REFINING OF A SETTING-UP MECHANISM FOR IMPACT WELDING

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الخلاصـــة :

تمَّ استخدام أساليب تصميم تقنية بالاستعانة بالرسم والكمبيوتر لتحسين أداء الأجهزة المستعملة في اللحام الصدمي . وهناك أجهزة كثيرة رباعيـة الأذرع تُصنع لتوليد الحركة المطلوبة ، حيث تستخدم فكرة الكتلة ثنائية التناول مع مصفوفتي رسم . ومن الواضح أن كلاً من الأجهزة الجديدة تمكّن اللّوح الطيار من الحركة الخطية بدلا من الحركة المنحنية في الجهاز المعدّل . وبذلك فإنَّ الجهاز المهجّن الناتج له فائدة السماح للّوح بالانحراف عن الأفقي .

ABSTRACT

Computer-aided graphical design techniques are used for the improvement of the behavior of an existing setting-up mechanism used for impact welding. To this end several four-bar linkages are synthesized for the generation of the required motion. The two-handled block concept is utilized in connection with two graphical matrices. It is shown that each of the new mechanisms enable the flyer plate to be moved by linear translation, as opposed to curvilinear translation in the original mechanism. The resulting hybrid mechanism has the advantage of allowing the platen to deviate from the horizontal.

Keywords: handle; impact welding; stand-off distance; straight-line trajectory; synthesis; translation; traverse mechanism.

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1. INTRODUCTION

The stand-off distance between the two plates to be welded is an important parameter in spot or seam welding operations employing the principle of oblique collision. The parent (base) plate and the flyer plate (Figure 1) need to be kept parallel during the process. The thickness of the flyer plate is generally between 0.3 mm and 3 mm. The parent plate can be several centimeters thick. The stand-off distance in general increases with increasing thickness of the flyer plate. The parent plate in Figure 1 [1] rests on a platen. The flyer plate is suspended by applying vacuum on its top surface. In order to allow a precise gap between the flyer plate and the parent plate, a parallel linkage mechanism [2] (Figure 2) was devised to traverse the flyer plate. A pneumatic air gun (Figure 1) was utilized for the impact welding operation. A position transducer was employed for the precise measurement of the stand-off distance (Figure 1).

The mechanism of Figure 2 ensures that the flyer plate is always parallel to the parent plate. It does not, however, ensure that the flyer plate is always vertically above the parent plate. The flyer plate is moved, in fact, by curvilinear translation. The curvilinear motion may be considered a serious drawback in certain welding applications, since the flyer plate is physically shifted sideways relative to the parent plate. This undesirable shift increases with increasing plate thicknesses and gaps.

We present below several mechanisms, synthesized by the use of computer graphics, to refine the behavior of the traverse linkage of Figure 2. We illustrate the related procedures [3, 4] in each case by the use of a design package that utilizes the blocking concept. The software must necessarily support two handles on the block. References [8–10] highlight a few of the more recent research efforts in this particular area of synthesis.

