HOLMES & NARVER, INC.
Engineers-Constructors

Surveys

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8-28-53

To: S. P. Howell JS

Job: 884

From: David L. Narver, Jr.

6 pages

Re: Alignment of Stations 1203, 2220, 2230

Date: August 28, 1953

The following procedures are recommended for alignment of the pipe arrays at Stations 1203, 1220 and 1230 to a horizontal and vertical tolerance of plus or minus 1.0 inch from a line of sight between working points at the extremities of the lines. The procedure consists of establishing horizontal control from an offset line parallel to the centerline of an array and bench marks at convenient intervals for vertical control. The alignment of the pipes is made by horizontal and vertical measurement from reference marks on the supports transfered from these control points. Procedure for the 7500 foot line at Station 1203 is outlined herein and can be modified to accomplish the alignment of the shorter lines at Stations 2220 and 2230.

With precise equipment and qualified personnel the accuracy which can be obtained in establishing the alignment controls is dependent on the methods used and the atmospheric conditions during the alignment operations. As the alignment of the pipe lines will be subject to additional factors affecting the accuracy of the results including construction tolerances of the pipe itself, Temperature distortion and wind deflection, it is imperative that the controls be established as accurately as is possible under the existing field conditions.

Horizontal Control Horizontal refraction is the most likely source of error in this operation and as it is an indeterminate quantity as related to the alignment, it will be necessary to accomplish the work under the most favorable conditions that can be obtained. As refraction is caused by variations in the temperature and density of the air and may be increased by unequal movements of air crossing the line of sight, alignment of the control stations should be accomplished at night when these variations are at a minimum. The hours just before daylight should approach the ideal conditions. Gusty, windy weather is unfavorable as it will be necessary to shelter the alignment equipment. However, a light breeze may help to minimize the conditions causing refraction. The line of sight should be as high as practical above the ground as the density of the air decreases with the elevation of the line of sight. The line should be cleared of vegetation and it is desirable that there be a free movement of

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air across the line, not broken by obstructions such as buildings and clumps of trees. As the pipe hangers will be under construction before the control surveys can be completed it will be necessary to establish these controls on an offset line and it is desirable, because of refraction problems, that the line be on the windward side of the structures and several feet away from them. After completion of the offset line, markers can be set on the true centerline of the pipe array of or a closer offset where they will be protected by the hangers.

Six points should be established on the control line. One opposite the working point at each end of the line and four approximately equally spaced along the line. Before the precise work starts these points should be established as accurately as is possible with standard equipment working under daylight conditions. They should be monumented with a plate or cap set in concrete which is large enough for the final alignment mark to be made on it after the adjustment is completed. From these six points the longest distance to an intermediate alignment point on the pipe lines will not exceed 750 feet and additional points can be easily established between any pair, if required. It should be recognized that as the line of sight is lengthened the probability of error in reading an offset to a pipe line increases and therefore the maximum distance between control stations should be well within the limitations of the equipment used for the survey.

Wild T-2 theodolites with diaphragms containing double vertical hairs are available. It has been proven that there is less observational error in centering a target between two parallel hairs then by use of the single hair. Target and alignment lights, with narrow slits and illuminated by diffused light, are on requisition. The alignment lights will be mounted on a support with a lateral micrometer adjustment similar to those used for the site Gene alignment (See Sketch No. 1). Portable radios will be required for communication.

The alignment procedure is to set up a target light at one end of the offset line, the observing instrument at the other end and establish the nearest intermediate line point to the instrument. Then, moving to each new point successively establish the remaining line points. Always moving ahead in the direction of the target light.

In establishing the intermediate points, an alignment light is used which is mounted on a base having lateral movement by means of a tangent screw and the amount of this movement can be read on a micrometer scale. The observer brings the vertical hairs of the theodolite in alignment with the illuminated slit in the target light then directs the movement of the alignment light, which has been set up over the immediate point, until the illuminated slit in this light bisects the vertical hairs in the instrument. The reading of the

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micrometer scale is recorded, the alignment light moved off line in the opposite direction, by means of the tangent screw, and the operation repeated. After a total of sixteen readings has been taken, eight from each side of the line, the alignment light is adjusted to set the micrometer scale at the mean of these sixteen readings. A plumb bob is then suspended from a scribe mark centering the light slit and a reference mark is made on the monument cap. The instrument is then moved to this newly established point, the alignment equipment to the next location and the operation repeated. The complete operation establishing and checking all intermediate points should be performed on three successive nights or until results indicate that alignment has been established to specified tolerances. The second alignment should be made in the reverse direction. Complete records should be made of each operation including the alignment micrometer readings and any variations found in the checks made on successive nights.

