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INFORMATIONAL ROUTING PAP-53

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Memorandum
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Denver, Colorado
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Results of model tests to improve the flow conditions for the louver installation--Delta-Mendota Canal headworks--Central Valley Project

The model tests as outlined in our letter to the Regional Director, Sacramento, California, on January 14, 1954, have been completed. This memorandum contains a summary of the tests and the recommendations that were derived.

The model studies were performed on two models. One was a hydraulic model of a 16-foot length of the line of louvers built to a scale of 1:4 to give an over-all picture of the flow pattern. The other, a full-size reproduction of part of the louver screen, was a 6-inch high portion of the louver about 4 feet in length, and was tested using air instead of water.

The investigation was directed at correcting an existing poor flow condition and to obtain a constant velocity in the approach channel and a uniform distribution through the louvers. For the initial tests the existing design was installed in both models and the poor flow condition duplicated in order to determine the cause. The poor flow condition was quite apparent in the models. Figure 1 shows the flow lines through the louver as traced by confetti. The concentration of flow lines along the right side shows that part of the flow is deflected parallel to the line of louvers, causing the water velocity to increase about 2-1/2 times from the upstream end of the louver to the downstream end. This is caused by the condition on the downstream side of the louver where the flow lines show that the flow is normal to the line of louvers for a considerable distance before it turns to the original flow direction. In order to turn the flow from each louver space, the water surface in the adjacent space (upstream) must be slightly higher. This backwater build-up progresses upstream from space to space along the line of louvers until at the upper end it allows very little flow through the louver. This is indicated by the absence of flow lines in this area. The build-up is also reflected downstream by an increased flow velocity along the left wall.

The investigation of this design in the air model showed practically the same conditions. Figure 2 shows the flow lines traced by smoke streamers induced into low velocity flow on the upstream side of the louvers. The deflected flow is indicated by the distance the smoke travels along the upstream face of the louver before it passes through. On the downstream side, the distance the smoke travels normal to the louver before it turns is also quite apparent. The preliminary tests indicated that if each unit of the louver would take its proportionate share of the flow, the flow would not be deflected and even flow distribution and a constant approach velocity would be attained.

The upstream side of the louvers could not be altered since it was thought that the fish repelling characteristics might be changed; therefore, the modifications were developed on the basis that they had to be placed on the downstream side. Preliminary tests showed that if the flow emerging from the louvers was forcibly turned so that it flowed in the proper direction the backwater build-up was minimized and good approach flow resulted. Good outflow conditions might also be accomplished by downstream channel realignment but obviously would be very expensive, so all further tests were made to determine the length and spacing of flow straighteners placed on the downstream side of the louvers. The length of the flow straighteners would depend on their spacing since in order to completely turn the flow the straighteners must overlap. The flow had to be turned about 70° which set the minimum spacing as one vane for every two louver spaces.

Two flow straighteners were investigated in the air model; the first had a vane for every two louver spaces, Figure 3, and the second a vane for every eight louver spaces, Figure 4. The flow patterns were traced by the smoke streamers and the results photographed. Figure 5 shows the pattern through the two flow straighteners. In both cases the smoke entered the louver more directly than it had in the case of the louver without the straighteners; it was also apparent that the stream was turned and flowed downstream with a fairly uniform distribution. Of the two flow straighteners tested, the closer spacing provided the better flow distribution.

Another method of determining the effectiveness of flow straighteners was to determine the velocity increase along the upstream side of the louver. The ratio of the increase in velocity versus the spacing of the straightening vanes has been plotted on Figure 6. The velocities were measured at the upstream end of the line of louvers, V_1, and at the downstream end, V_2.

The spacing was measured normal to the flow lines. For this test both models were used; in the air model tests were made with the two flow straighteners previously described. In the water model two tests were made, one with the louvers alone, and one with a flow straightener patterned after the wider of the two tested in the air model.

Flow in the air model without a flow straightener can also be considered as flow with a straightener every 15 inches with the upper and lower model boundaries being the straighteners. Data were obtained from the models for five different spacings; in addition, data were used from information available of tests that had been performed in the test flume at the Delta-Mendota Canal headworks. From the curve on Figure 6 it is possible for the designer to determine the best spacing in keeping with the desired flow efficiency and construction economy. The curve shows that any spacing up to 6 inches will provide good velocity distribution.