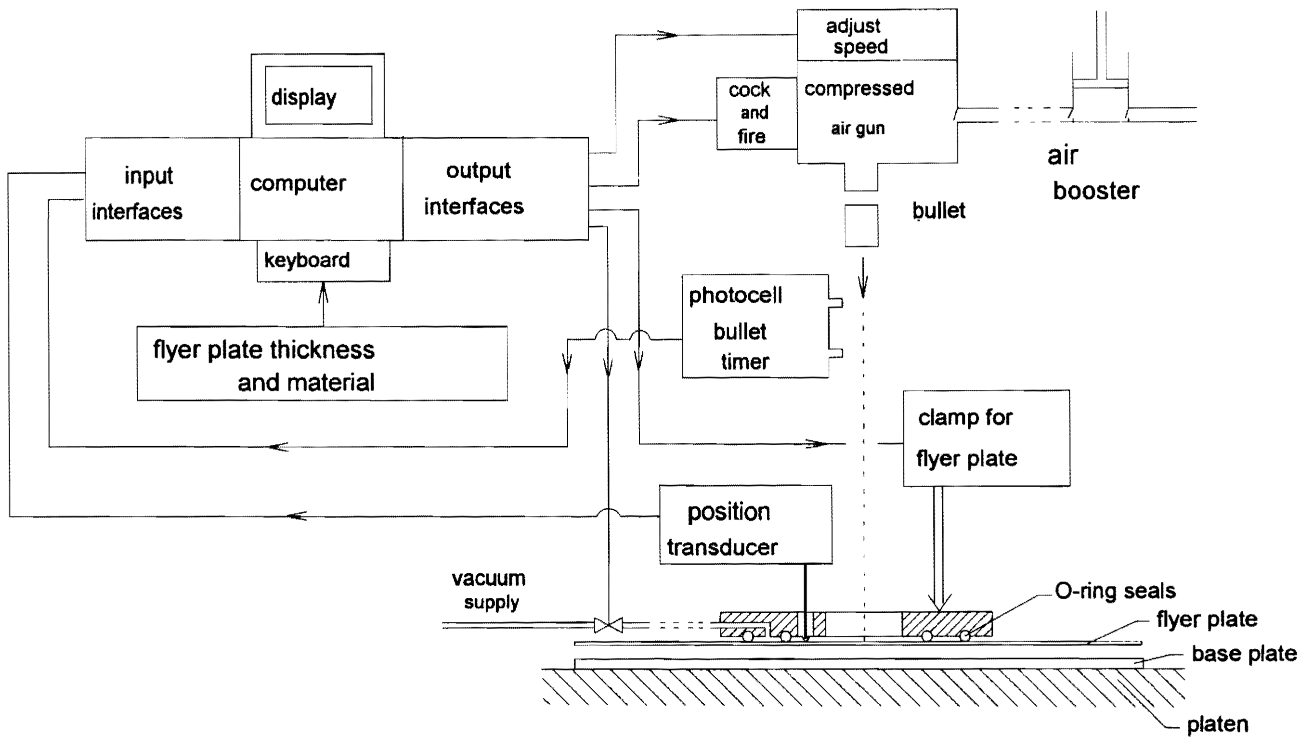

Figure 1. A Semi-Automatic Device for Impact Welding [1].

2. SYNTHESIS BY THE USE OF THE ONE-DIMENSIONAL MATRIX D-1

Consider that at least four significant points (numbered 1, 2, 3, and 4 in Figure 3) are needed on an approximate straight-line to be generated by a four bar linkage. Assume that the location of a fixed pivot A_0 is also specified. The process of synthesis is started by letting the diameter of a circle with center at A_0 to be somewhat larger than the distance between the significant points 1 and 4, assuming that the number of points is 4. Select a distance L that can span the distance from each of the given points to the circumference of this circle, and lay off the corresponding rays, shown dashed in Figure 3. The rays intersect the circle at crank positions 1′ to 4′.