Vertical Control To establish a straight line between the working points at the extremities of the line for vertical control, the effects of curvature of the earth's surface and refraction must be eliminated. As the effects of this refraction cannot be accurately predetermined, it is believed that greater refinement in vertical alignment can be obtained by establishing a level line and compensating for curvature of the earth's surface than by attempting a direct line of sight between working points.

A series of bench marks should be established along the line at approximately 500 foot intervals. A precise level and Invar rods are available at the jobsite and are satisfactory for this purpose. The procedure is, starting at one end, set up the level midway between each successive pair of bench marks and carry the elevations through to the opposite end of the line and return, by the same method, through the bench marks to the initial mark. Extreme care should be taken in leveling of the instrument and the plumbing and reading of the rod. The effect of refraction and instrumental error will be negligible if the rod readings are taken with the instrument set up midway between each pair of bench marks. The operation is repeated and an additional check made between any two bench marks where an obvious discrepancy is found. The closing error in each circuit should not exceed 0.017 foot times the square root of the distance in miles. The adopted elevations of the bench marks are the mean elevations of the two circuits after the closing error has been porportioned through the circuits.

When satisfactory elevations of the bench marks have been established, the relation is computed between the level line following the curvature of the earth's surface and a straight line tangent to this curvature at the mid point of the line. This correction is based on the radius of curvature of the earth's surface at the latitude of the observer and the azimuth of the line. The correction is then applied to the elevation of each bench mark and the resulting elevation is the height above a datum plane perpendicular to the radius of curvature and passing through the vertical axis of the working points at either end of the line. Grades and elevations, based on this datum, have been competed for each pipe line.

Stations 1220 and 2230 The procedures to establish vertical and horizontal control for these stations should be generally the same as for Station 1203 but can be modified somewhat due to the shorter lines. Three intermediate points are recommended for Station 2220 and two for Station 2230. Due to the greatly reduced overall distance at Station 2230 the transit with double vertical hairs, which is available at the jobsite, should be satisfactory for the alignment operations.

Pipe Line Alignment Procedure Alignment of the individual pipes requires two operations. Vertical alignment and horizontal alignment. Due to the large number of adjustments to be accomplished the time and man power required to make an individual adjustment must be held to a minimum. The following procedure is submitted as a basic method subject to modification and improvement resulting from experience gained during the progress of the work. This method provides for establishing basic controls on the pipe supports from which the actual adjustments can be made with a minimum of support from survey personnel. The first step is to bring the pipes into vertical alignment followed by the horizontal alignment and permits completing all adjustments at a support before moving to the next support.

Vertical Alignment This adjustment is made by relation to a reference plane established on each set of pipe support posts (See Sketch No. 2). To simplify the computations it may be practical to establish a group of these reference planes at the same elevation. For example, elevation 13.00 from station 0 + 27.3 to station 30 + 00 and elevation 10.00 from station 30 + 00 to station 74 + 60.75.

(1) A level circuit is run on each side of the array checking through all bench marks. A spike is set in the face of the outer posts, on the opposite side from the cross beams, to the elevations as suggested above. The spike must be stable and provide an accurate surface for support of the reference beam.

(2) A wire is stretched taut between the two spikes at a pipe support and spikes set on this line in the intermediate posts. This will provide a line of spikes at each pipe support all at the same elevation.

(3) A length of standard 3" structral aluminum I beam is laid across a pair of spikes providing a reference plane of known elevation.

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(4) A level rod with a target attachment as shown on sketch No. 2 is used to measure vertically for the adjustment. The level rod with the target set to a predetermined grade rod is set on the reference beam and the pipe adjusted to it. The operation is repeated at each pipe between adjacent posts, then the beam is moved across to the next posts to continue the adjustments.

Horizontal Alignment Due to the height of some of the pipes above ground level this adjustment must be made from controls transfered to the pipe supports as direct measurement from the offset control line is not practical.

(1) Establish monumented control points on a line two feet left (or north) of the centerline of the pipe array by offset from the primary horizontal control line. These points should be at approximately the following stations to space them between pipe supports. (a) 0 + 36, (b) 15 + 20, (c) 30 + 06, (d) 44 + 95, (e) 60 + 00 and (f) 74 + 50.

