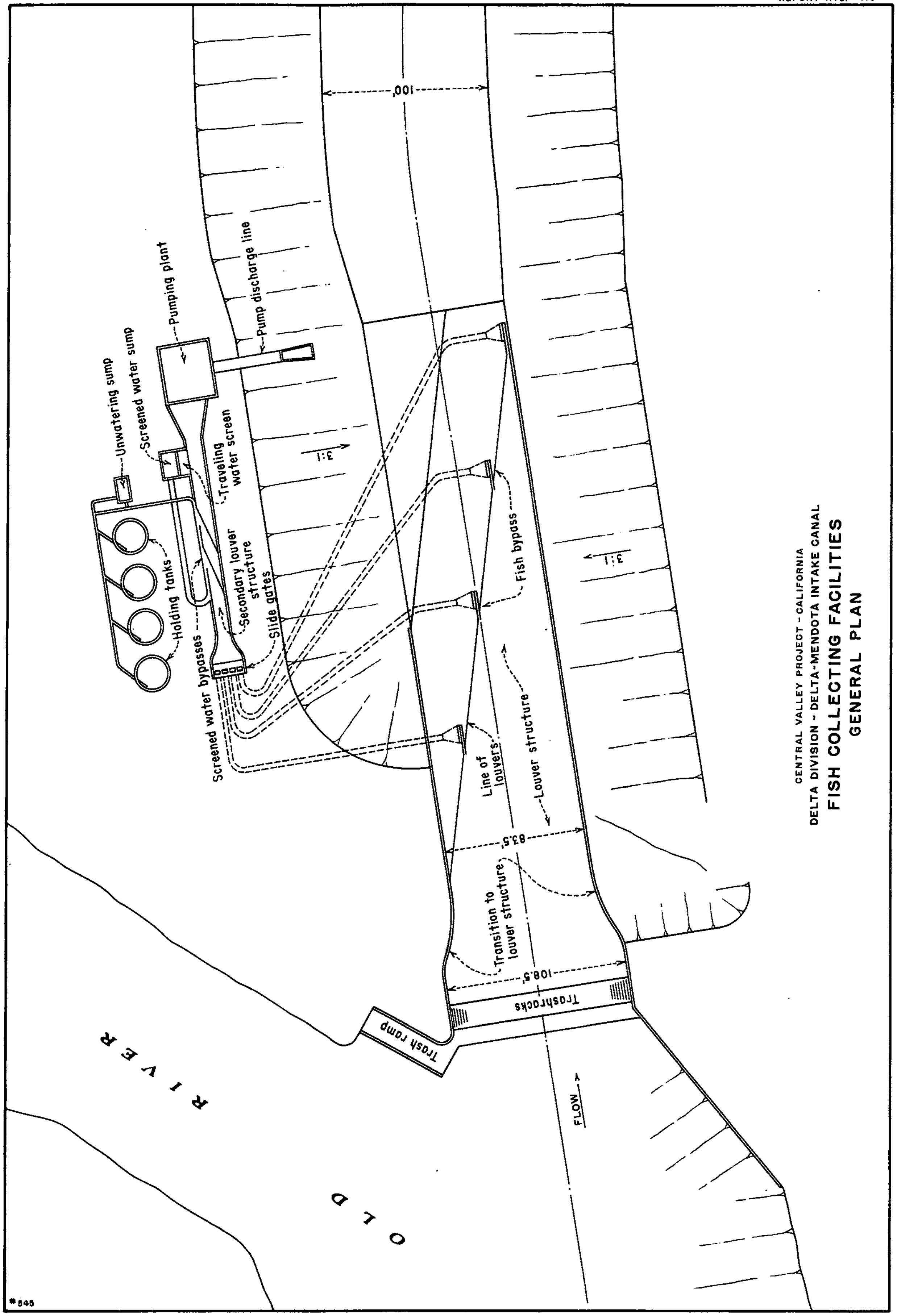
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT-CALIFORNIA
DELTA DIVISION DELTA MENDOTA INTAKE CANAL

FISH COLLECTING FACILITIES

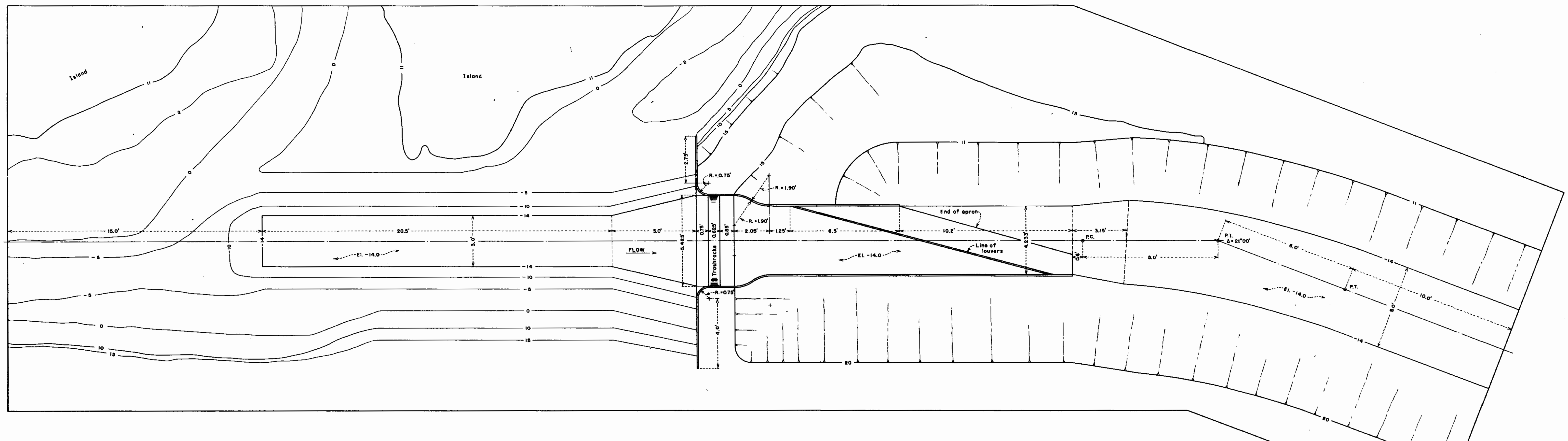
LOCATION MAP

DRAWN: G.E.N.	SUBMITTED: [illegible]
TRACED: M.C.F.	RECOMMENDED: [illegible]
CHECKED: [illegible]	APPROVED: [illegible] ASSOC. CHIEF ENGINEER
DENVER, COLORADO, JUNE 8, 1955	214-D-19555

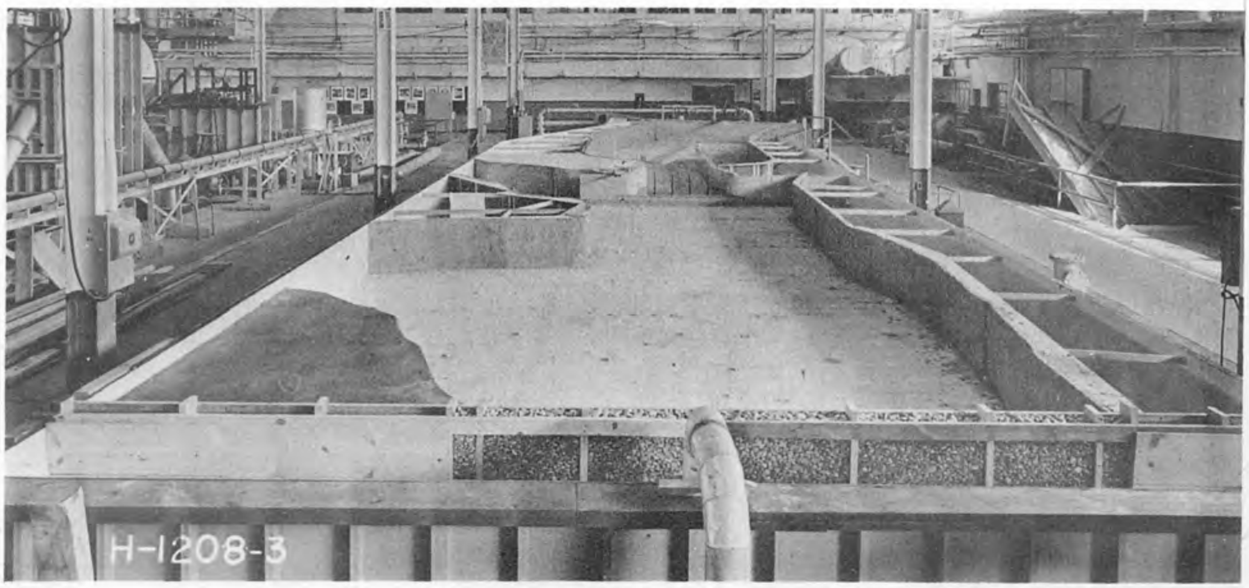
FIGURE 2
REPORT HYD.-410



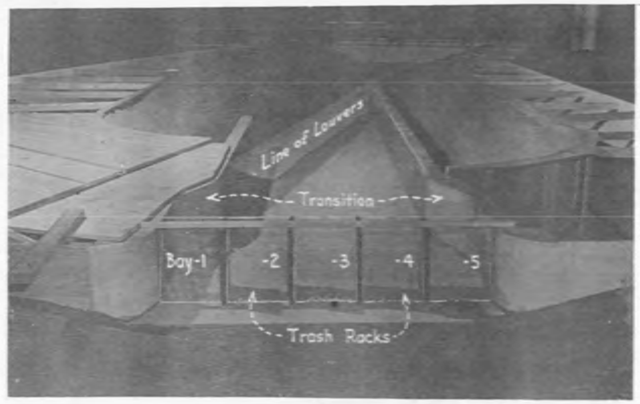
CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES
GENERAL PLAN



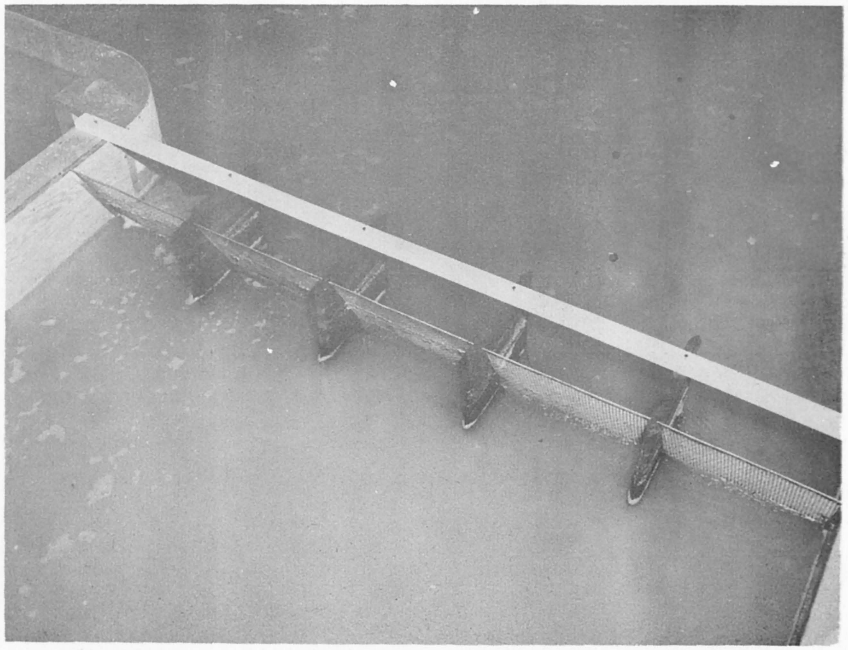
CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES MODEL
PRELIMINARY DESIGN
SCALE 1:20



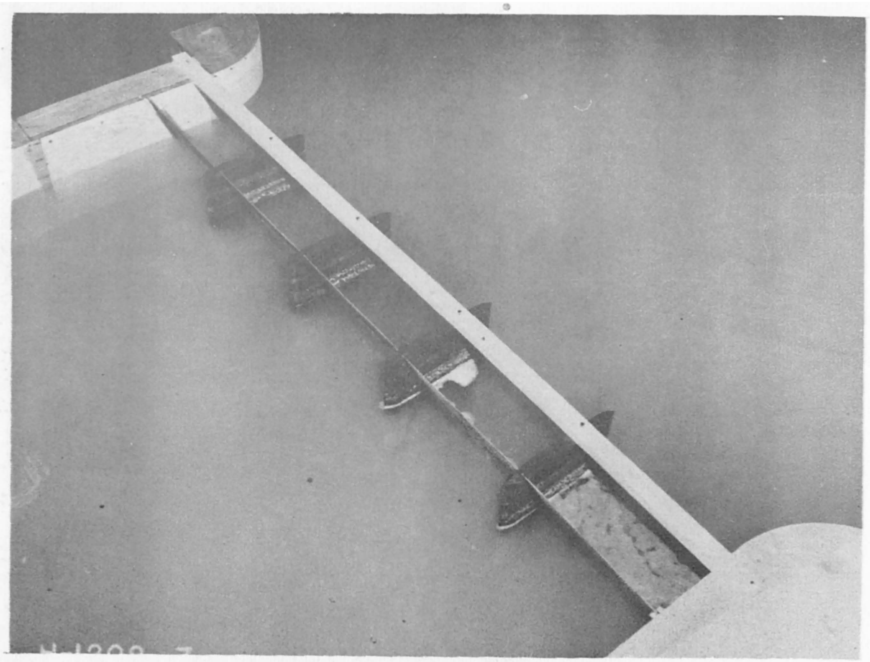
Delta-Mendota Intake Canal
CANAL HEADWORKS
Model Before Placement of Sand Contours. Note Vertical Rods to Show Sand Depth. 1:20 Scale



(A) Trashracks, transition section, and line of louvers

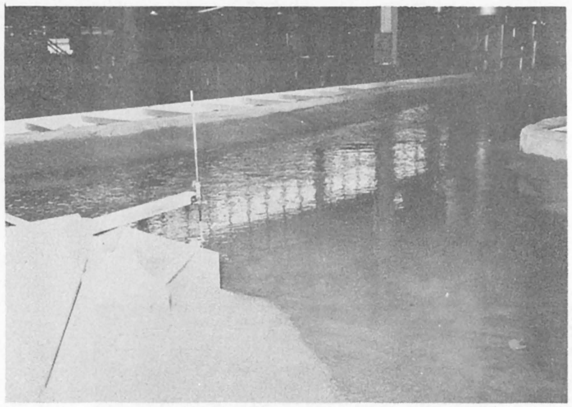


(B) Trashrack section, discharge representing 4860 cfs, W. S. Elev. +2.0. Flow concentration through Bays 4 and 5 indicated by foam.

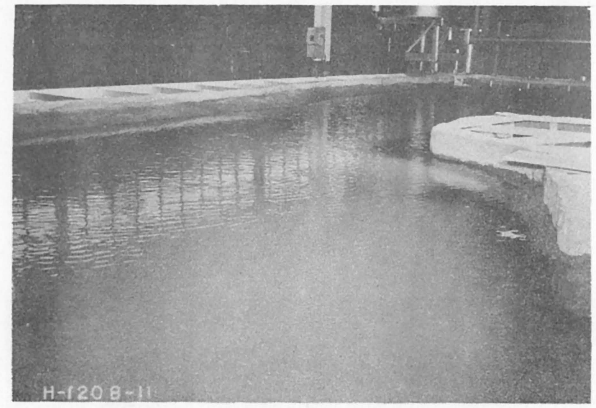


(C) Trashrack section, discharge representing 5065 cfs, W. S. Elev. +6.0. Foam collection Bay 1 indicated unequal flow distribution through headworks.

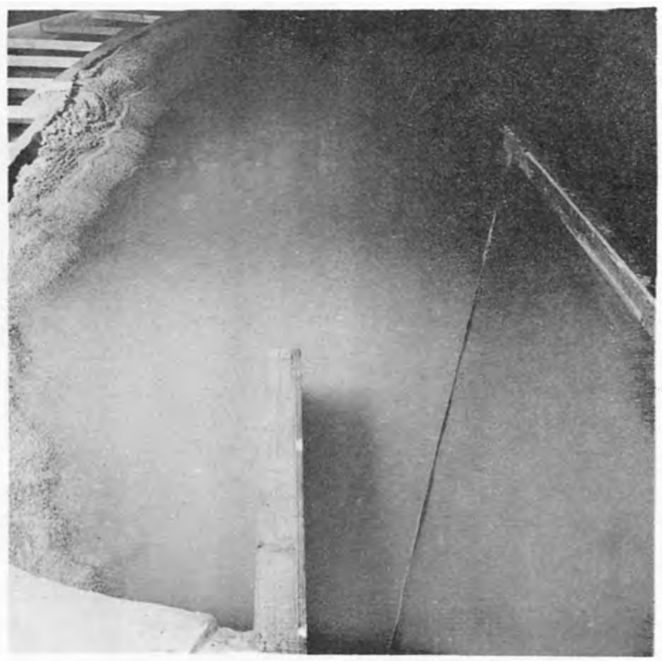
Delta-Mendota Intake Canal
CANAL HEADWORKS
Flow Conditions Through Trashrack Structure, 1:20 Scale Model Preliminary Design.