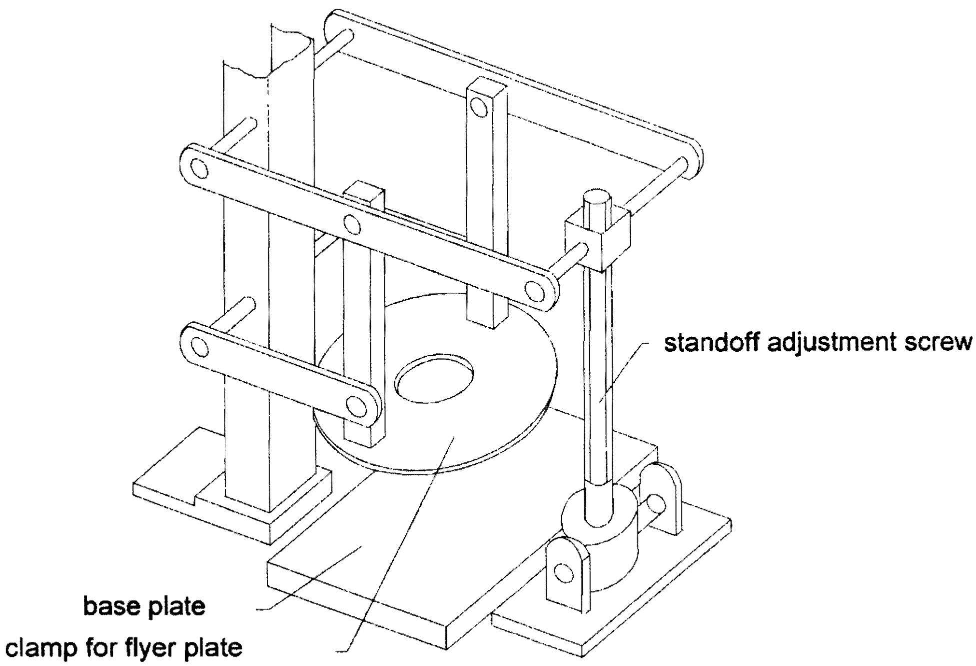

Figure 2. The Original Traversing Mechanism.

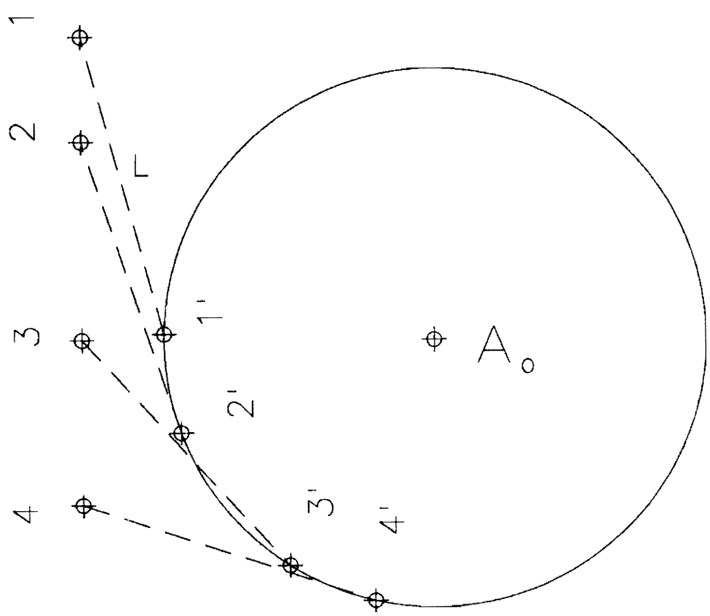

Figure 3. Precision Points for Graphical Synthesis.

The one-dimensional matrix D-1 [3, 4] comprises a series of ordered numbers from 1 to 12 and two handles, *A* and *B* on a straight line. Matrix D-1 is blocked, with the first handle at *A* and the second at *B*, and is set at each of the four configurations of the dashed lines of Figure 3, corresponding to points 1–1′, 2–2′, 3–3′, and 4–4′. Figure 4 displays the resulting motif of numbers.

Now a circular arc may be passed through any three of the four positions of any specific character of D-1. The arc needs to be passed through the same inherent handle of this particular character. The fourth position of the character provides a check as to how closely the four positions of the identically numbered character fit on the circular arc. The zoom feature can be used effectively during this exercise. The reader may verify that characters numbered 1, 2, 3, and 4 provide good fits to a circular arc. The resulting circular arcs *c*, *d*, *e*, and *f* respectively, are also shown in Figure 4, along with their centers c_o, d_o, e_o, and f_o.