(2) Construct rigid instrument stands and observers platforms at each of these stations to provide a line of sight two feet above the top cross beams of the pipe supports.

(3) Set up a theodolite at point (A) and sight over the line of cross beams to a target at point (B), then set a reference mark on line on each cross beam from (A) to a support midway to (B).
Set up the instrument at (B) sight on the target at (A), check the last reference mark set from the previous set up and continue marking through to (B).
Reverse the instrument and setting on target at (C) continue marking through to the mid point between (B) and (C). Set up at (C) etc. completing setting reference marks through to (F) by the same method.
It may be practical to accomplish this operation during day-light hours by taking advantage of favorable atmospheric conditions, if not, it can be accomplished at night.

(4) By suspending a heavy plumb bob (32 oz.) from the reference mark on the top cross beam at each pipe support, establish a reference mark on the lower beam. If any disturbance of the plumb line by wind is experienced, the effect can be dampened by suspending the plumb bob in a container of water.

(5) By horizontal measurement from the reference mark in both directions on the cross beam set a mark at the offset for one side of each pipe.

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(6) With a straight edge with an offset level attached, as shown on sketch No. 3, plumb down from each of the reference marks and make the horizontal adjustment of the pipe.

The actual adjustments after completing the horizontal reference marks described above and the vertical reference plane would require a maximum of two surveyors working with each adjustment group. One man on the rods and one computing grade rods and assisting as required.