(A) Upstream approach channel flow conditions, discharge representing 4860 cfs, W. S. Elev. +2.0



(B) Upstream approach channel flow conditions, discharge representing 5065 cfs, W. E. Elev. +6.0



(C) Downstream channel flow conditions, discharge representing 5065 cfs, W. S. Elev. +6.0

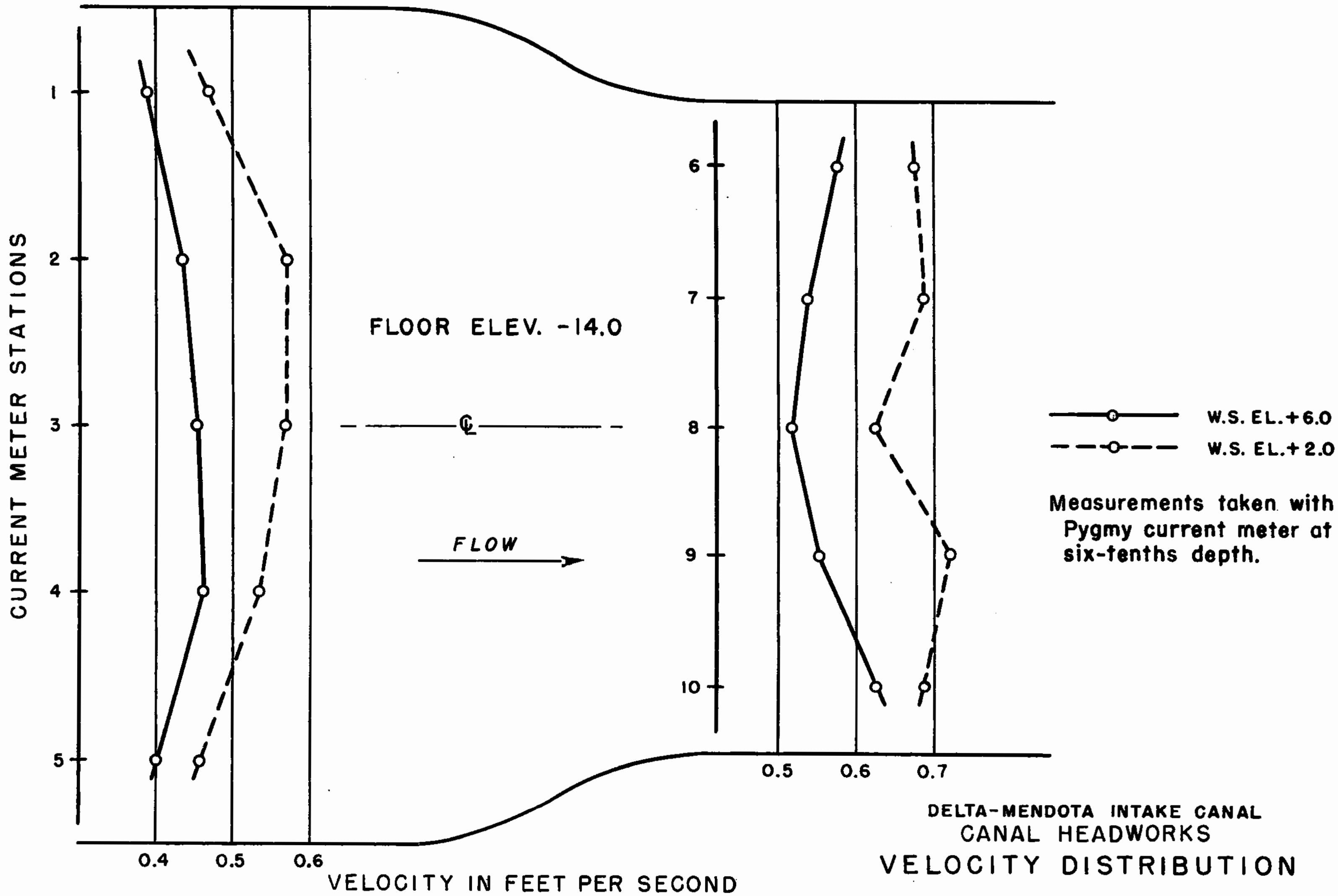
FIGURE 6
Report Hyd 410

FIGURE 7
Report Hyd 410

(A) Sand movement in upstream channel following test at discharge representing 4860 cfs, W. S. Elev. +2.0, for a time of approximately 2 hours.

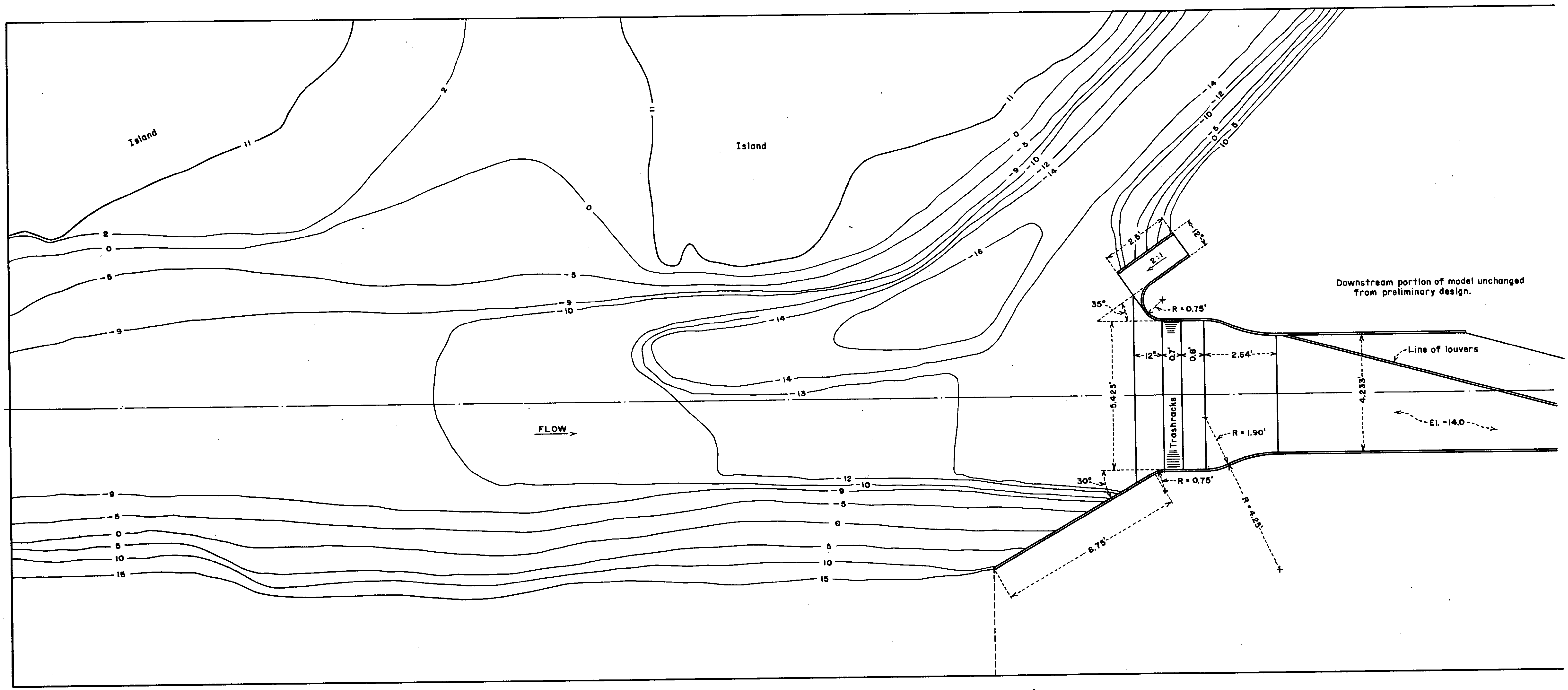
(B) Sand movement in downstream channel following test at discharge representing 4860 cfs, W. S. Elev. +2.0.

Delta-Mendota Intake Canal
CANAL HEADWORKS
Sand Movement in Upstream and Downstream Channels



DELTA-MENDOTA INTAKE CANAL
CANAL HEADWORKS
VELOCITY DISTRIBUTION
PRELIMINARY DESIGN
STRUCTURES MODEL

FIGURE 8
REPORT HYD.410



CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES MODEL
FINAL DESIGN
SCALE 1:20

545

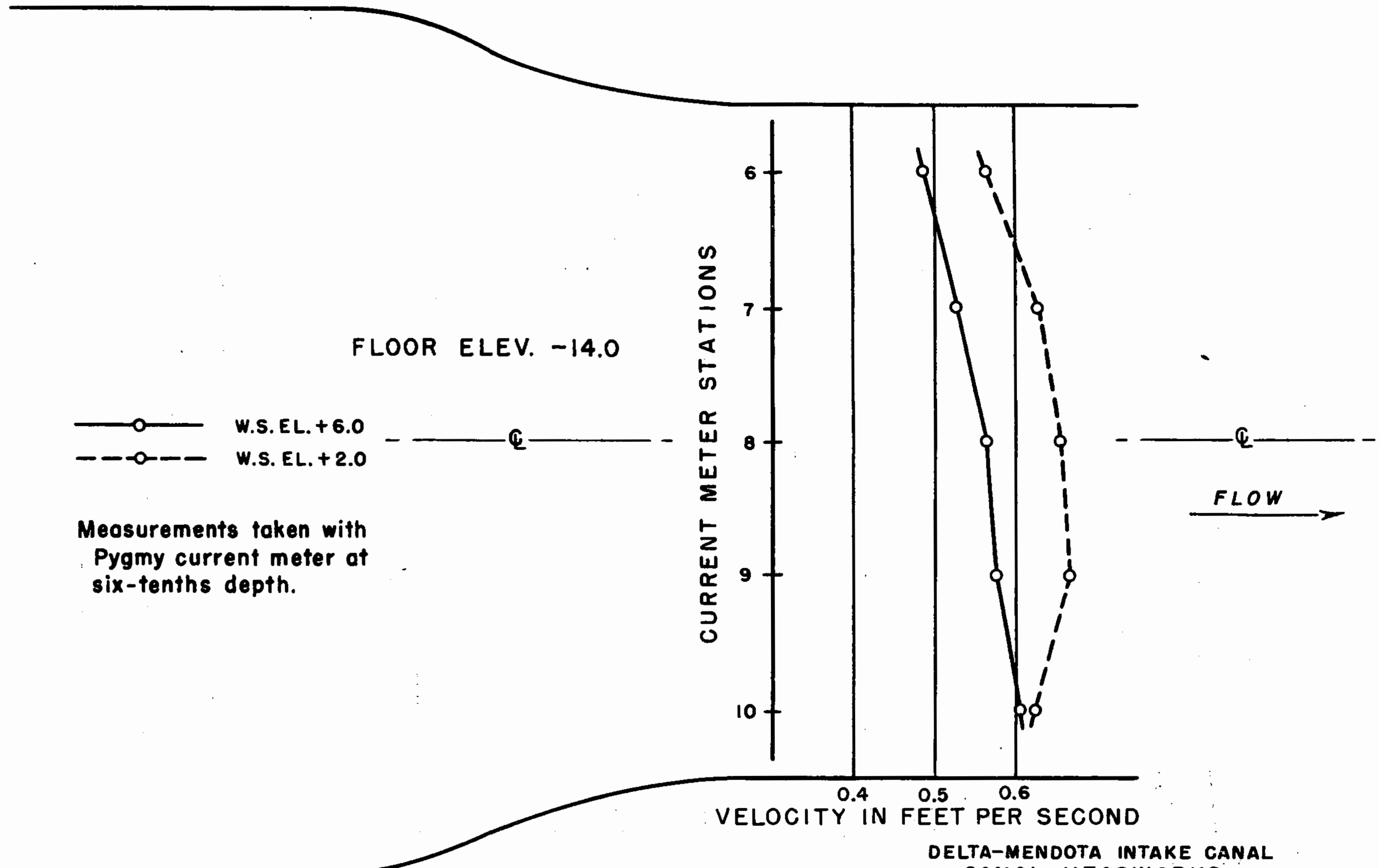
(A) Trashracks, ramp, transition, line of louvers

(B) Upstream approach channel flow conditions, discharge representing 5065 cfs, W. S. Elev. +6.0

(C) Sand movement in upstream channel following test in (B)

Delta-Mendota Intake Canal

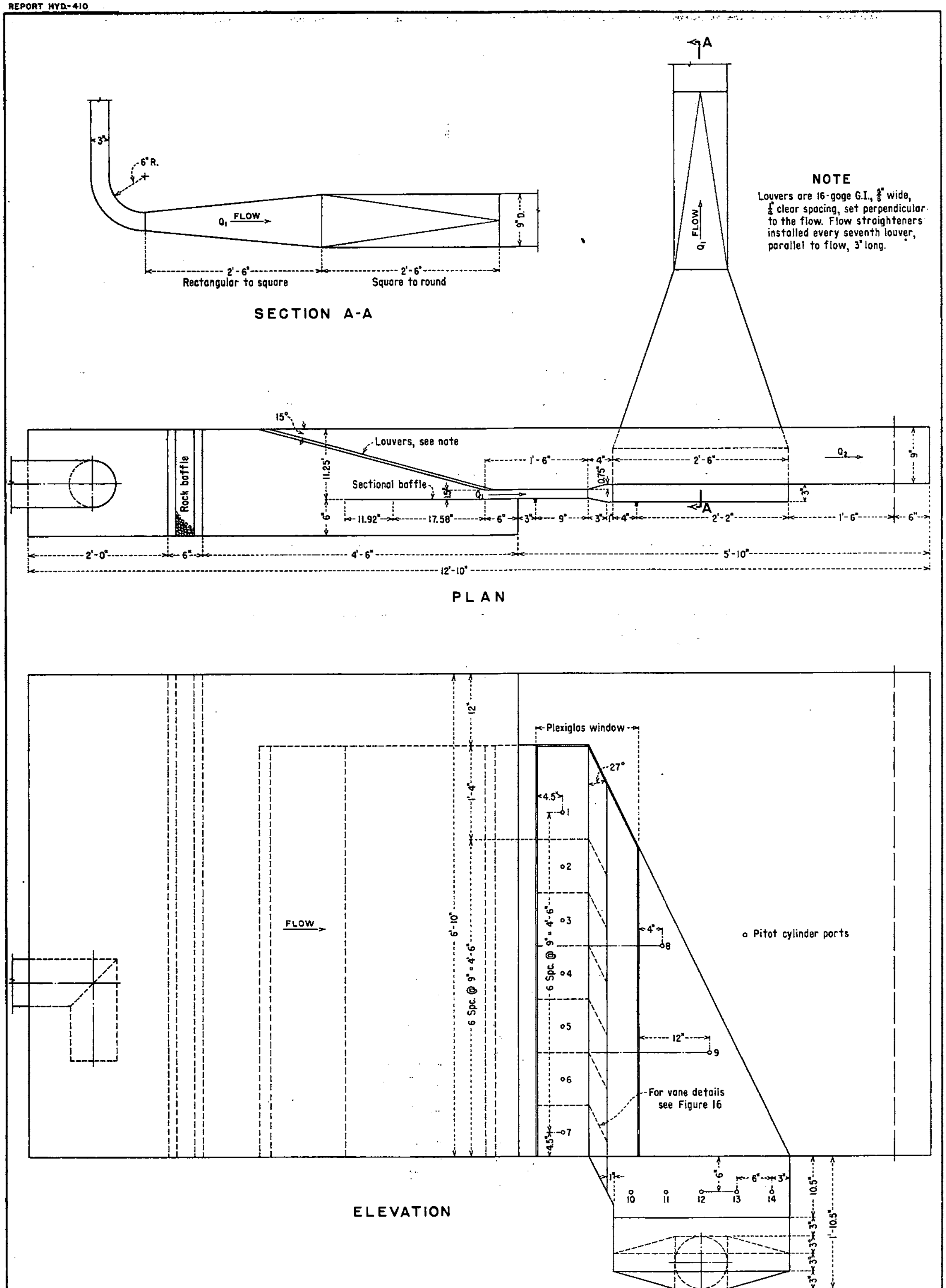
FIGURE 10
Report Hyd 41



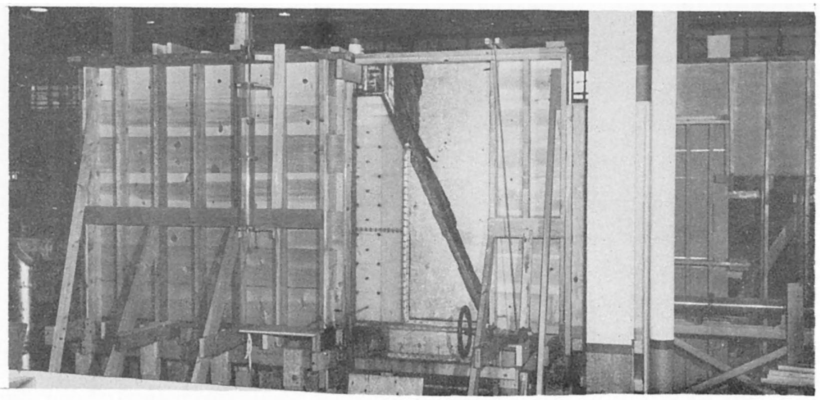
DELTA-MENDOTA INTAKE CANAL
CANAL HEADWORKS
VELOCITY DISTRIBUTION
FINAL DESIGN
1:20 SCALE MODEL

FIGURE 11
REPORT HYD. 410.