We pick, arbitrarily, arc *c* with center at c_o. Thus A_oc_o defines the frame of the four-bar linkage. If it is desired to draw the mechanism at a configuration corresponding to precision point 3, rays are drawn from A_o to 3′ (*A*) and from c_o to matrix element 1 (*C*) at the third position (Figure 5). Joining *A* to *C*, and *C* to *D* at the location of the third precision point completes the mechanism. The relevant dimensions of the resulting mechanism A-1 are $A_oA = 1$, $AC = 0.495$, $C_oC = 0.772$, $CD = 1.635$, $A_oC_o = 0.474$ units, and $\Delta ACD = 1.871°$ and the angle of A_oC_o with the horizontal is 256.29°. It is to be noted that *ACD* is rigid. It may be verified, by the use of the software package Al-Yaseer [5, 7] that point *D* of the resulting modified mechanism A-1 generates a trajectory which is an approximate straight line, as shown in Figure 6. Al-Yaseer, available from the authors, enables the static and dynamic analysis of plane mechanisms and machinery. Illustrated in the same figure is the trajectory arc generated by the parallel linkage mechanism of Figure 2.

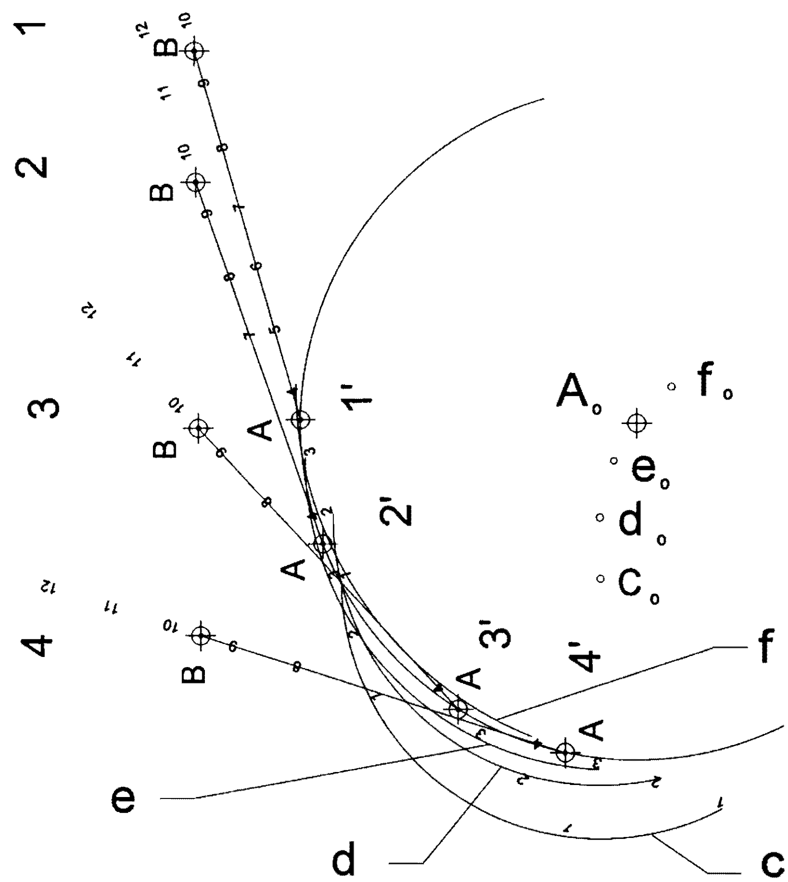

Figure 4. Elements of D-1 Matrix on Circular Arcs.