The head loss across a system of louvers with or without the flow straightener was also obtained from the models. In the 1:4 model the head loss was determined from a point about 4 feet (prototype) upstream from the start of the line of louvers to a point about 4 feet (prototype) downstream from the end of the line of louvers. The test showed that the head loss for the louver without the flow straightener was about 0.24 foot; when the flow straightener was added, the head loss was reduced to about 0.14 foot, a reduction of about 40 percent. Similar measurements taken in the air model also showed the flow straightener reduced the head loss, with the closer spacing being more effective than the wider spacing.

With a flow straightener vane fastened directly to a louver slat, the flow area for the louver space immediately downstream is constricted. Although this does not reduce the flow, the possibility that it might become clogged with trash necessitated a test to determine the effect of separating the flow straighteners from the louvers. Figure 7 shows the flow pattern with the flow straighteners about 2 inches from the louvers. There was very little change in the flow pattern and the effectiveness of the flow straighteners was not impaired. Although tests were not made, it is thought that if the louver slat is extended to intersect the displaced flow straightener vane its effectiveness would not change.

For comparison, the flow lines in the 1:4 model when the flow straightener is used are shown in Figure 8; both the upstream and downstream distribution is much evener than that shown in Figure 1.

Acknowledgement is made of the assistance and cooperation that were received from Messrs. H. W. Kidder and W. E. Leegan during the progress of the model tests.