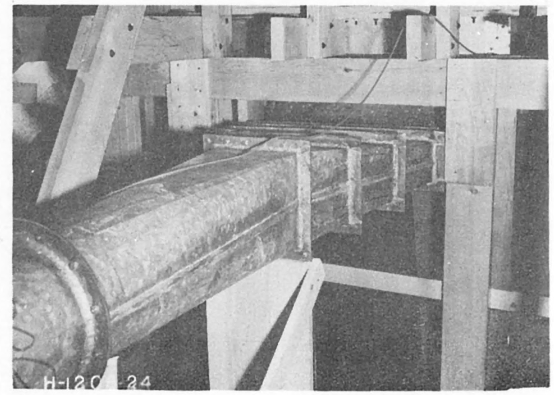
FIGURE 12
REPORT HYD-410



CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES
FISH BYPASS MODEL
SCALE 1:4



(A) General side view of model

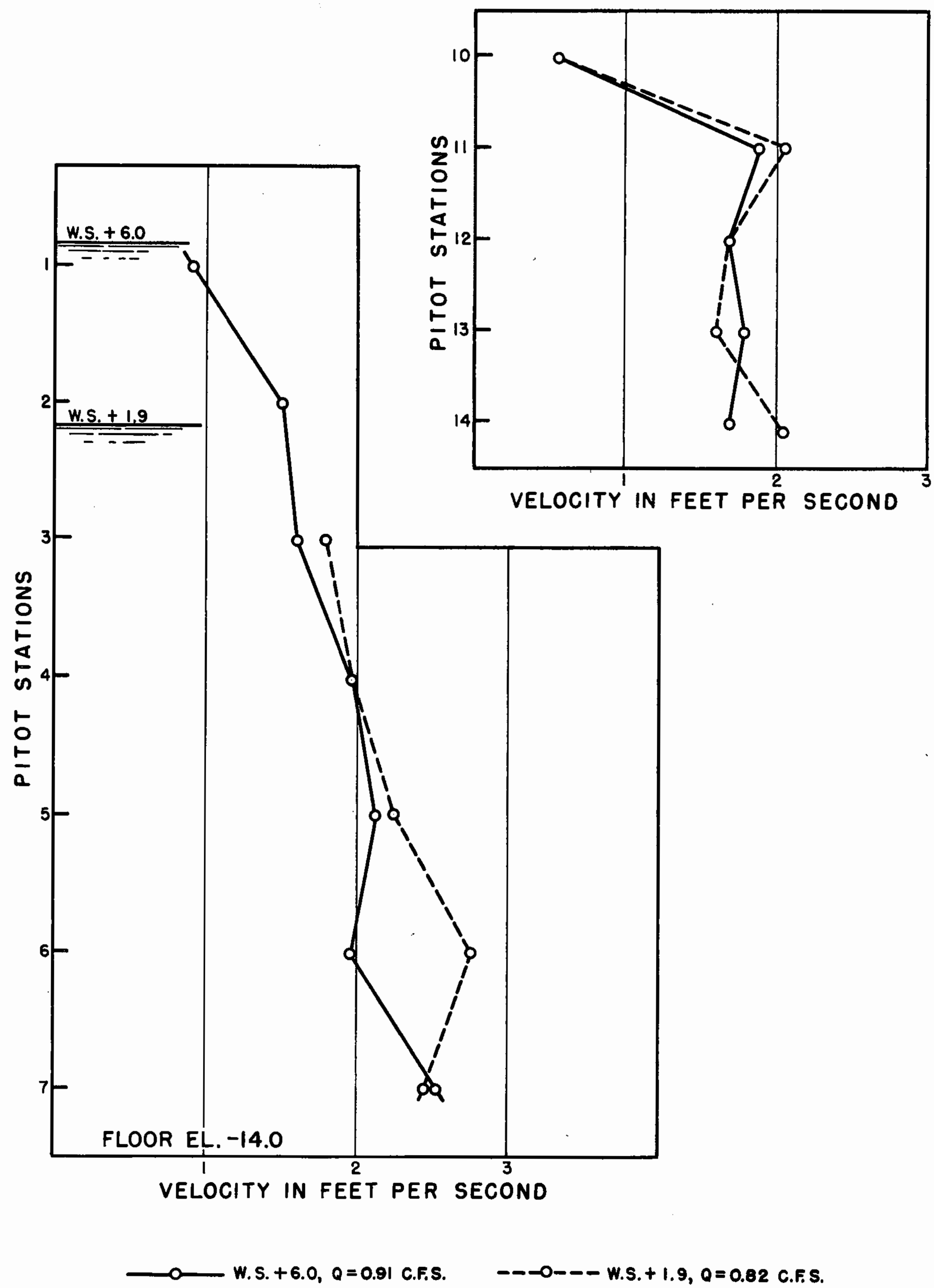


(B) Transition section downstream of bypass

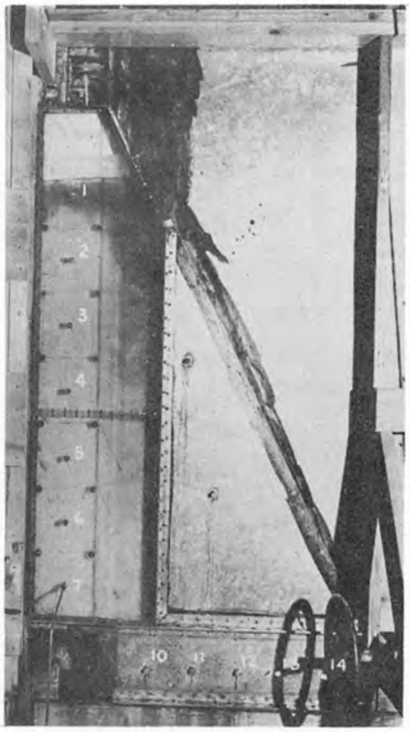
(C) 90° V-notch weir in tailbox for measurement of discharge through bypass

Delta-Mendota Intake Canal
FISH BYPASS
1:4 Scale Model and V-notch Weir

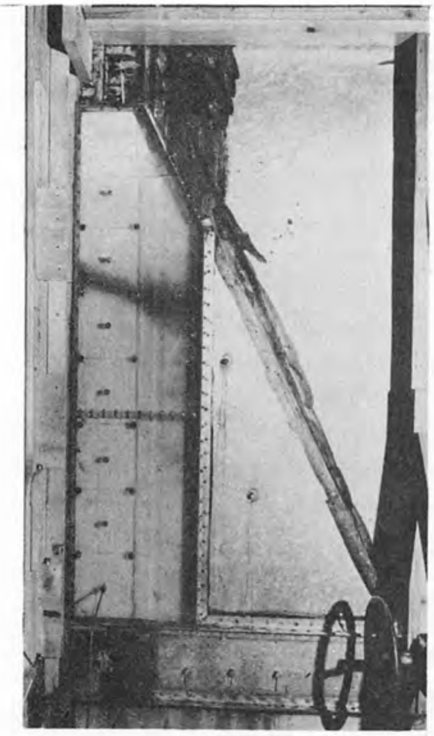
FIGURE 13
Report Hyd 410



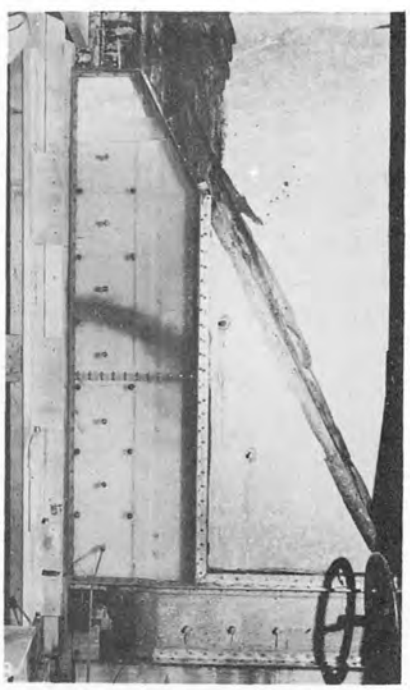
DELTA-MENDOTA INTAKE CANAL
BY-PASS MODEL
VELOCITY DISTRIBUTION
WITHOUT GUIDE VANES OR LOUVERS



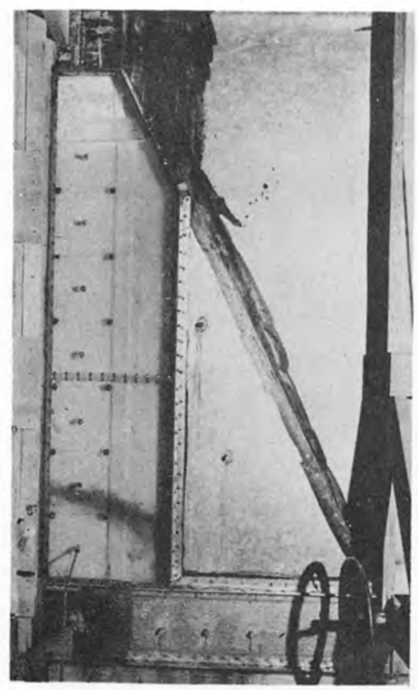
(A) Elevation +5.5



(B) Elevation +2.5

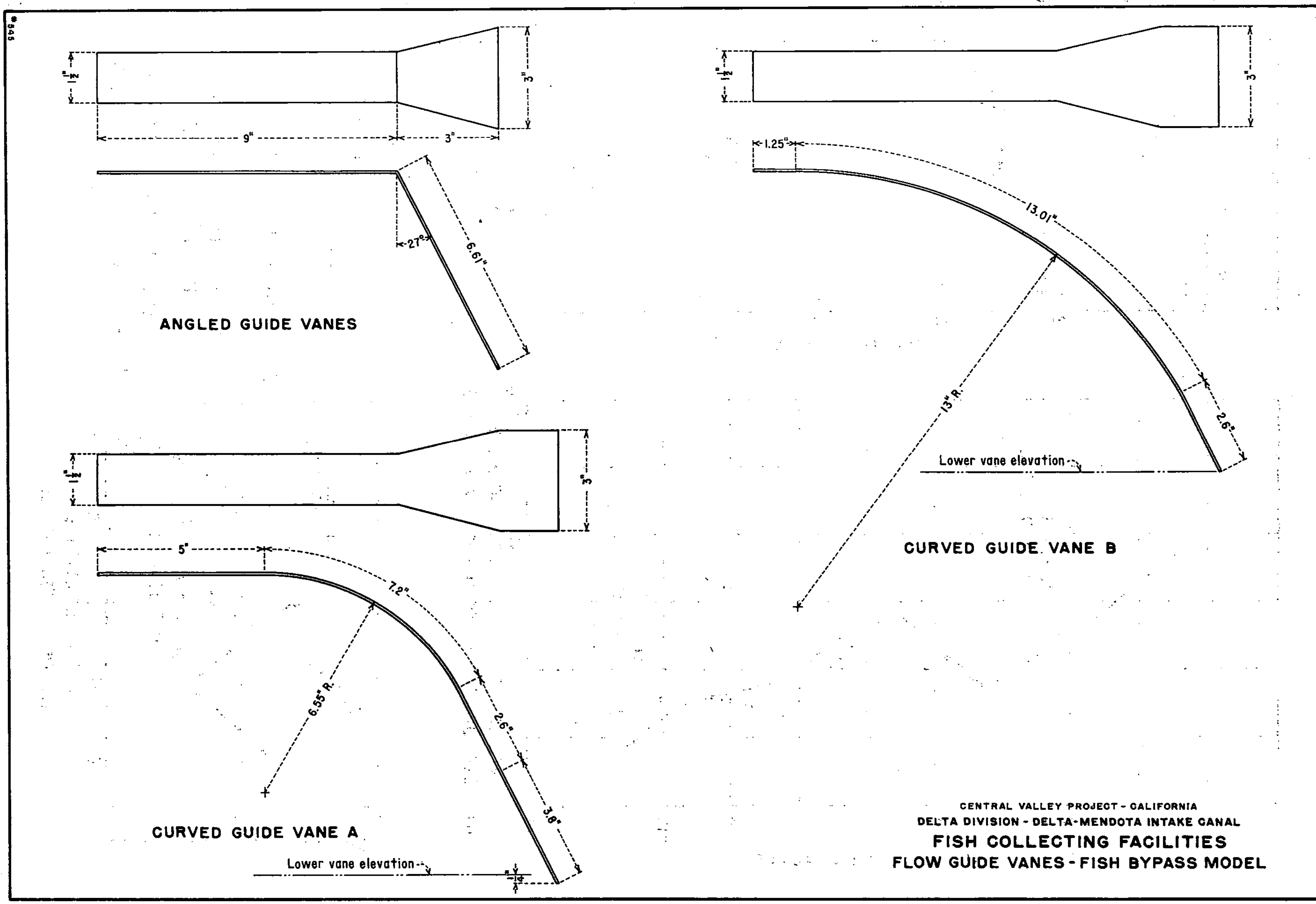


(C) Elevation -0.5



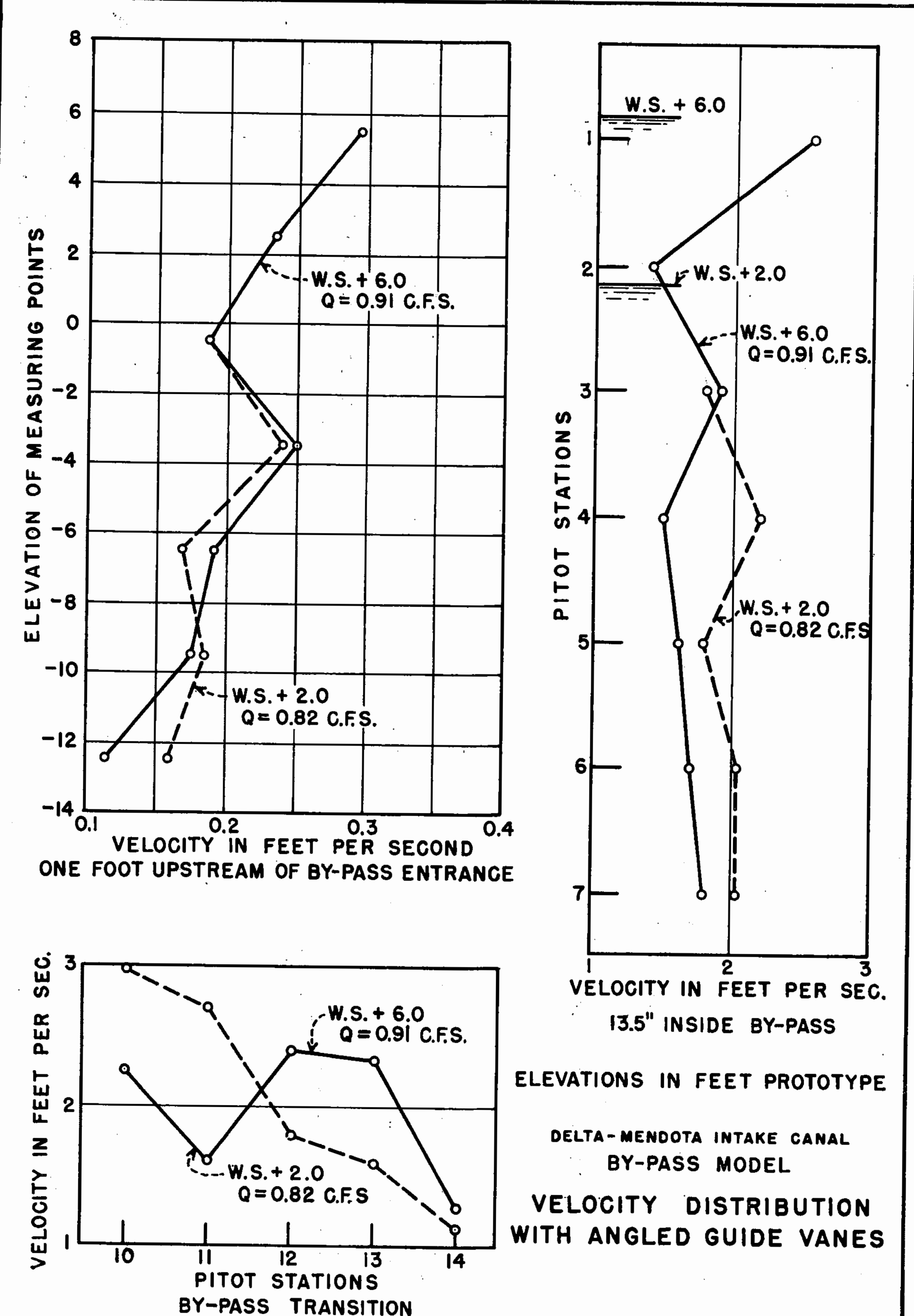
(D) Elevation -9.5

Delta-Mendota Intake Canal
FISH BYPASS
Flow Direction Indicated by Dye Injection, no Guide Vanes, W. S. Elev. +6.0



CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES
FLOW GUIDE VANES - FISH BYPASS MODEL