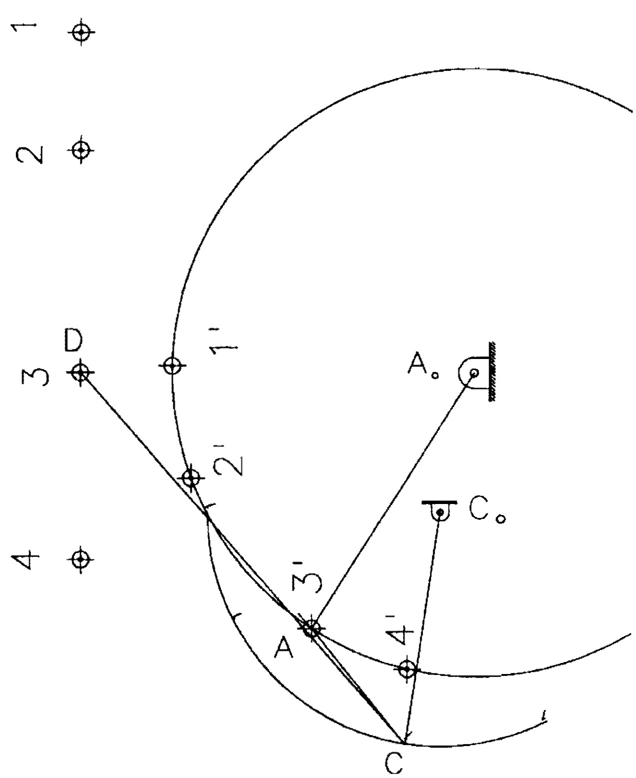

Figure 5. Synthesis of Mechanism A-1.

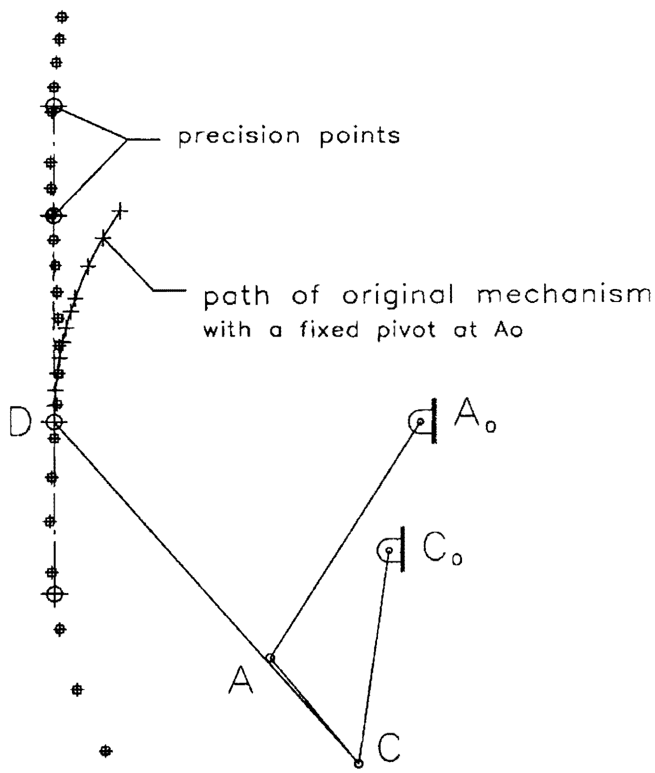

Figure 6. The Trajectory of Point D *of A-1.*

3. SYNTHESIS BY THE USE OF THE TWO-DIMENSIONAL MATRIX D-2

The two dimensional matrix D-2 [3, 4] may be also utilized to synthesize a linkage for the generation of a straight line. To illustrate the use of the D-2 matrix, one starts again with Figure 3. Following the same procedure as for the D-1 matrix, the D-2 matrix is set on the four positions of the dashed ray of length *L*, with the first handle coinciding with point *A*, and the second handle with *B*. Scrutiny of the resulting mesh reveals that there exist a number of possibilities for suitably circular fits (Figure 7).