Figure 1--Flow lines in 1:4 scale model

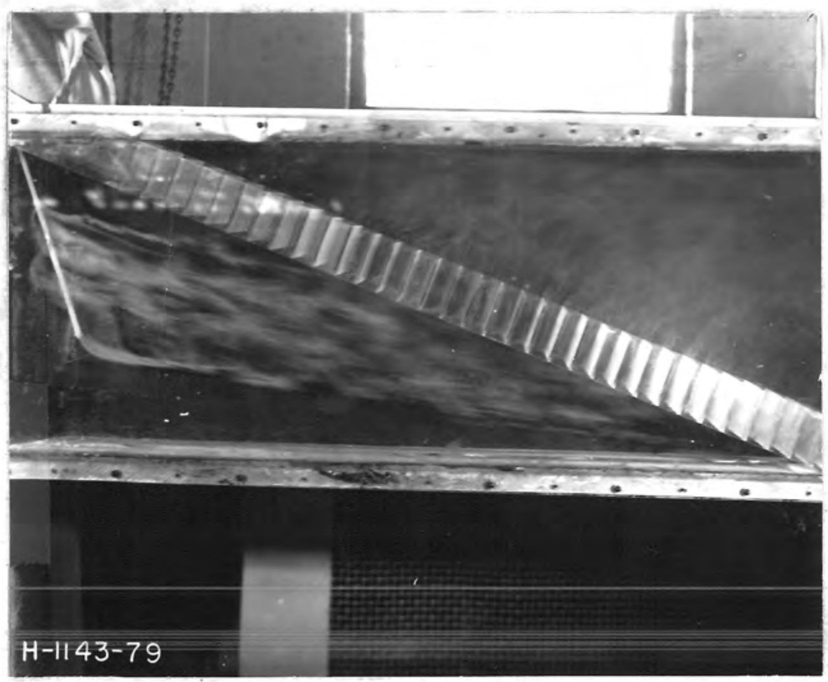
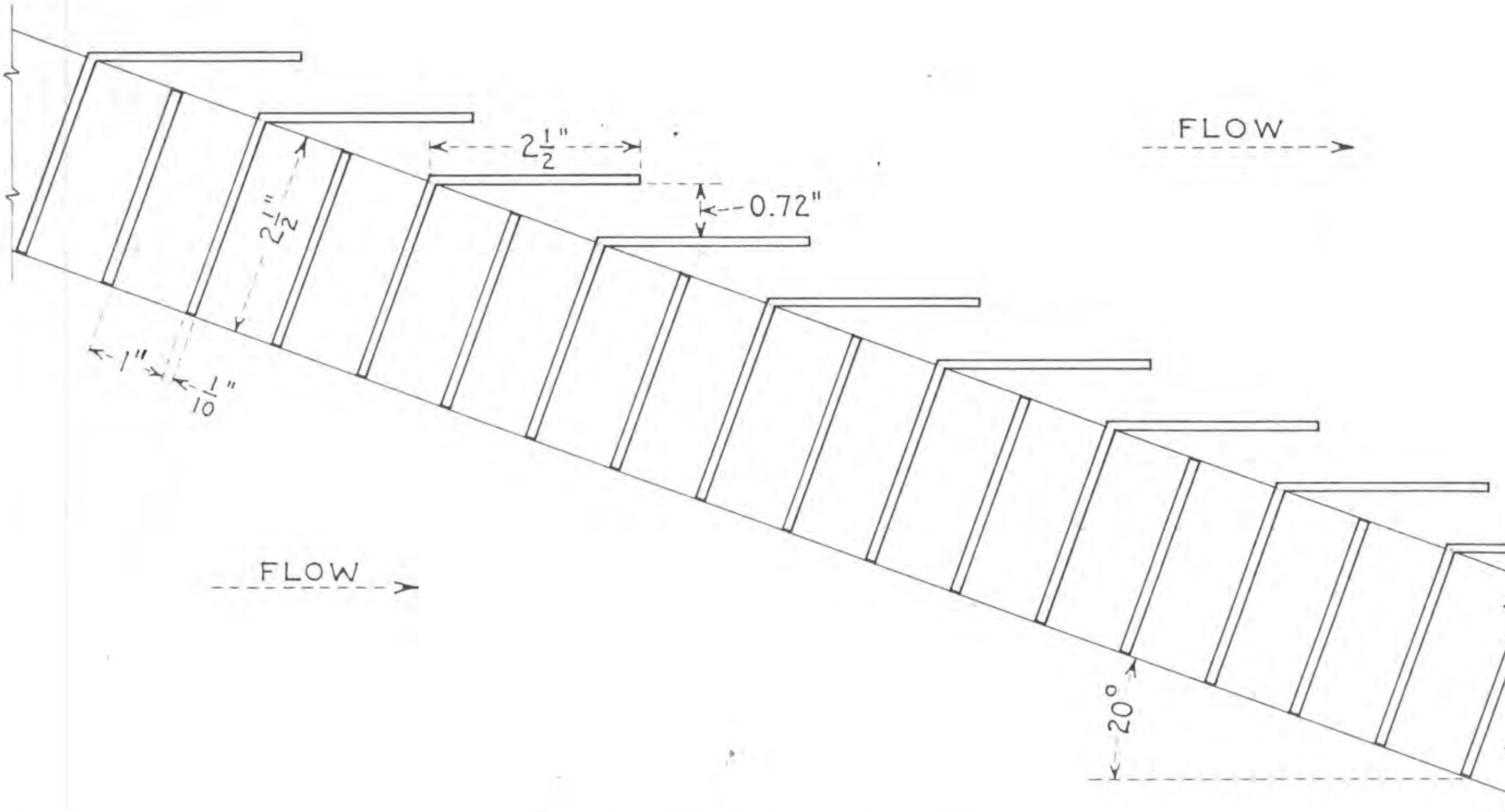