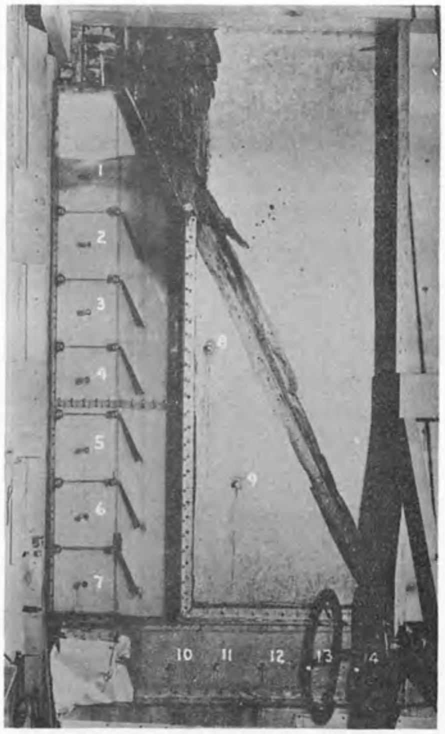
FIGURE 16
REPORT HYD-410



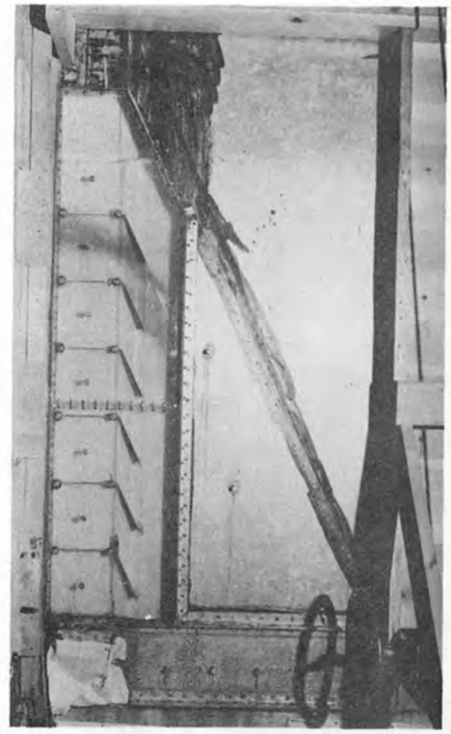
ELEVATIONS IN FEET PROTOTYPE

DELTA-MENDOTA INTAKE CANAL
BY-PASS MODEL

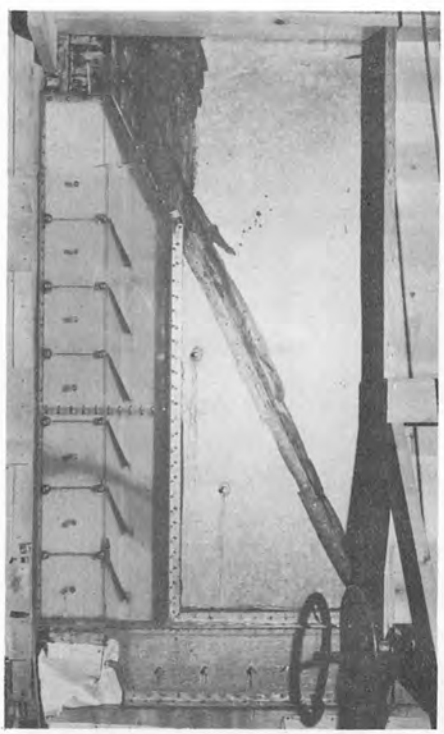
VELOCITY DISTRIBUTION
WITH ANGLED GUIDE VANES



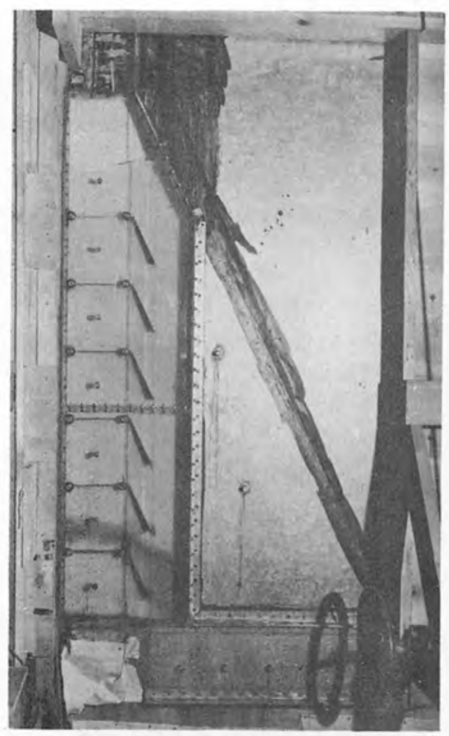
(A) Elevation +5.5



(B) Elevation +2.5

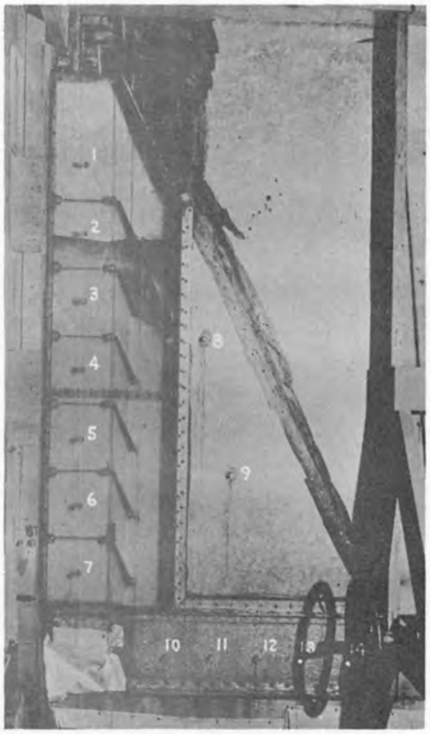


(C) Elevation -6.5

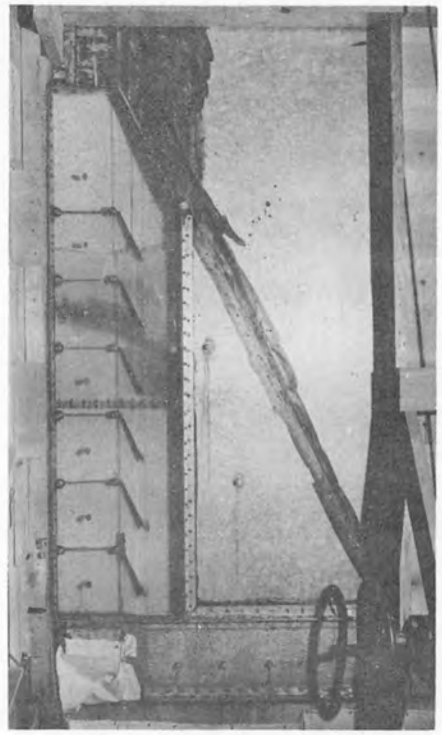


(D) Elevation -9.5

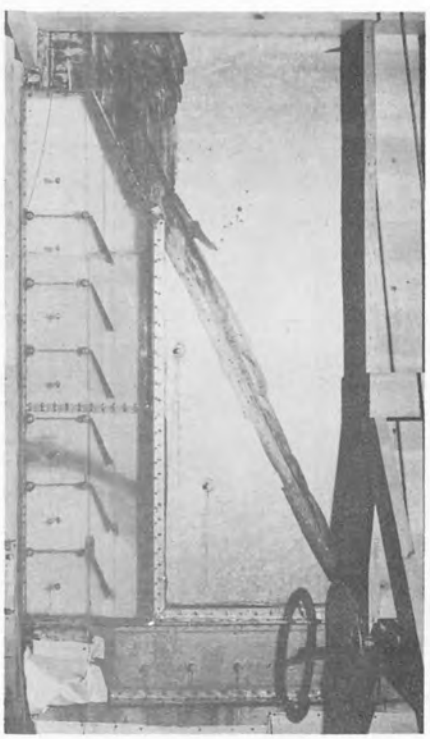
Delta-Mendota Intake Canal
FISH BYPASS
Flow Direction Indicated by Dye Injection, Angled Guide Vanes, W. S. Elev. +6.0



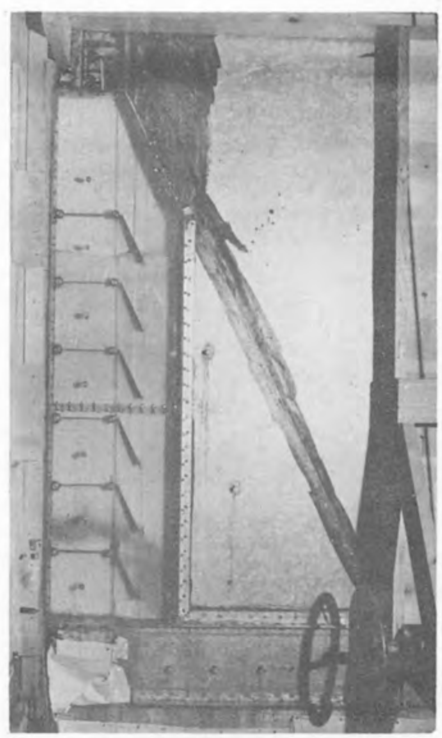
(A) Elevation +2.5



(B) Elevation -0.5

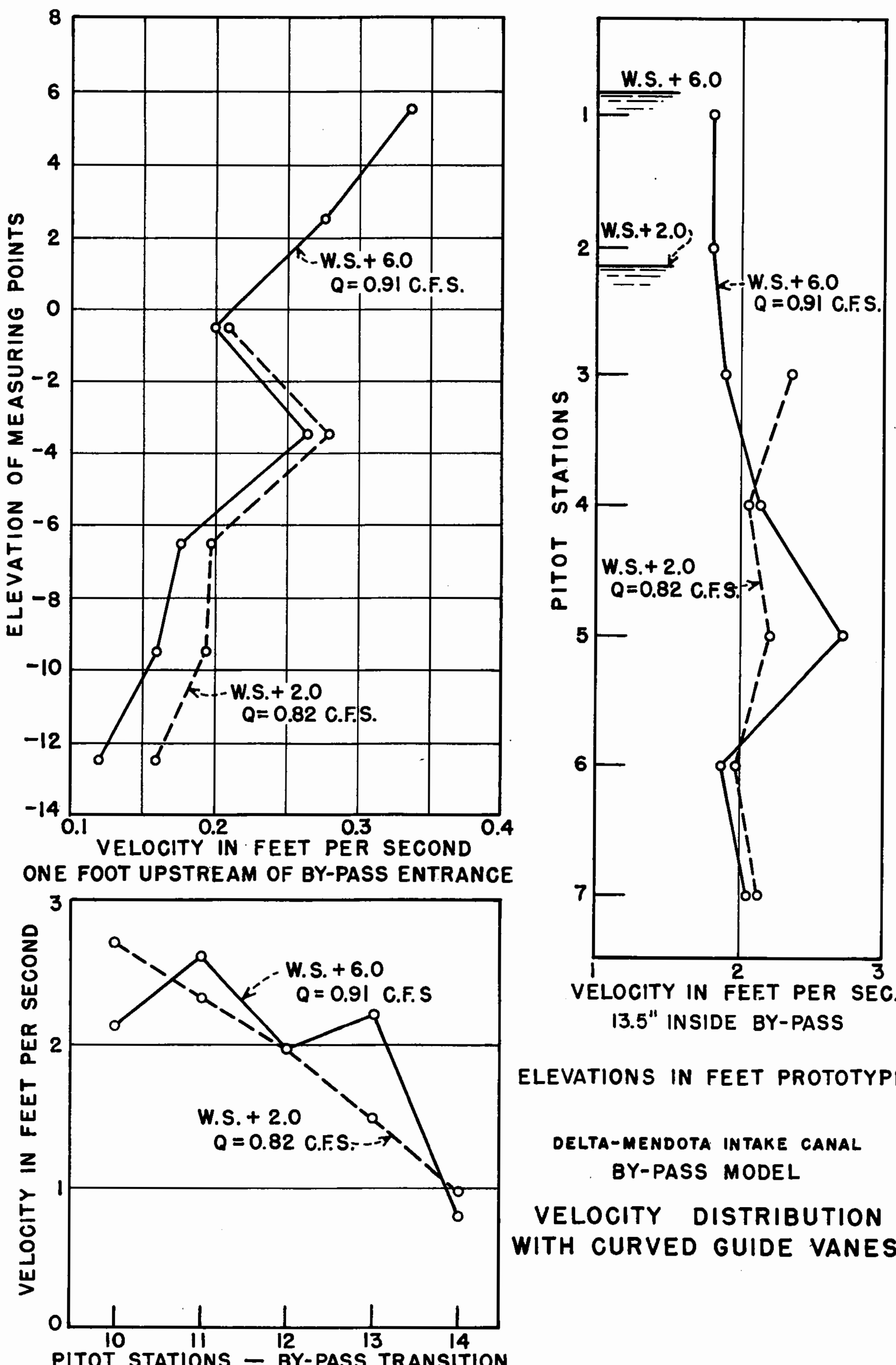


(C) Elevation -6.5



(D) Elevation -9.5

Delta-Mendota Intake Canal
FISH BYPASS
Fow Direction Indicated by Dye Injection, Angled Guide Vanes, W. S. Elev. +2.0

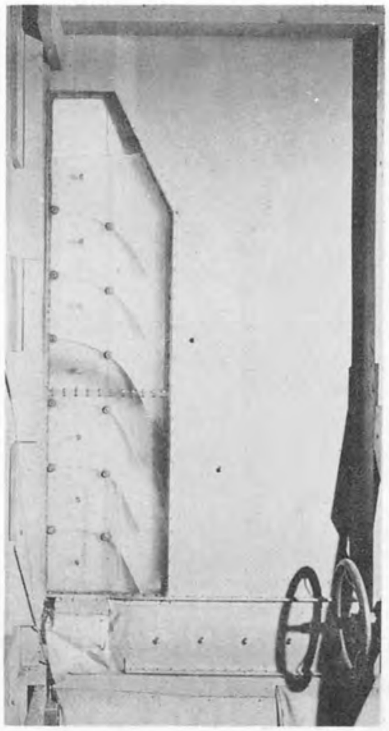


ELEVATIONS IN FEET PROTOTYPE

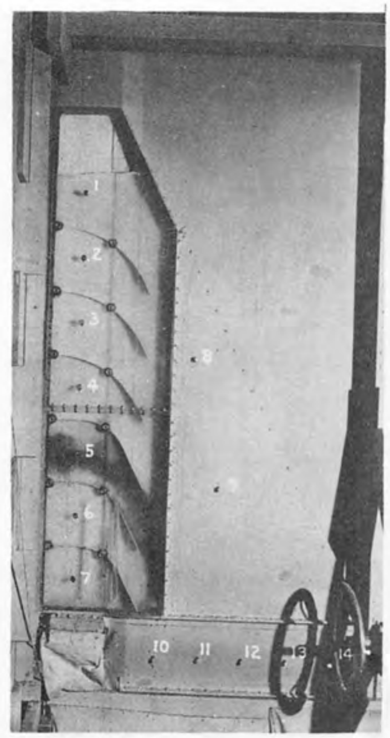
DELTA-MENDOTA INTAKE CANAL
BY-PASS MODEL

VELOCITY DISTRIBUTION WITH CURVED GUIDE VANES

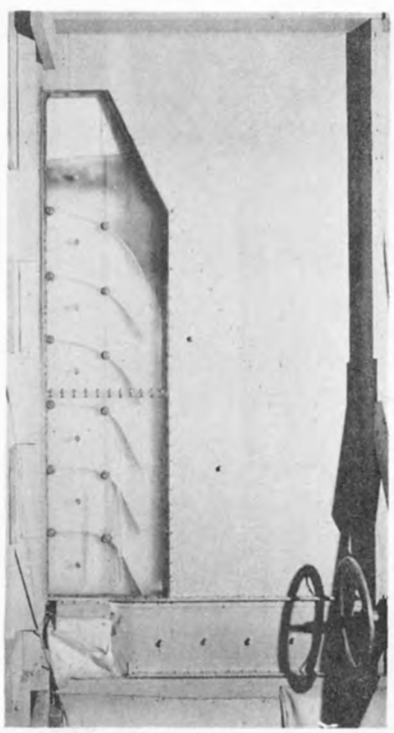
545



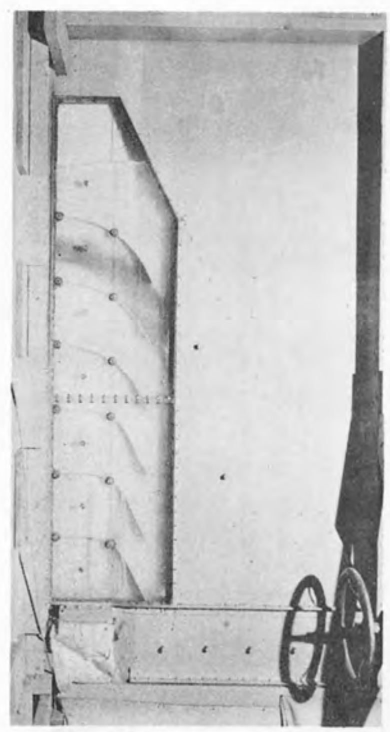
(A) Elevation +5.5



(B) Elevation +2.5



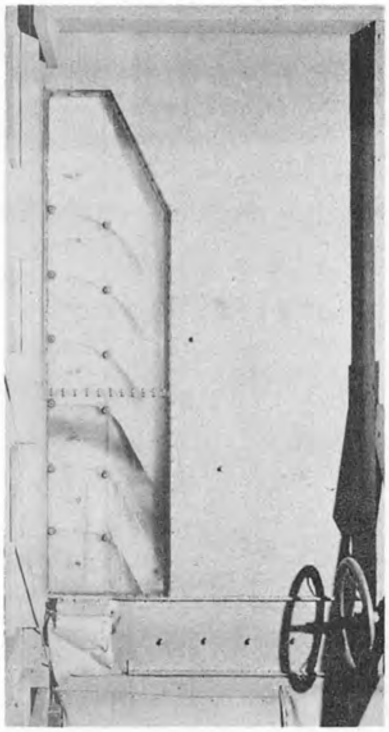
(C) Elevation -3.5



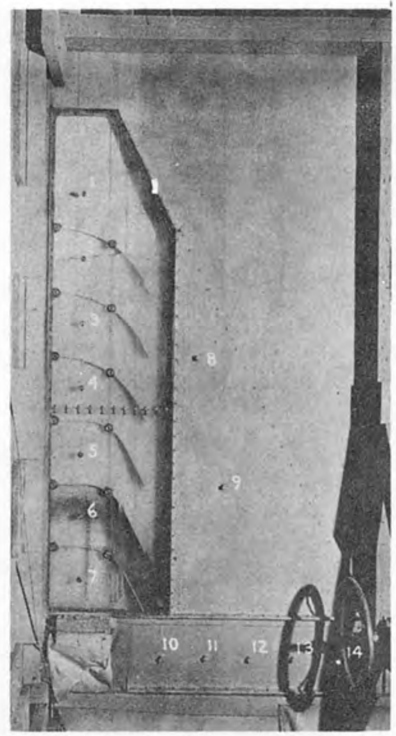
(D) Elevation -6.5

Delta-Mendota Intake Canal
FISH BYPASS
Flow Direction Indicated by Dye Injection, Curved Guide Vanes, W. S. Elev. +6.5