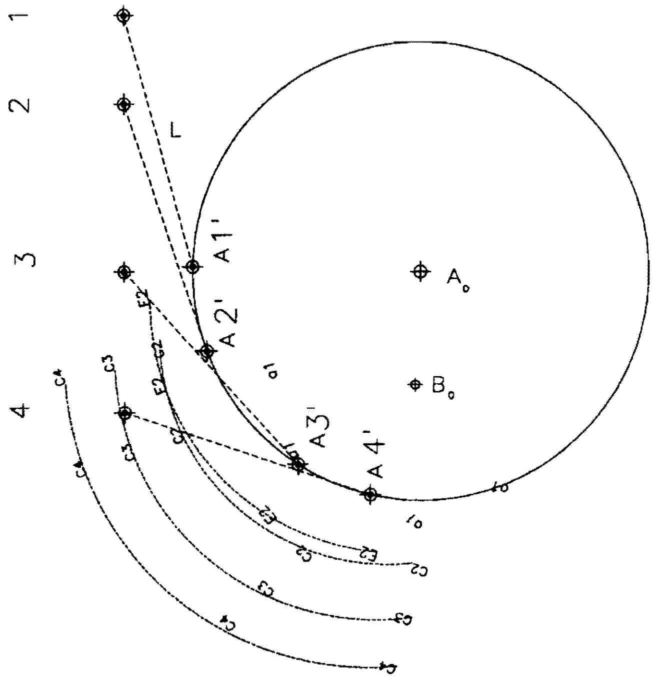

Figure 7. Circular Arcs for Elements of D-2.

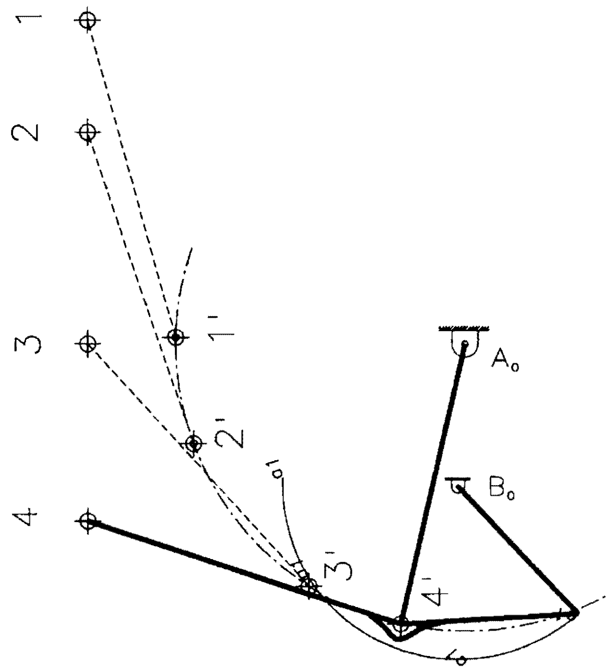

Figure 8. Synthesis of Mechanism A-2.

We pick the circular arc that passes through the four positions of character *a1* due to considerations of compactness. The center of the *a1* arc is the fixed pivot B_o. The resulting crossed four bar linkage (A-2) is shown in Figure 8 at its configuration corresponding to precision point 4. The dimensions of A-2 are $A_oA = 1$, $AB = 0.613$, $B_oB = 0.606$, $AC = 1.138$, $A_oB_o = 0.495$ units, and $\Delta BAC = 158.199°$ and the angle of A_oB_o with the horizontal is 267.23°. Figure 9 shows A-2 along with the trajectory of point C in the region of interest. Shown on the same figure is the trajectory of the flyer plate as generated by the mechanism of Figure 2. The trajectory generated by A-2 seems to be superior to that of A-1 in terms of vertical linearity. It may be further observed that mechanism A-2 is more compact than A-1.

4. DISCUSSION

It is observed from Figures 6 and 9 that both mechanisms, A-1 and A-2, generate vertically straight paths within the region of interest. The approximation to linearity in these paths is considered adequate for most impact welding applications. It is not feasible, however, to employ either of these mechanisms in solo to manipulate the flyer plate. This is due to the general motion executed by the coupler. Thus the angle of the flyer plate relative to the parent plate would be altered during traversing, although the flyer plate itself would be kept vertically above the parent plate.