Figure 2--Flow lines through louvers in full-size sectional model



LOUVER FISH SCREEN
MODEL STUDIES

FLOW STRAIGHTENERS

FIGURE 3

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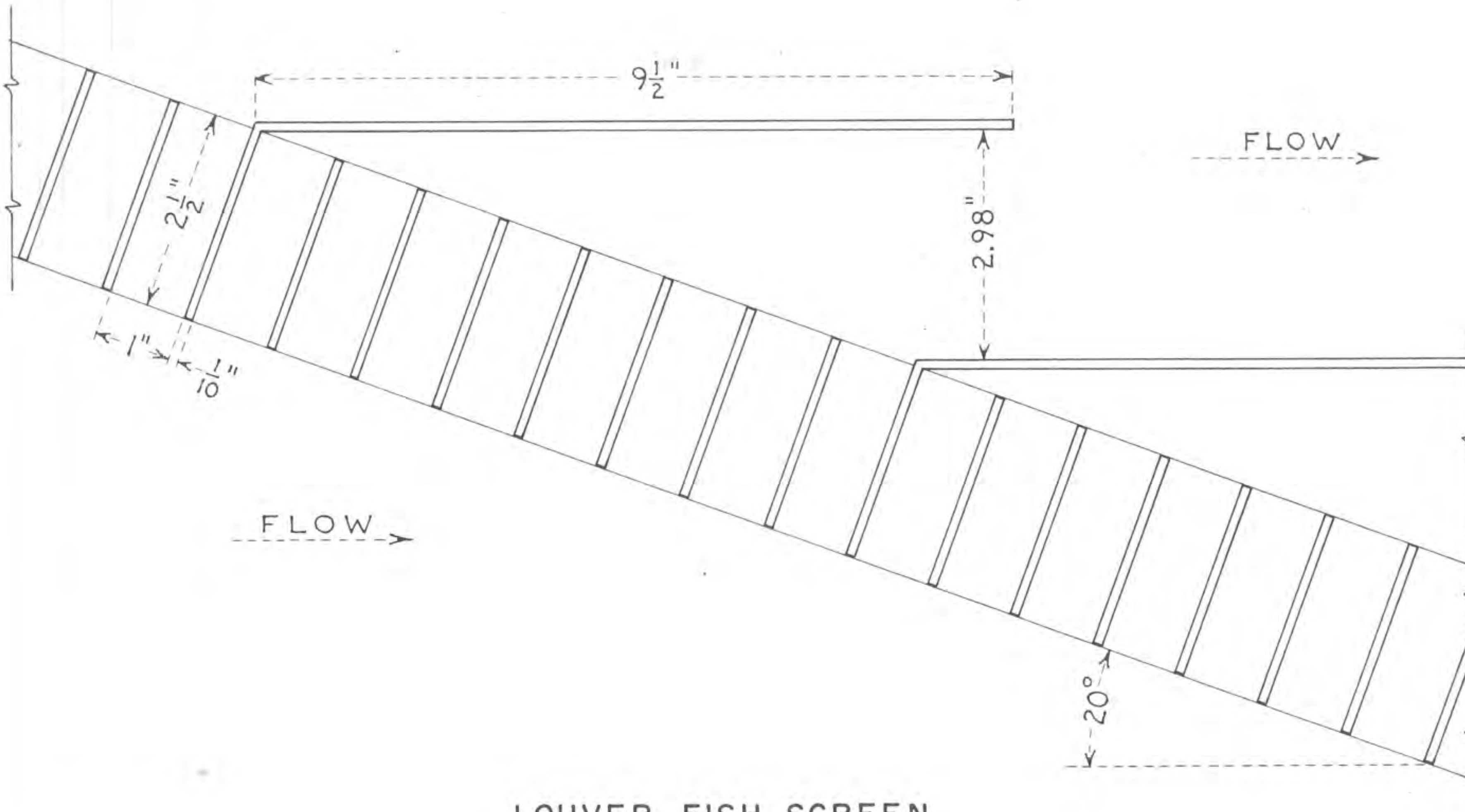