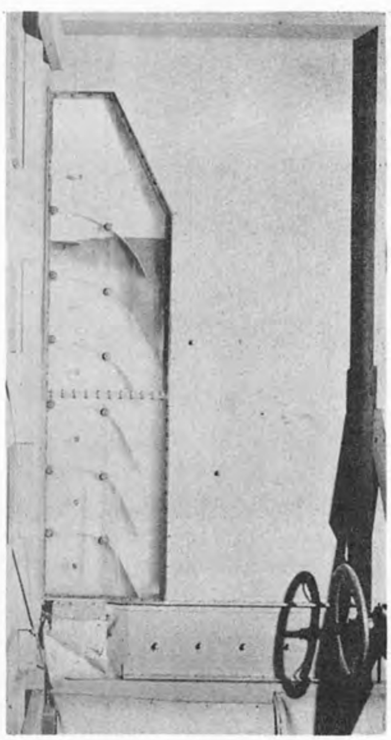
FIGURE 22
Report Hyd 410



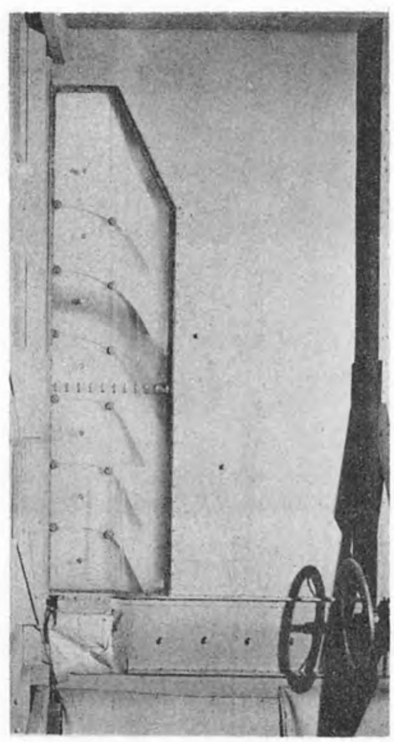
(A) Elevation +2.5



(B) Elevation -0.5



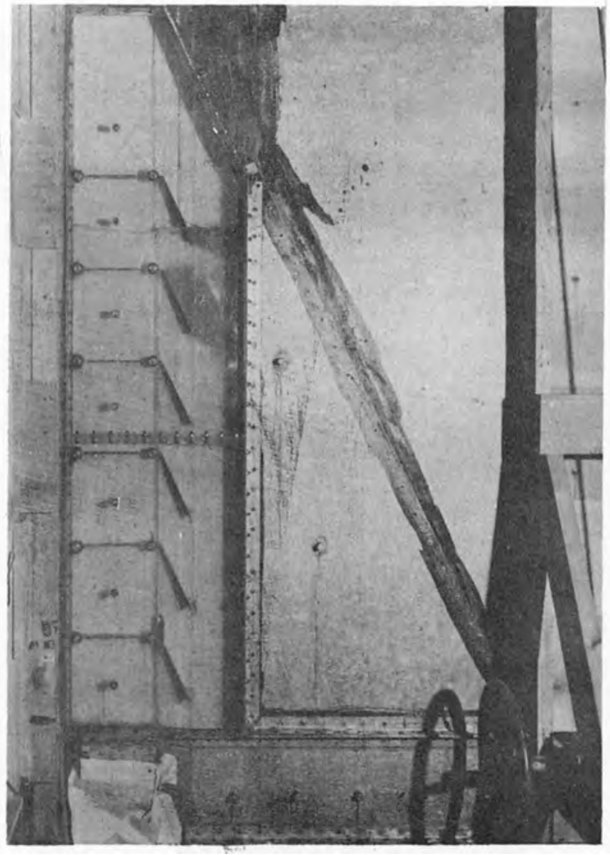
(C) Elevation -6.5



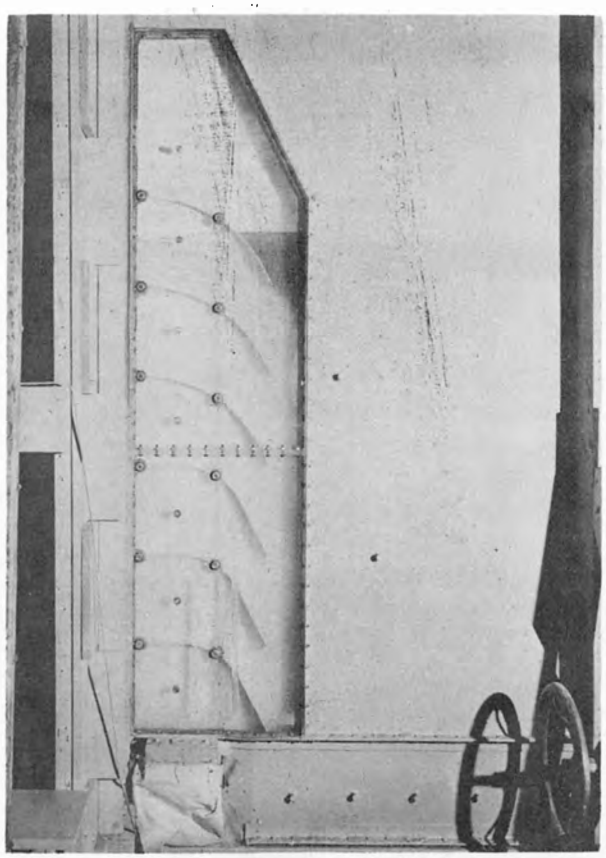
(D) Elevation -9.5

Delta-Mendota Intake Canal
FISH BYPASS
Flow Direction Indicated by Dye Injection, Curved Guide Vanes, W. S. Elev. +2.5

FIGURE 23
Report Hyd 410

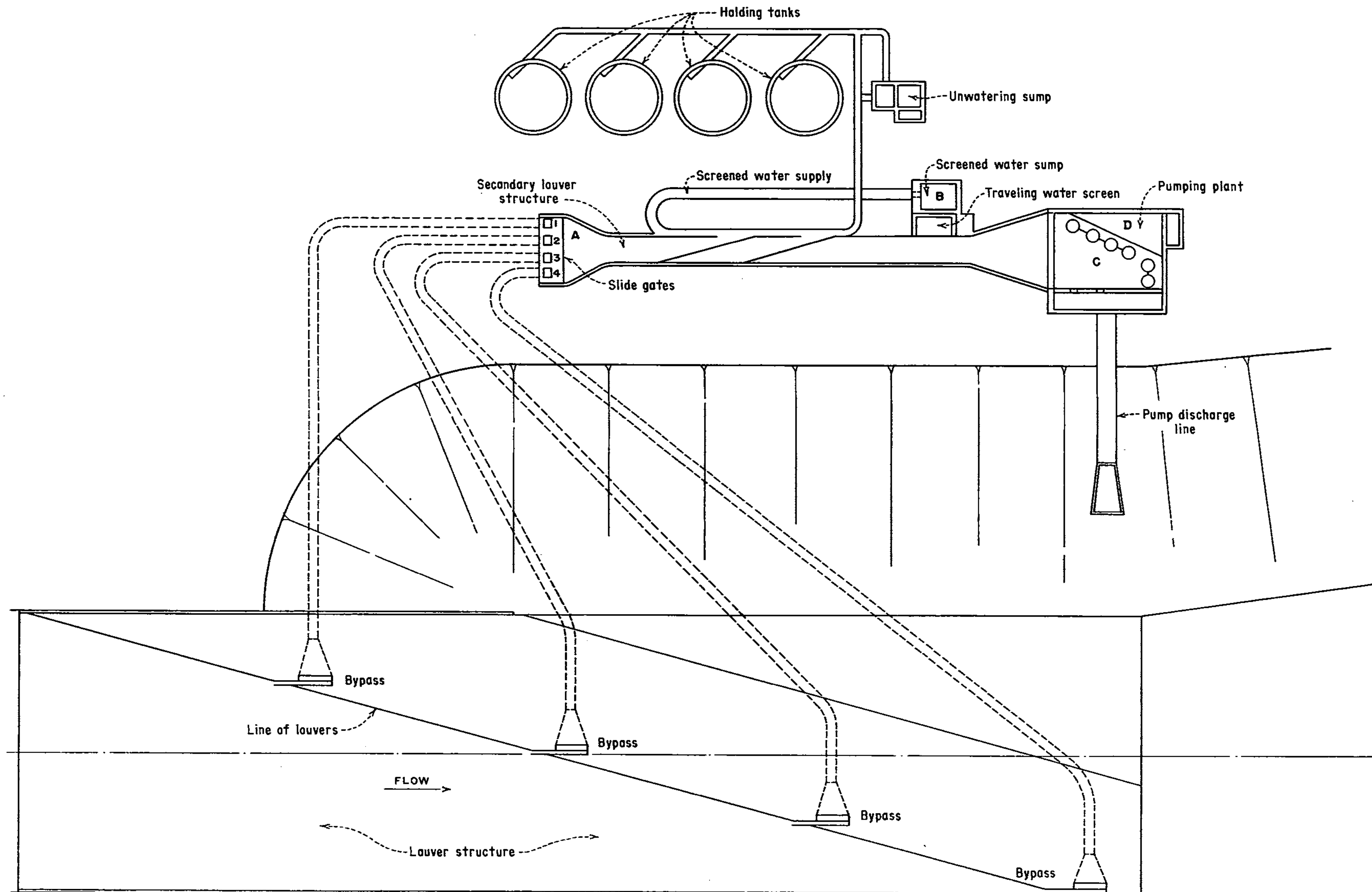


(A) Angled guide vanes, showing eddy areas



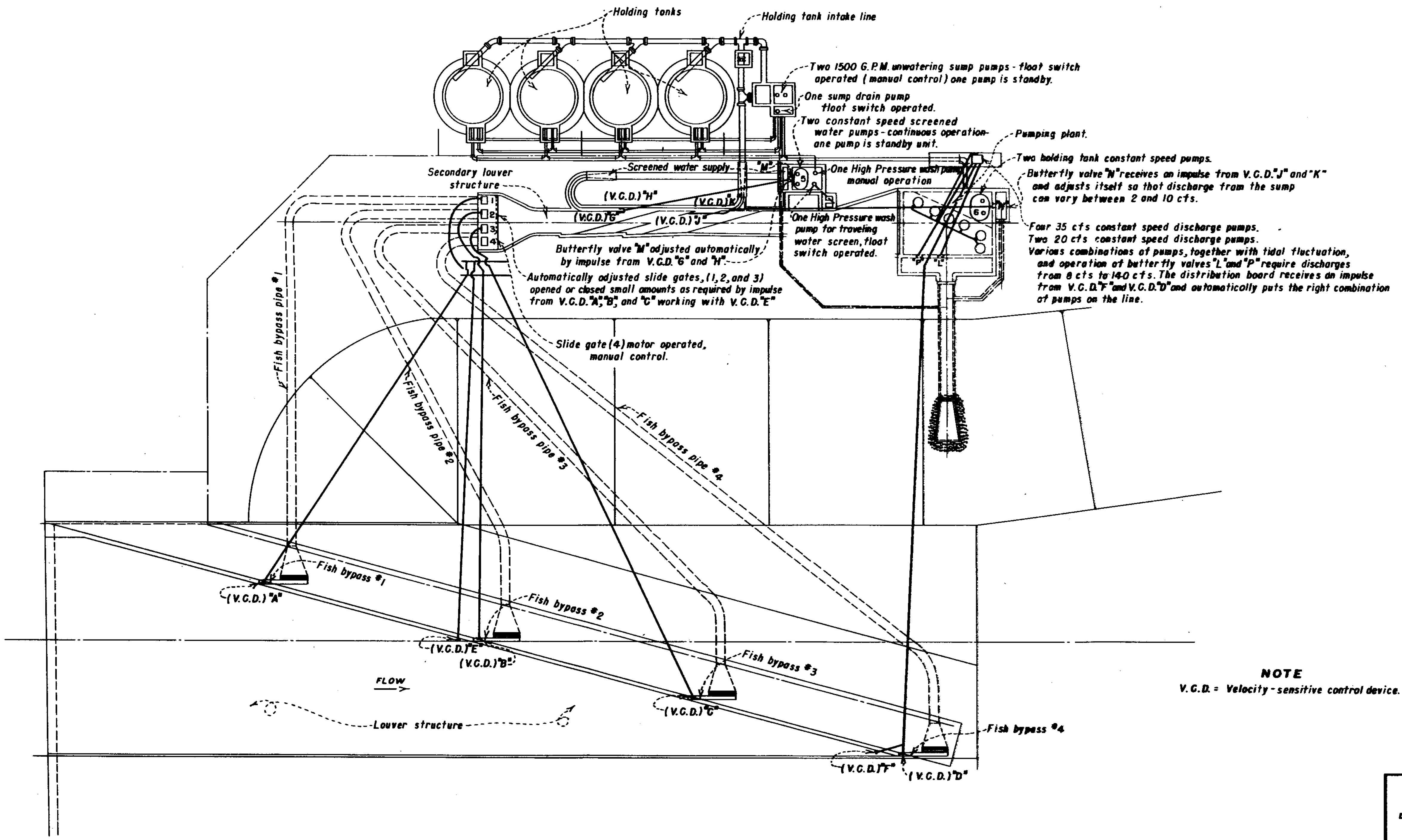
(B) Curved guide vanes, showing eddy areas

Delta-Mendota Intake Canal
FISH BYPASS
Comparison of Eddy Formation, Angled and Curved Guide Vanes W. S. Elev. +2.0



CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES
PARTIAL PLAN

FIGURE 24
REPORT HYD-410



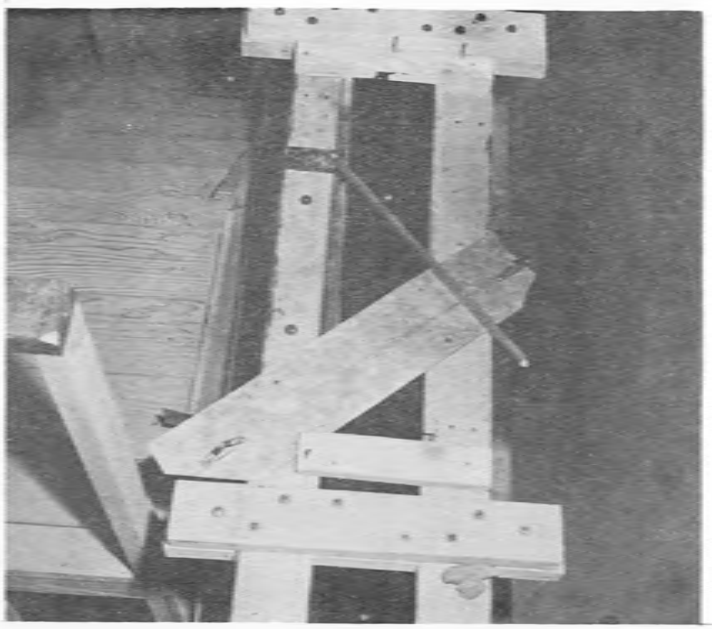
NOTE
V.C.D. = Velocity-sensitive control device.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT—CALIFORNIA
DELTA DIVISION—DELTA MENDOTA INTAKE CANAL