for W. L. Dietz
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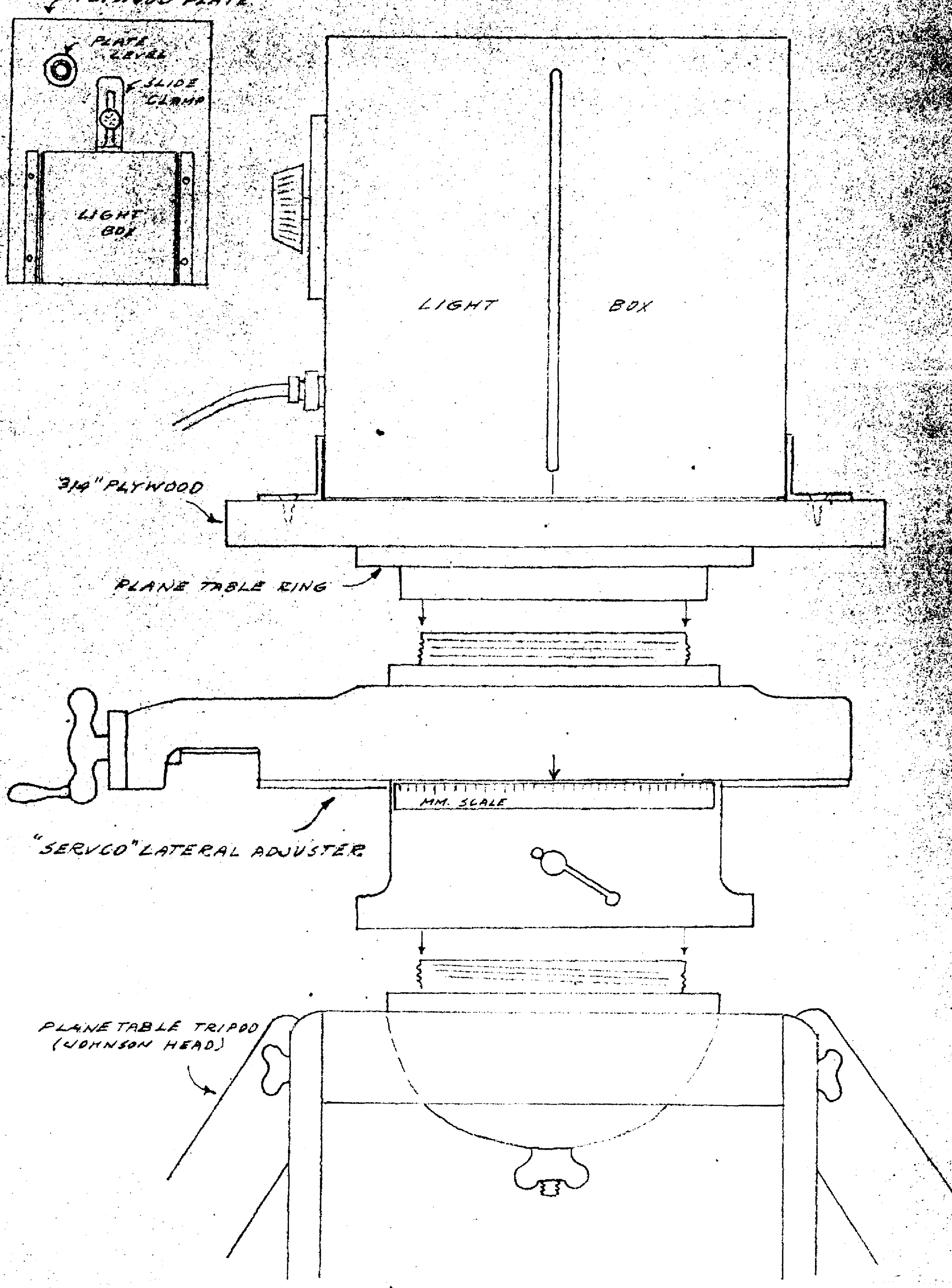
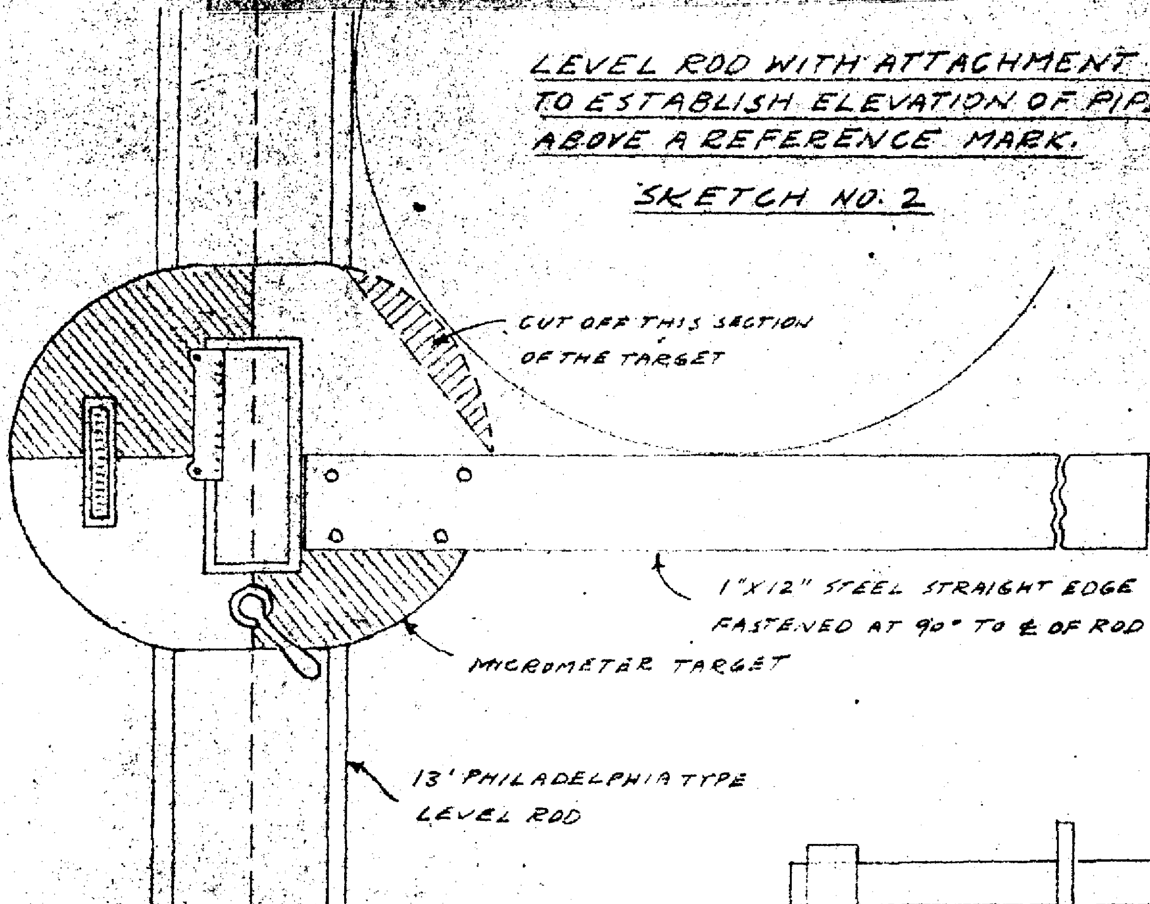
ALIGNMENT LIGHT ASSEMBLY