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FIGURE 4

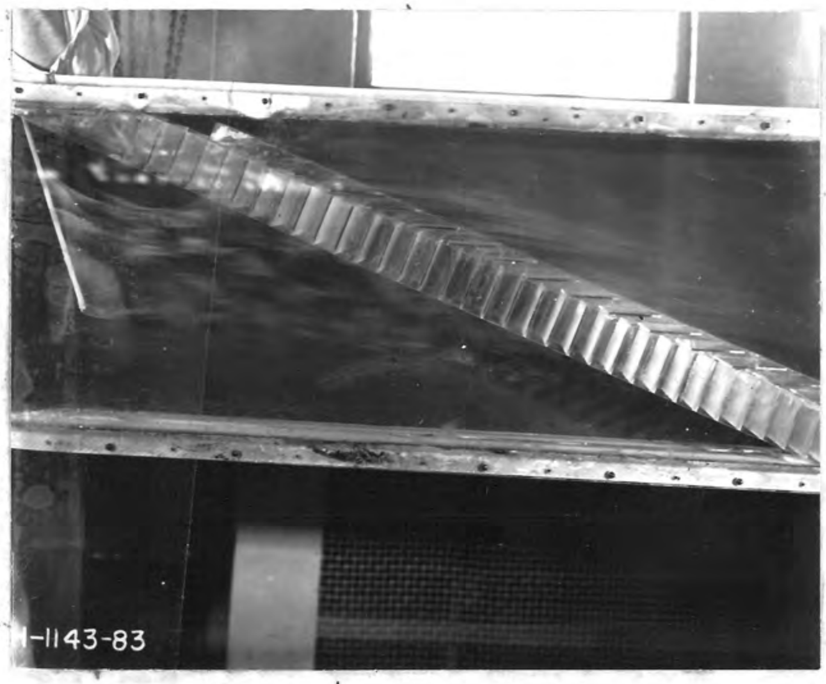


Figure 5-A--Flow lines through louvers--close-spaced flow straighteners in place

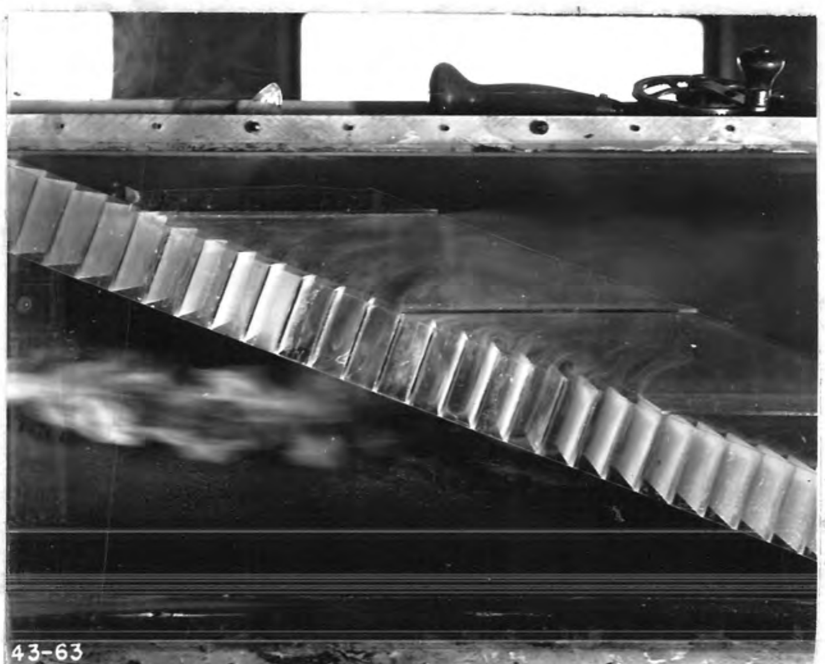
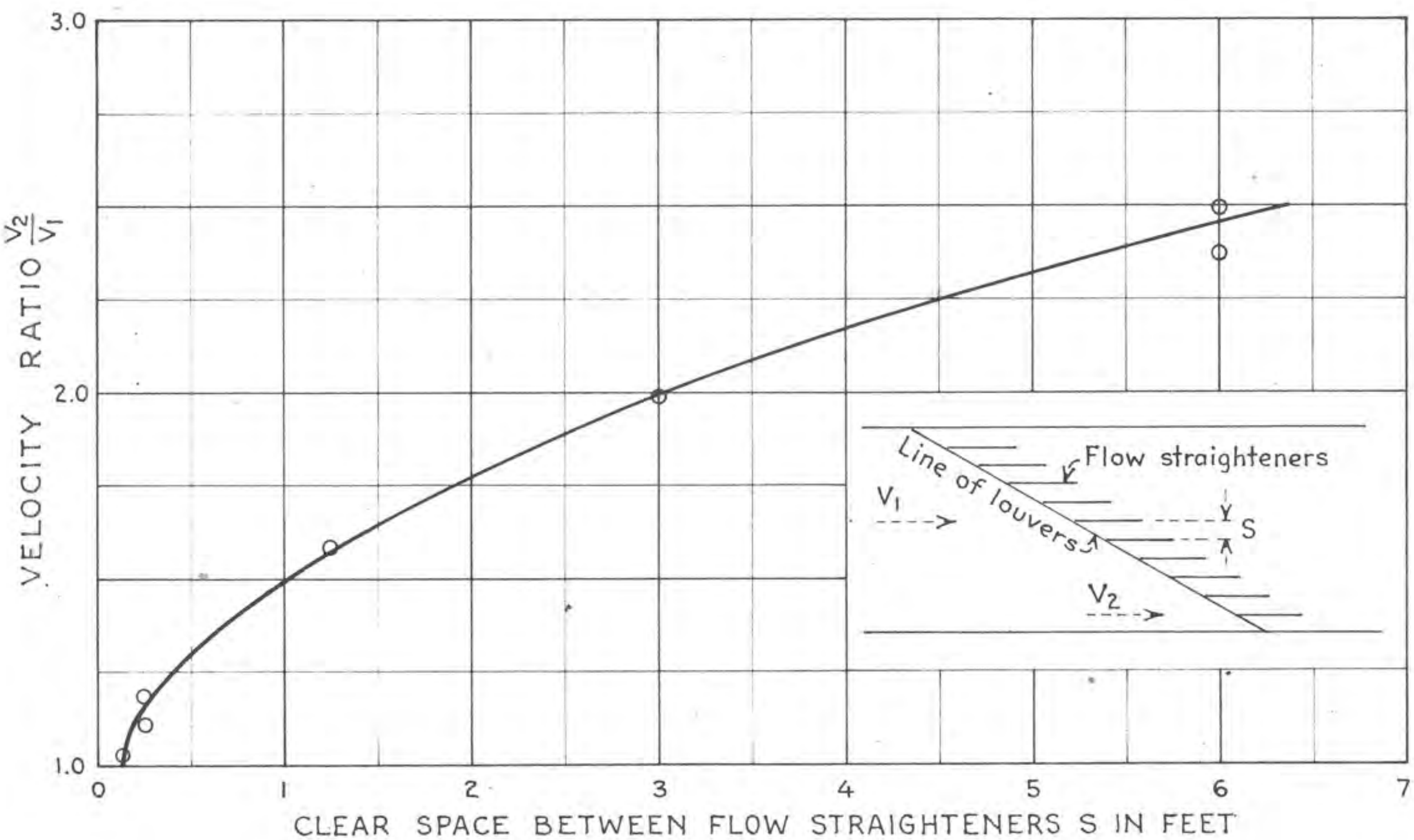