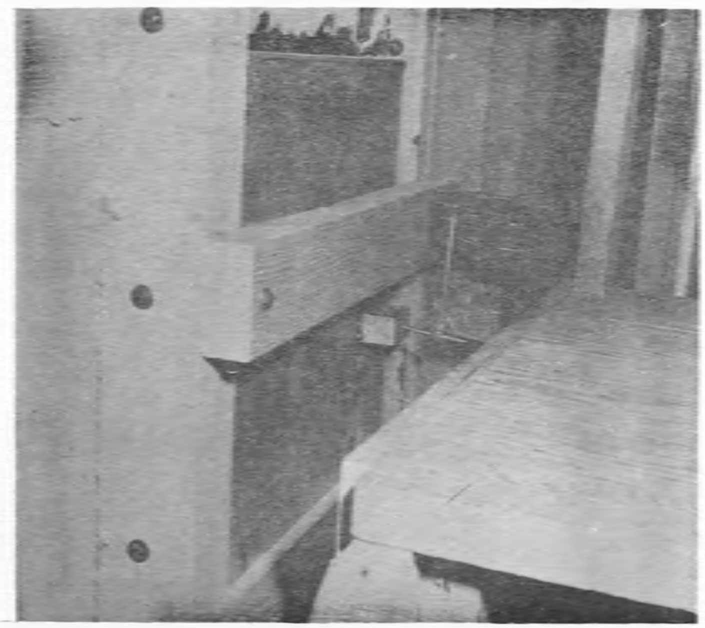
FISH COLLECTING FACILITIES
CONTROL ARRANGEMENT

DRAWN: G.J.H. SUBMITTED: [signature]
TRACED: J.L.V.—E.V.C. RECOMMENDED: [signature]
CHECKED: [initials] APPROVED: [signature] CHIEF ENGINEER
DENVER, COLORADO, 214-D-19575

(A) General view of facilities



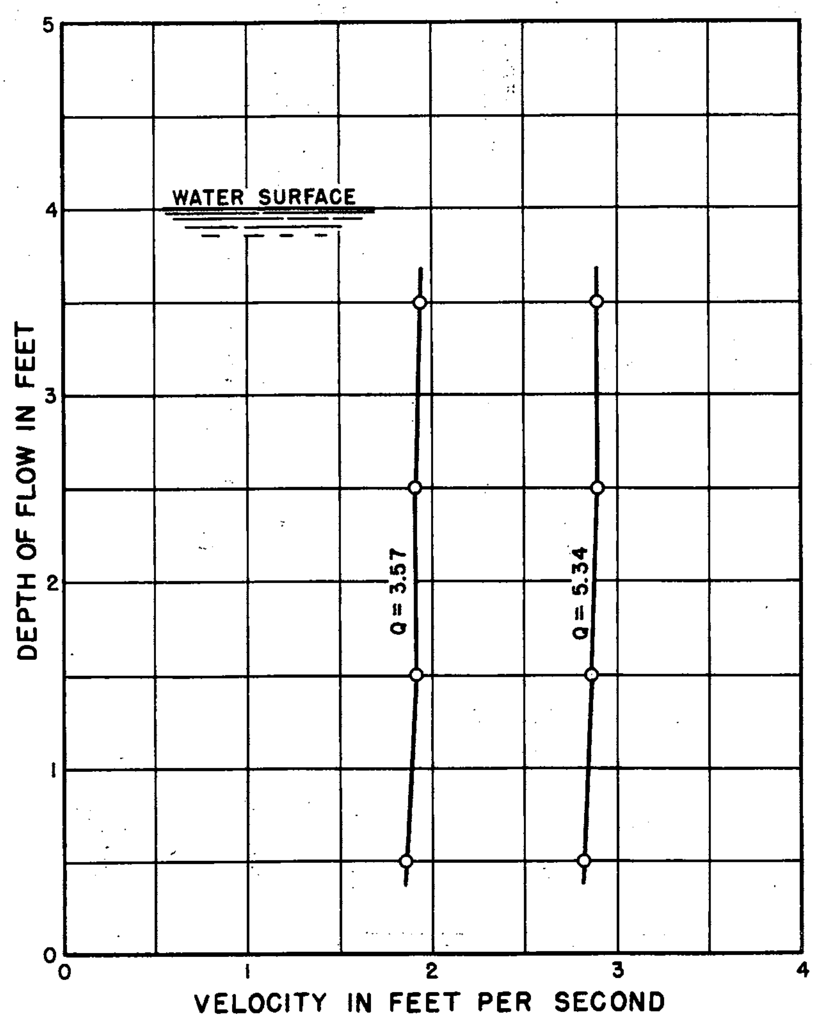
(B) Deflection indicating arm and loading mechanism



(C) Deflection indicator on vane box.

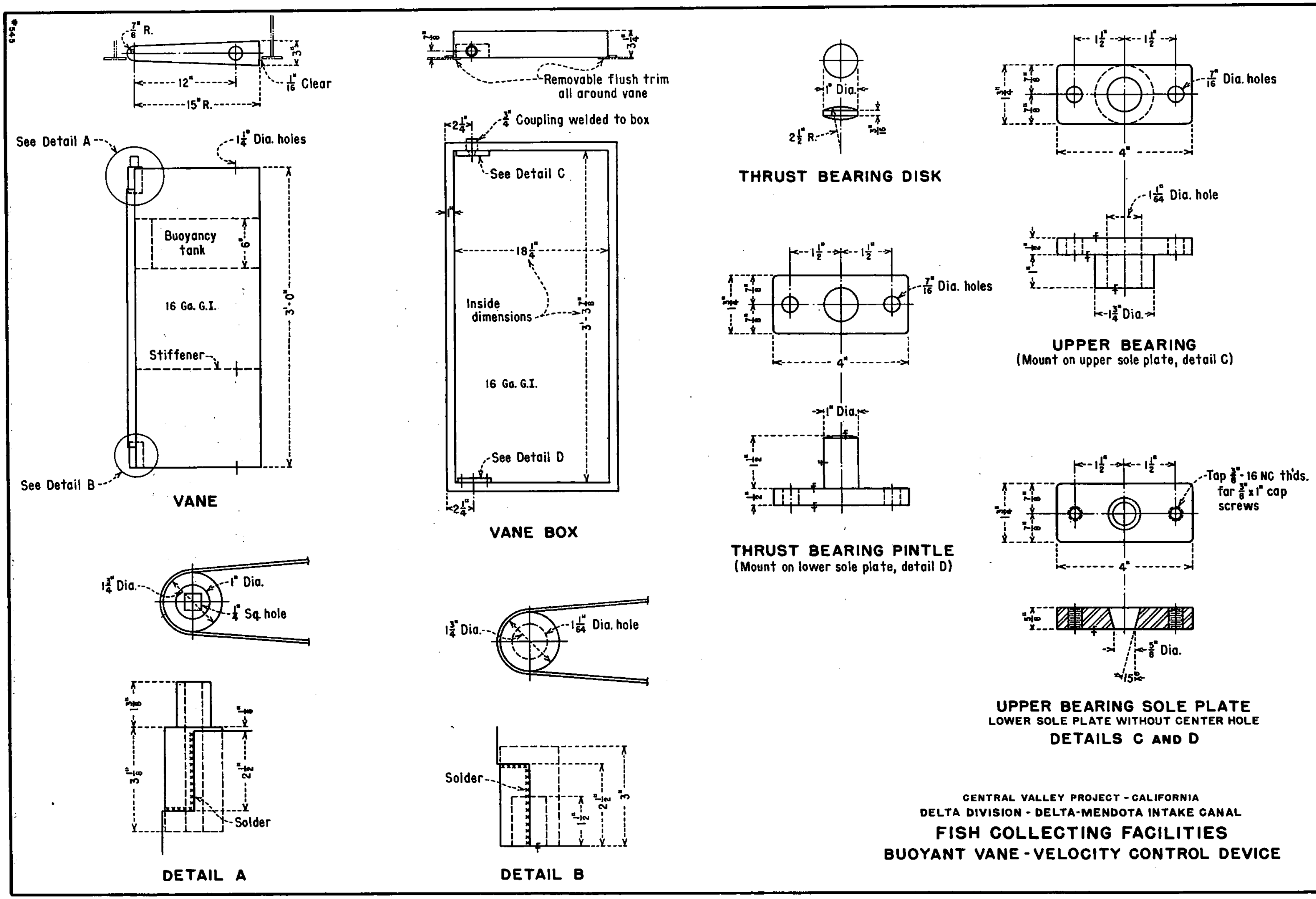
Delta Mendota Intake Canal
VELOCITY CONTROL DEVICE
Test Facilities

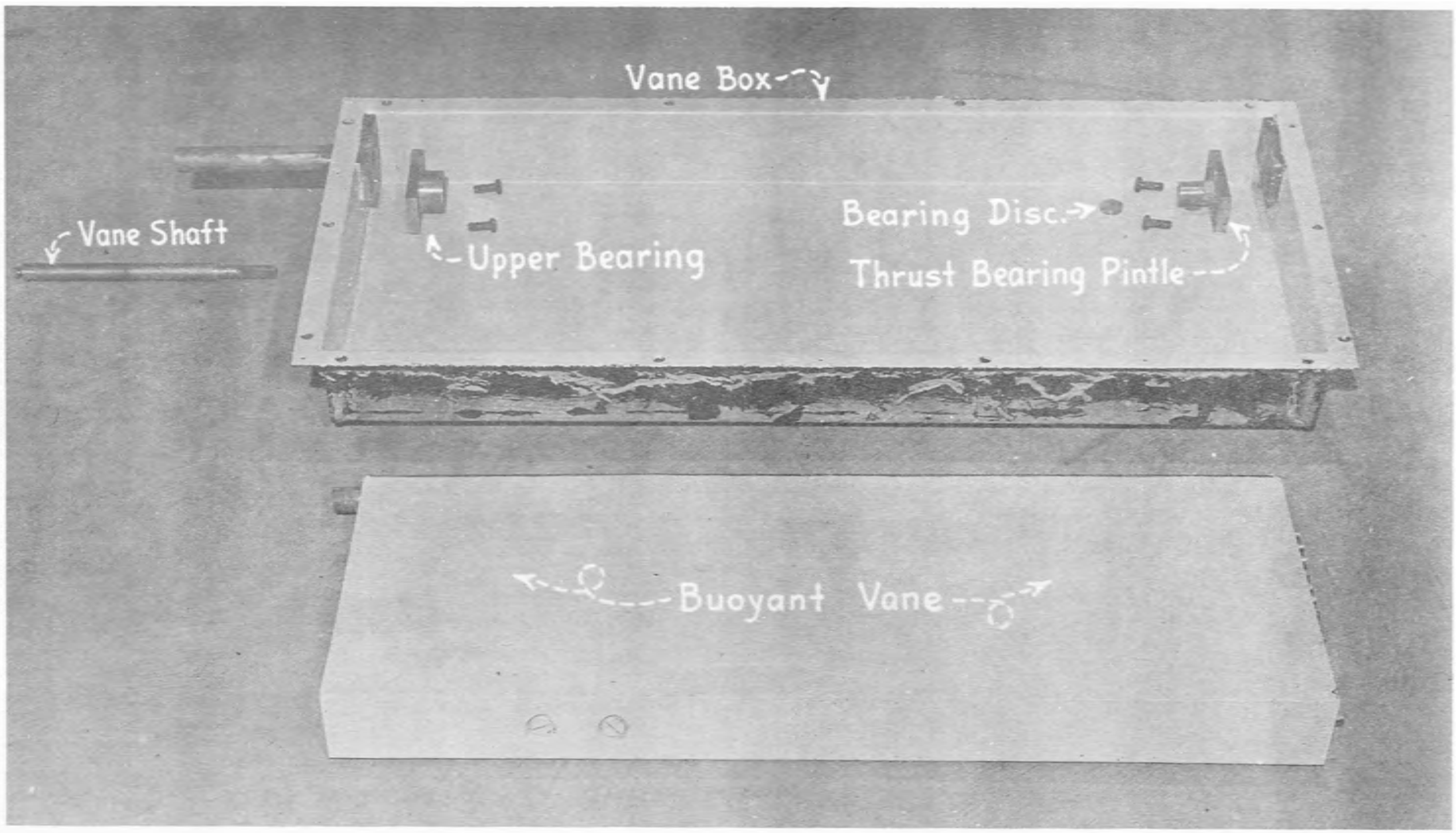
FIGURE 26
Report Hyd 410



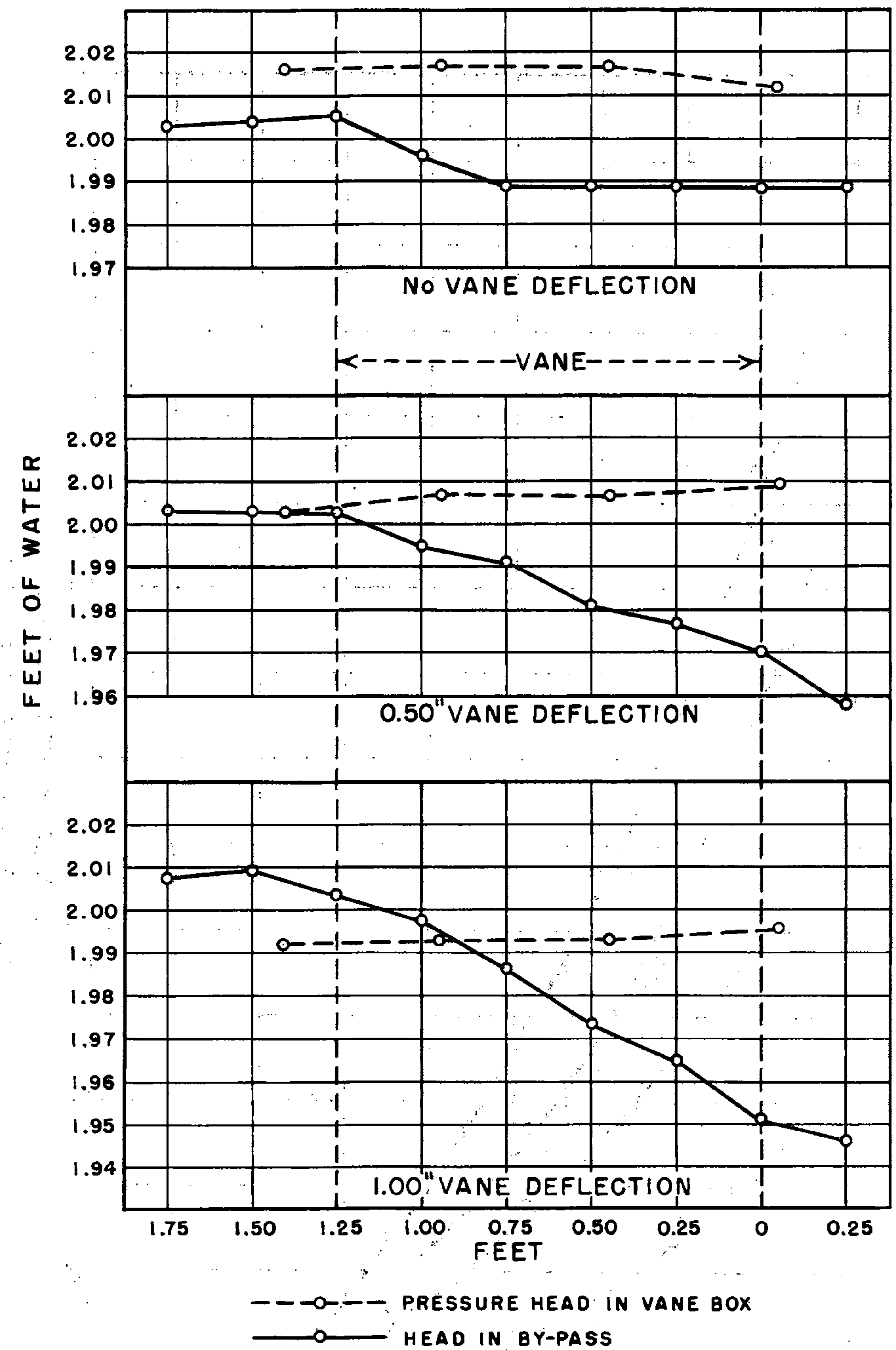
DELTA-MENDOTA INTAKE CANAL
VELOCITY CONTROL DEVICE
VELOCITY DISTRIBUTION IN 6-INCH TEST CHANNEL
3 FEET UPSTREAM OF CONTROL SECTION