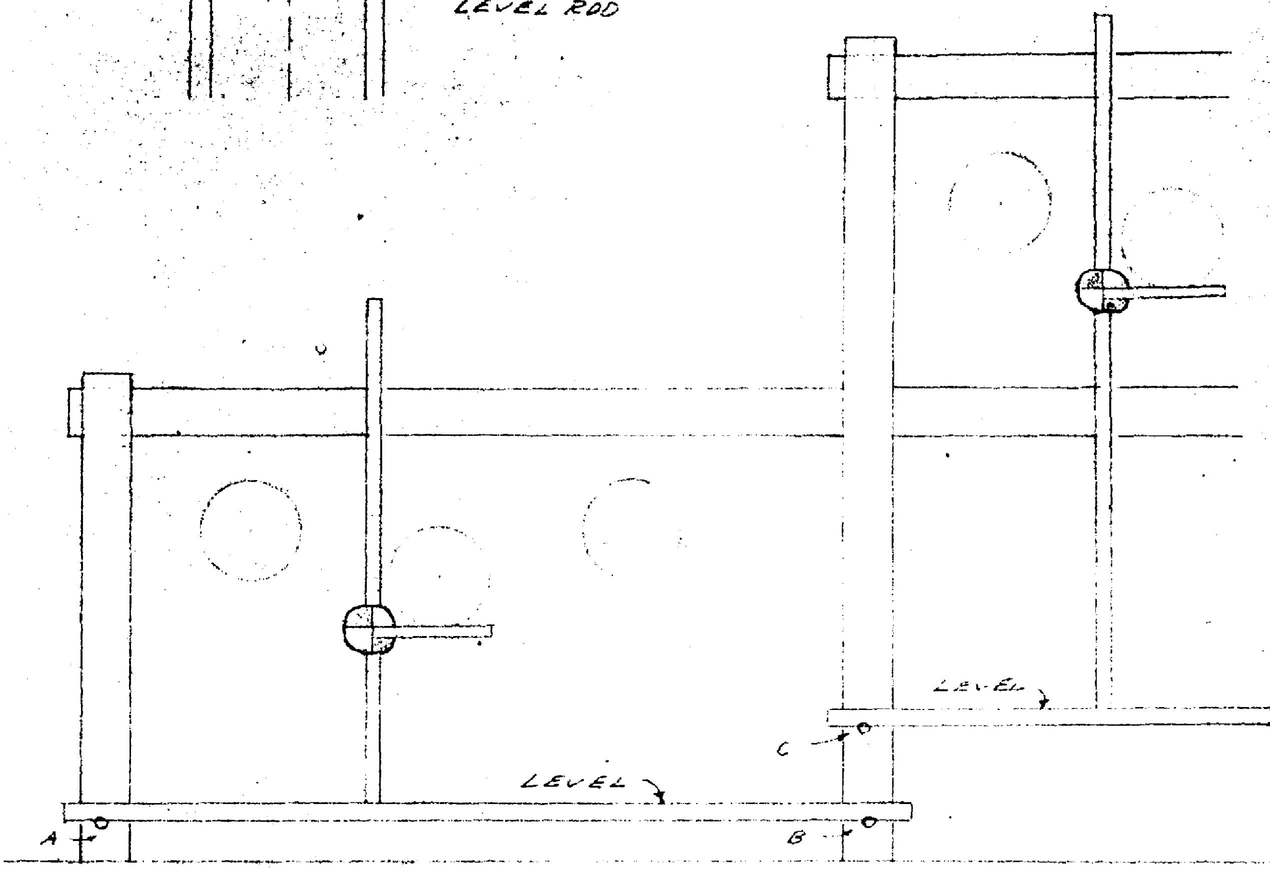
SKETCH NO. 1



LEVEL ROD WITH ATTACHMENT USED TO ESTABLISH ELEVATION OF PIPE ABOVE A REFERENCE MARK.

SKETCH NO. 2





(1) SET SPIKES AT A, B, C ETC. AND DETERMINE THEIR ELEVATION.

(2) LAY ALUMINUM I BEAM OF PREDETERMINED THICKNESS ACCROSS SPIKES.

(3) COMPUTE GRADE ROD AND SET TARGET.

(4) ADJUST PIPE TO TARGET HEIGHT.

METAL STRAIGHT EDGE FOR PLUMBING FROM REFERENCE MARK TO EDGE OF PIPE.

SKETCH NO. 3