Figure 5-B--Flow lines through louvers--wide-spaced flow straightener in place



RELATION OF FLOW STRAIGHTENER SPACING
TO VELOCITY INCREASE ALONG UPSTREAM SIDE OF LOUVERS

FIGURE 6

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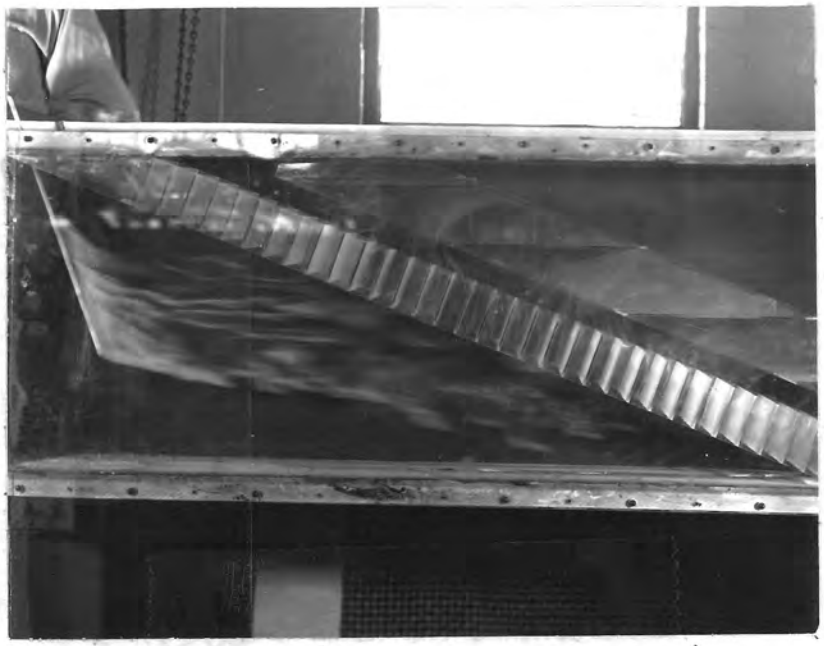

Figure 7--Flow lines through louvers--wide-spaced flow straightener separated from louvers by about 2 inches

Figure 8--Flow lines in 1:4 scale model with flow straightener in place