FIGURE 28
REPORT HYD-410

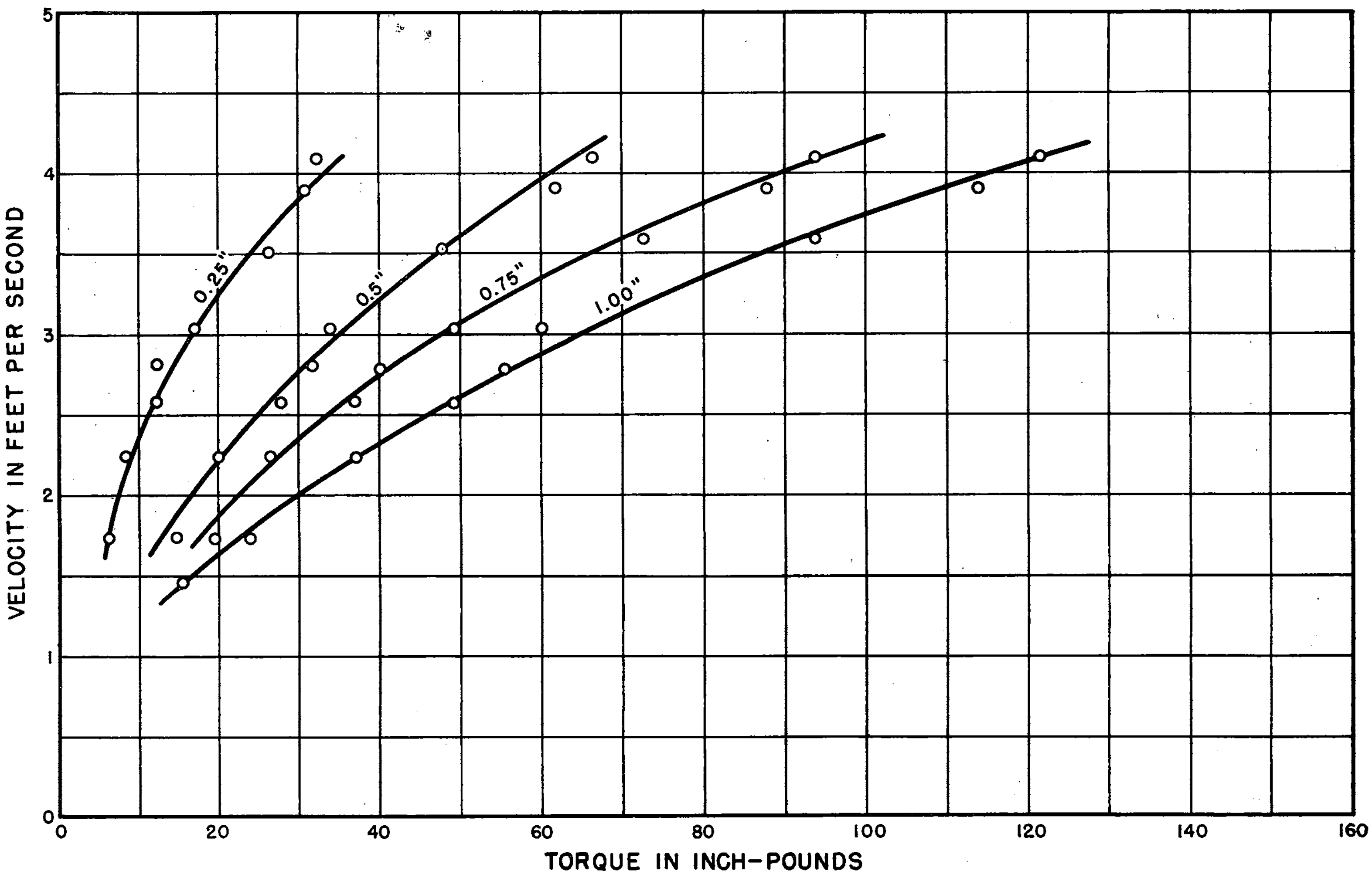




Delta-Mendota Intake Canal
VELOCITY CONTROL DEVICE
Buoyant Vane Model

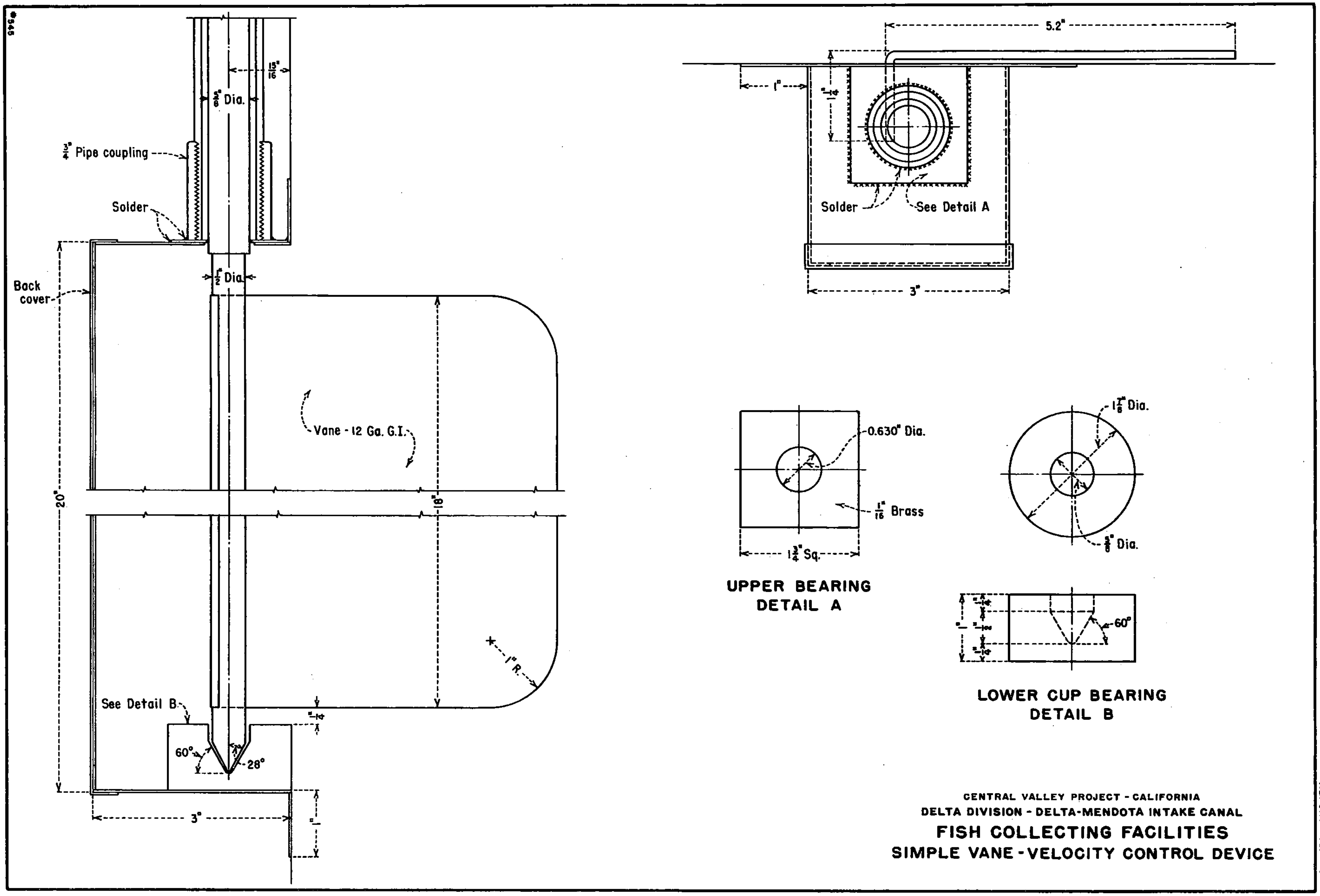


DELTA-MENDOTA INTAKE CANAL
VELOCITY CONTROL DEVICE
PRESSURE DIFFERENTIALS
BUOYANT VANE
V=3.11 FEET PER SECOND



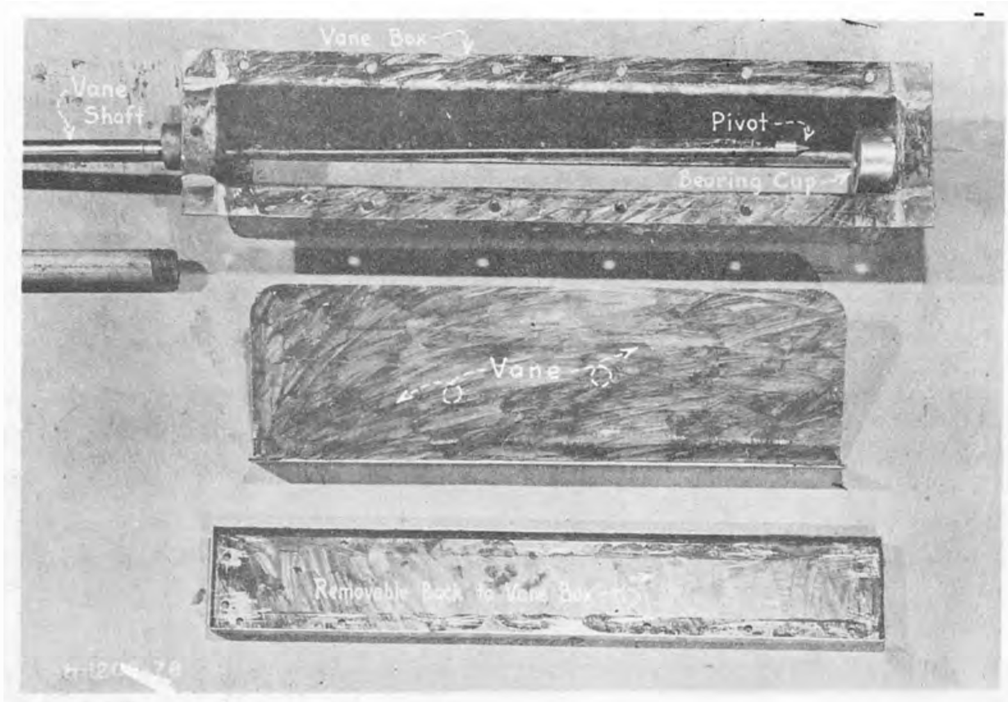
TORQUE CHARACTERISTICS
BUOYANT VANE

VELOCITY VS. TORQUE
FOR VARIOUS VANE DEFLECTIONS
MOVEMENT OF VANE INTO VANE BOX
WITH INCREASING VELOCITY

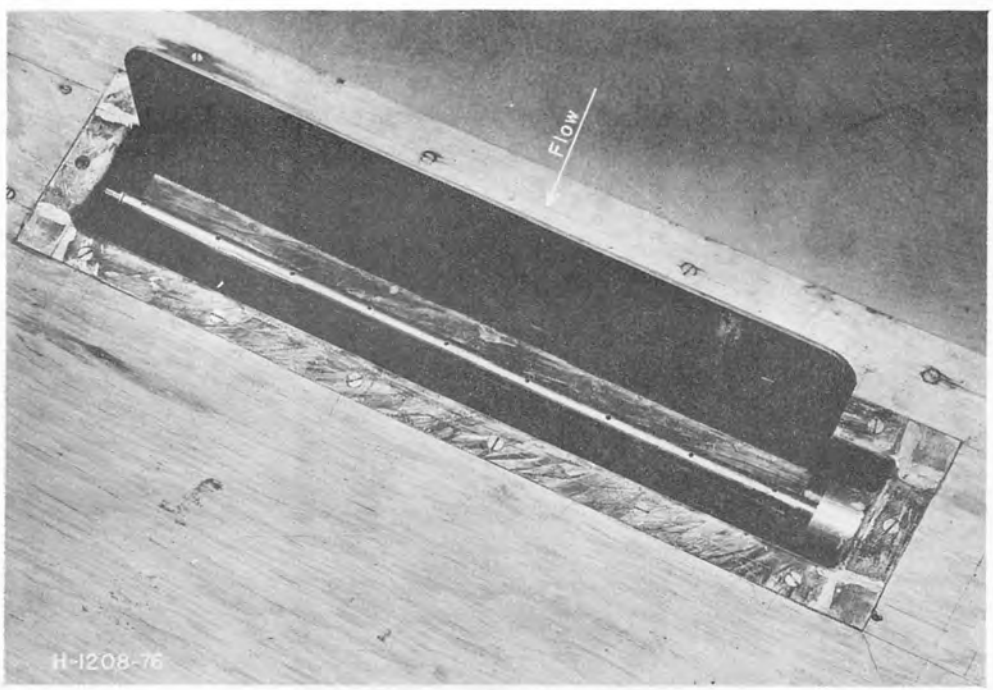


CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES
SIMPLE VANE - VELOCITY CONTROL DEVICE