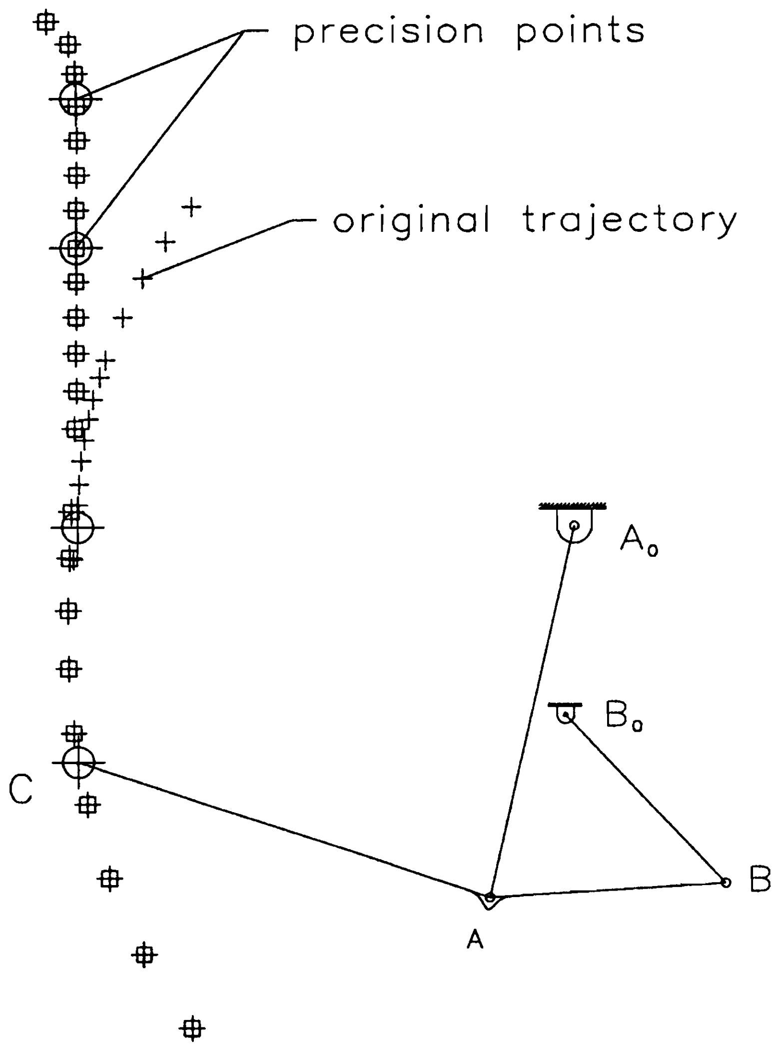

Figure 9. The Trajectory of Point C *of A-2.*

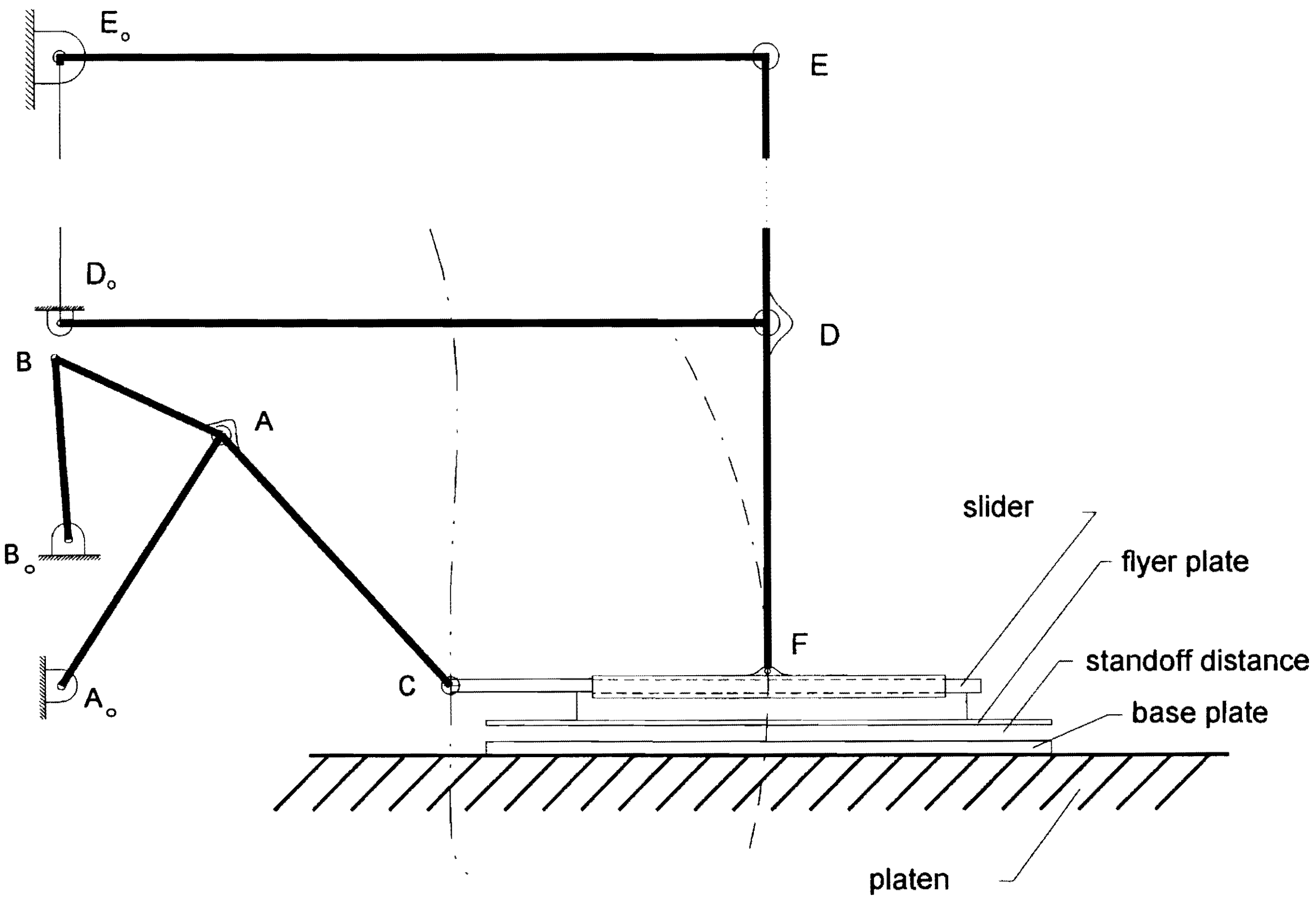

Figure 10. Hybrid Mechanism for the Traversing of the Flyer Plate.

A feasible solution to the traversing problem can be had when both the parallel linkage mechanism of Figure 2 and either of mechanisms A-1 or A-2 are utilized in a traverse mechanism. Thus the parallelity of the plates would be safeguarded by the parallel linkage mechanism, while either of the new mechanisms would ensure that the flyer plate is always vertically above the parent plate, irrespective of the thickness of the plates and the standoff distance. Figure 10 illustrates a stick diagram for such a traverse mechanism, where the clamp of the flyer plate is allowed to slide relative to the coupler of the parallel linkage mechanism. Point *C* of mechanism A-2, pin-jointed to the slider, ensures that the flyer plate remains vertically above the base plate for all practical purposes. It may be further pointed out that the platen in Figure 10 need not be horizontal; it is possible for it to deviate from the horizontal, which fact may be considered an advantage in practice.

5. CONCLUSIONS

In conclusion, the semi-automatic mechanism of Figure 1 utilizes a parallel linkage mechanism to manipulate the flyer plate, with the result that the flyer plate is traversed along a trajectory in the form of a circular arc. Therefore the location of the welding must be computed for each batch. A straight line mechanism can be readily synthesized by either of the methods presented to rectify this drawback. The resulting hybrid traversing mechanism manipulates the flyer plate along a normal to the parent plate without distorting the parallelity of the two plates. The hybrid mechanism has the further advantage of allowing the platen to deviate from the horizontal.

The graphical method of synthesis presented herein allows the rapid determination of the dimensions of straight-line mechanisms. One outstanding feature of the approach is that the designer is able to synthesize the required mechanism without losing sight of the physical situation.

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