FIGURE 32
REPORT HYD-410

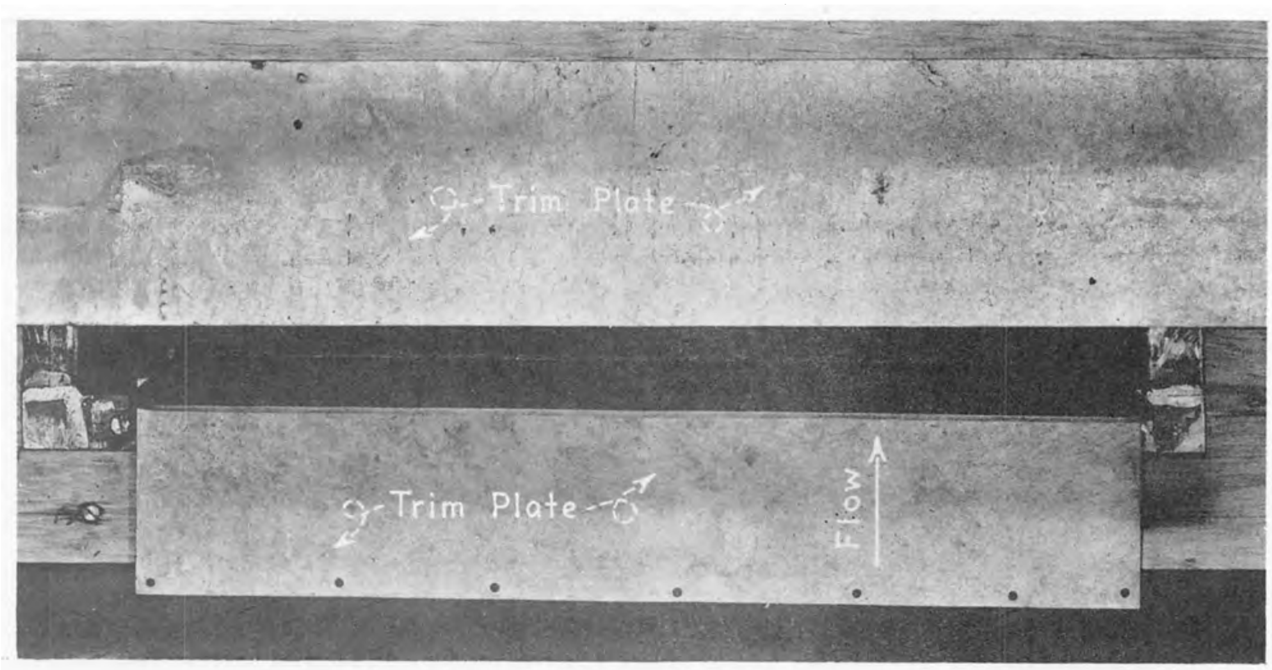


(A) Simple vane unassembled

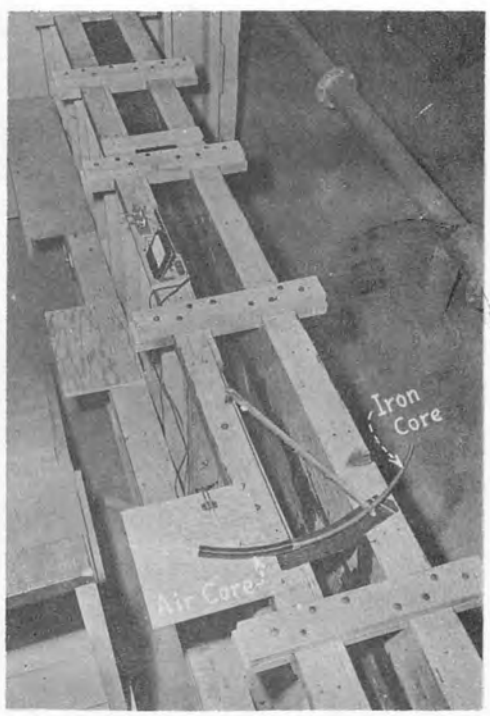


(B) Simple vane at position for zero velocity

Delta-Mendota Intake Canal
VELOCITY CONTROL DEVICE
Simple Vane Model

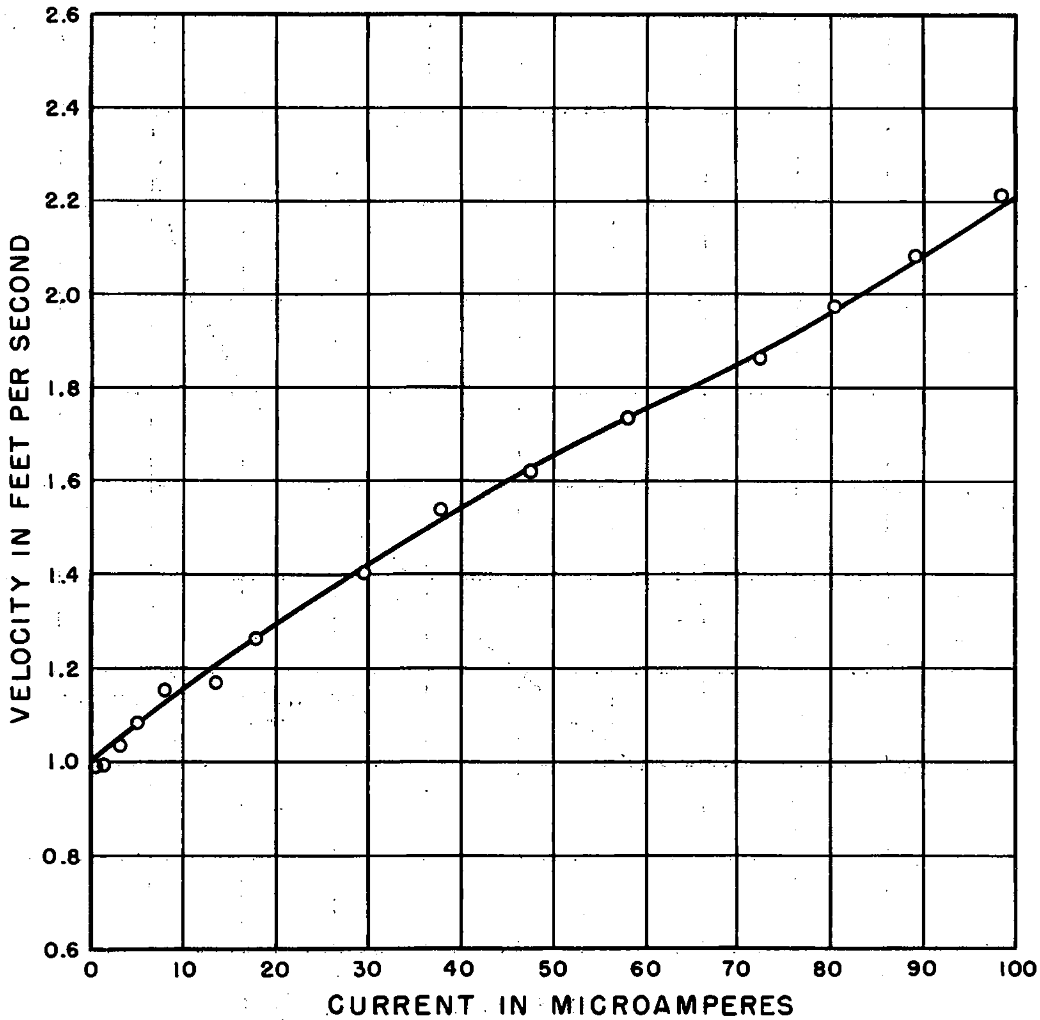


(A) Simple vane with trim plates installed

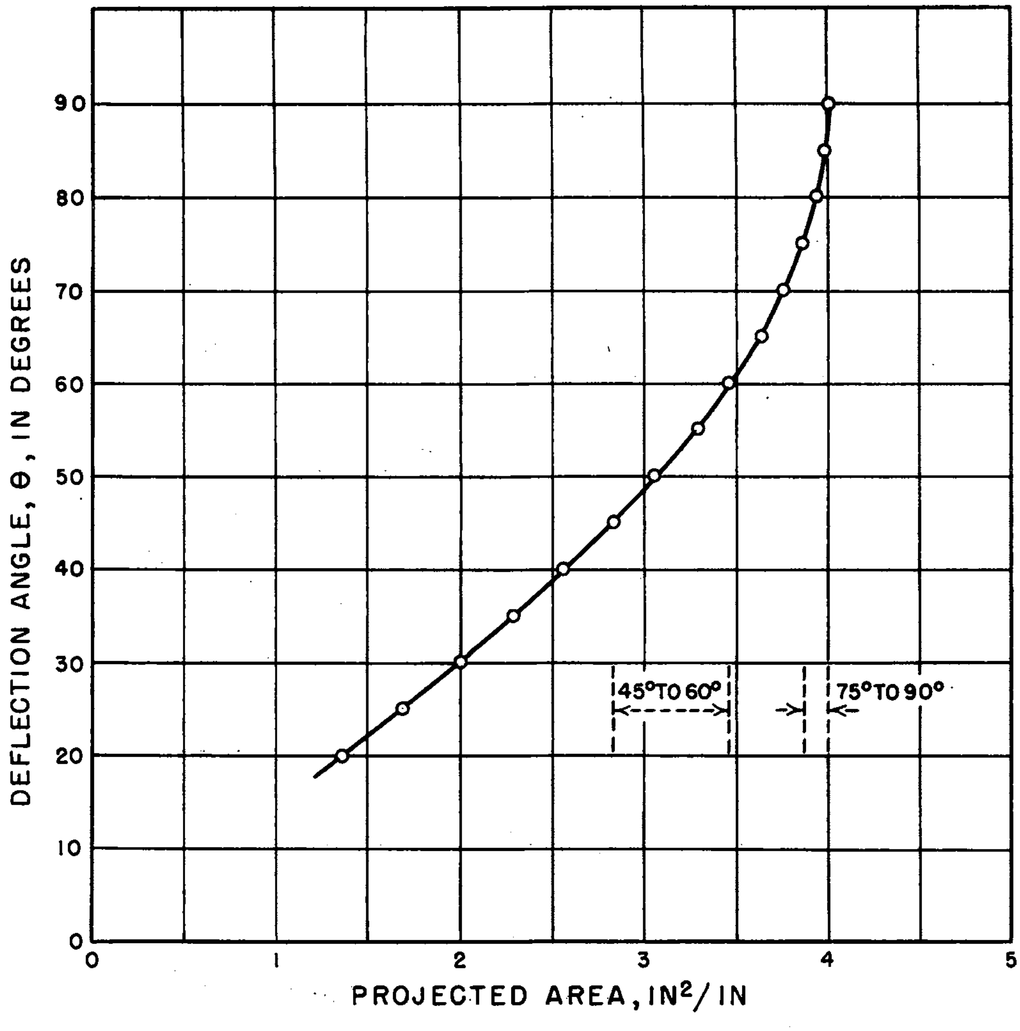


(B) Impedance bridge assembly

Delta-Mendota Intake Canal
VELOCITY CONTROL DEVICE
Modified Simple Vane and Electrical Position Indicator

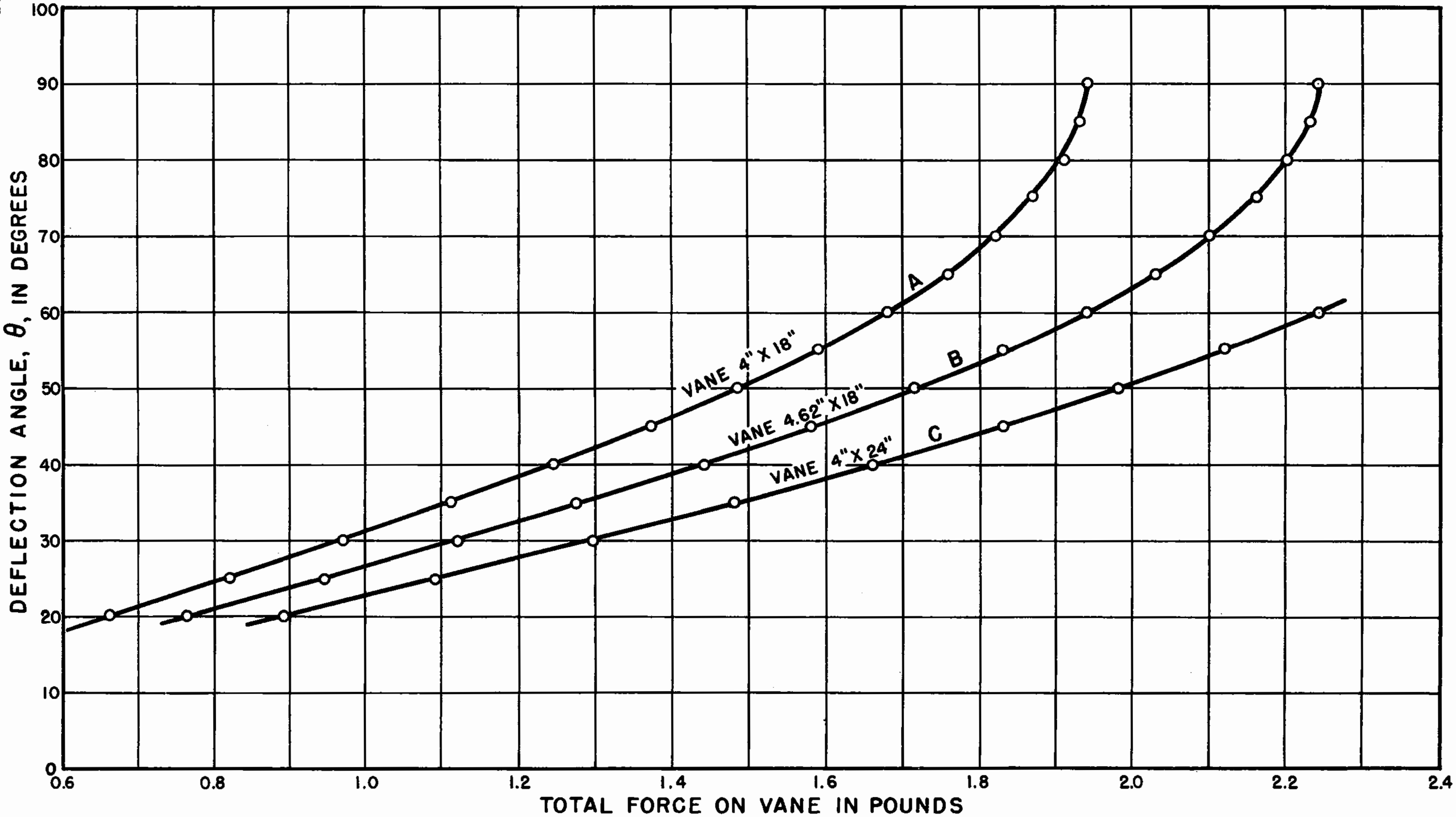


DELTA-MENDOTA INTAKE CANAL
VELOCITY CONTROL DEVICE
SIMPLE VANE DEVICE
4" x 18" VANE
VELOCITY VS. CURRENT FLOW



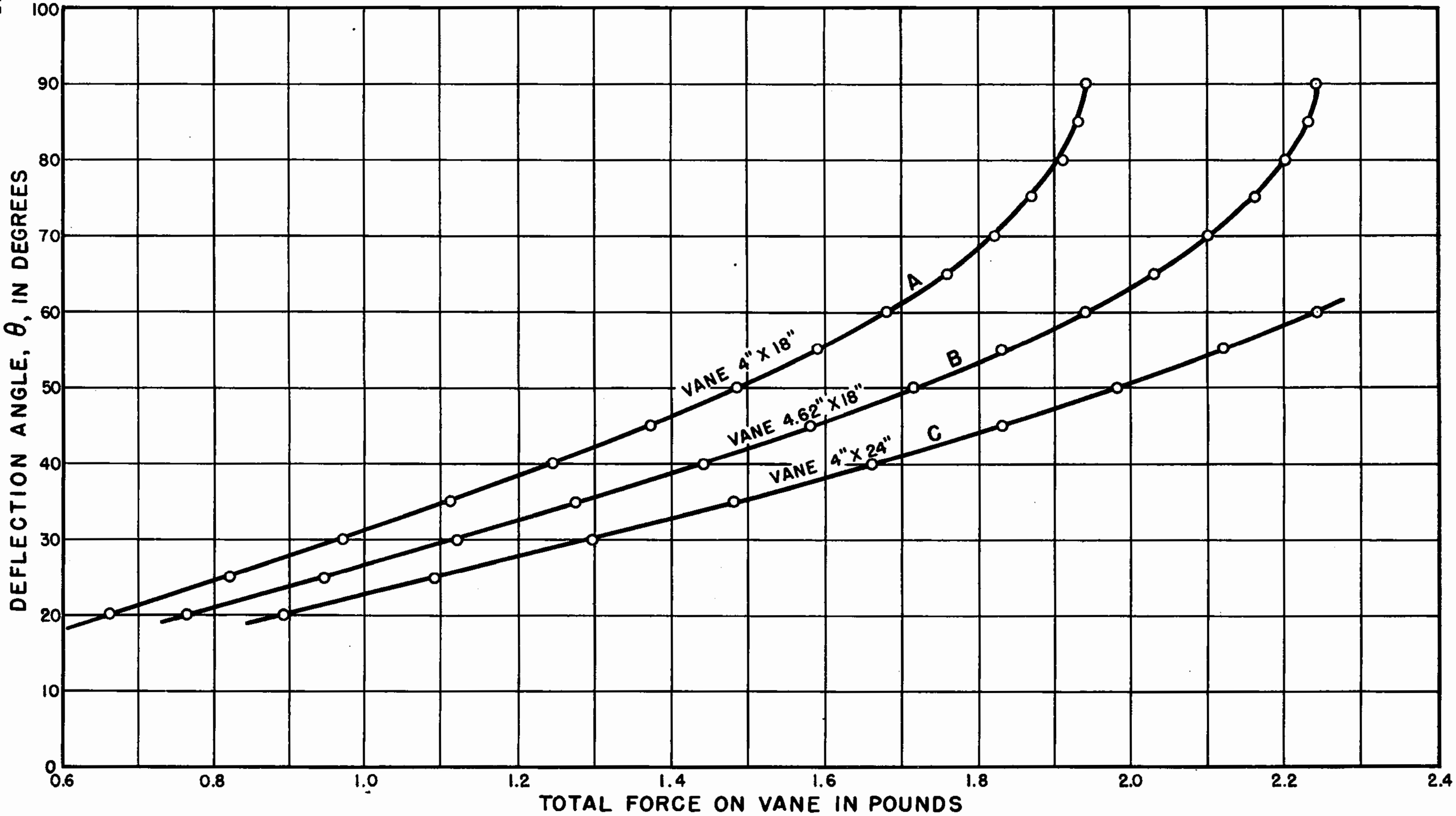
DELTA-MENDOTA INTAKE CANAL
VELOCITY CONTROL DEVICE
PROJECTED AREA VS. VANE DEFLECTION
CHANGE IN PROJECTED AREA OF A VANE
4" WIDE FOR EACH UNIT HEIGHT WITH
VARIOUS DEFLECTION ANGLES

545



DELTA-MENDOTA INTAKE CANAL
VELOCITY CONTROL DEVICE
VANE ANGLE VS. VANE FORCE
FOR VARIOUS SIZES
V= 2.0 '/s

FIGURE 37
REPORT HYD. 410

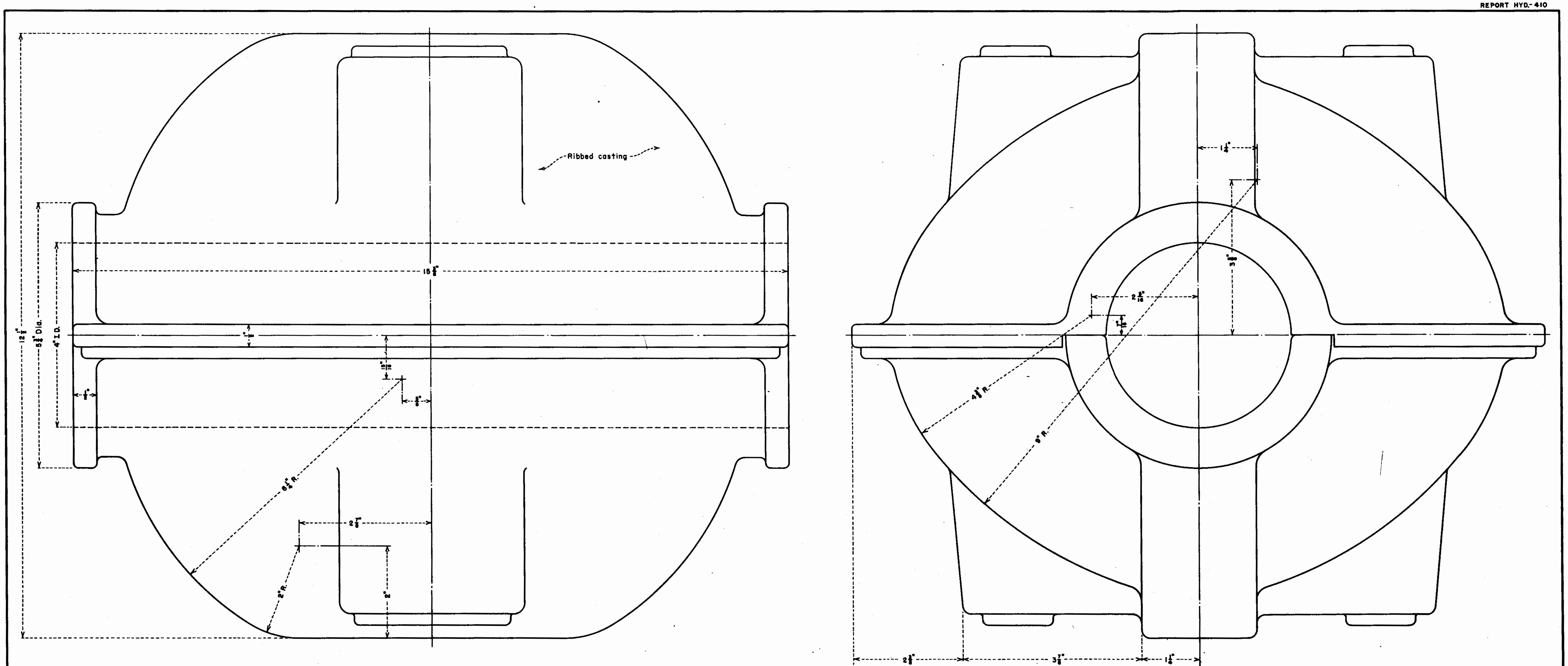


DELTA-MENDOTA INTAKE CANAL
VELOCITY CONTROL DEVICE
VANE ANGLE VS. VANE FORCE
FOR VARIOUS SIZES
V= 2.0 '/s

545

FIGURE 37
REPORT HYD. 410

FIGURE 38
REPORT HYD.-410



CENTRAL VALLEY PROJECT - CALIFORNIA
DELTA DIVISION - DELTA-MENDOTA INTAKE CANAL
FISH COLLECTING FACILITIES
MAGNETIC FLOWMETER - VELOCITY CONTROL DEVICE