A COMPUTER AIDED MANUFACTURING SYSTEM FOR STEEL BRIDGES

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ABSTRUCT

The practice of computer-aided manufacturing of steel bridges in Japan already dates back to about 30 years ago. And today, some computerized systems are applied to the production of an overwhelming majority of I-girder and box-girder bridges. But recently, many steel bridges have become large in scale and complicated, so that these systems can't be applied.

This paper reports the newly developped CAM system which is mainly applied to deck-girder bridges. This system offers the following features, amang others.

(1)Any type of steel bridges are modeled as the composite of stiffened panels. A solid and expanded shapes are determined by the element mesh method.

(2)It was developed in cooperation with 16 bridge manufactuers for standardi-zation therefor the output data is in very orthodox and easy-to-understand formats.

(3)It is easy-to-use batch total system. All that one must do to get results is to input and check the data.

(4)All results are stored in a disk file called a master file. One can access the data easily at any time.

(5)It gives a series of production information. It handles not only full scale expantion of stiffened panels, but also supports documents for shop assembly checkings.

(6)It prepares a variety of output formats, such as lists, drawings, rulers, templates, and NC-data. One can choose any format according to the needs in the factory.

(7)It can be used on almost all computers, because it is entirely programed in FORTRAN77.

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ABSTRACT: The developments of computer-aided manufacturing system for steel bridges in Japan date from the nineteen-seventies. And today, some computerized systems are applied to the production of an overwhelming majority of I-girder and box-girder bridges, substantially contributing to the reduction of costs and production times. However nowadays, many steel bridges have become long, huge and complicated, therefore these systems which have specialized applications to I-girder and box-girder bridges, are difficult to be applied.

This paper reports the newly developed CAM system which can be applied to all the types of stiffened panel structures, especially to deck-girder bridges.

1. INTRODUCTION

A steel bridge consisting of a large variety of members, is not a producut of a mass production. Therefore, the rationalization of manufacturing process or the incorporation of NC machine tools can not contribute the savng of lavor remarkably in the field of steel bridge fabrication. Accordingly, it has been aimed to establish a computer-aided manufacturing system which is capable of processing fabricating information totally.

The early developed CAM systems are batch type systems which have specialized applications to I-girder and box-girder bridges. They have been maintained and renewed the function year by year. Nowadays, they are tried to apply to steel structures like deck-girder bridges which are beyond the extent of applications. However, production efficiency is far from satisfactory. Therefore, many manufactures of steel bridges have need to develop a new system which is applicable to a great variety of bridge types and complex steel structures.

In 1988, we started a development of a new CAM system, named "MASTERSON" with 16 major heavy industrials and manufactures in Japan. The joint development organization consisted of the technical committee, the project team and the secretariate. The specifications for the function and the output of the system were determined by the technical committee. The development was devided into three stages according to grouping of members of steel bridges and it took five years to complete all the system. A batch type system was adopted for processing large volume of data efficiently.

2. CHARACTERISTICS

This system offers the following features, among others.

(1) Any type of steel bridge is modeled as the composite of stiffened panels. Solid and expanded shapes are determined by the element mesh method as shown in Fig.1.

(2) It was developed in cooperation with 16 bridge manufactuers for standardization, therefore the output data is in very orthodox and easy-to-understand formats.

(3) It is easy-to-use batch total system. All that one must do to get results is to input and check the data.

(4) All results are stored in a disk file called a master file. One can access the data easily at any time.

(5) It gives a series of production information. It handles not only full scale expantion of stiffened panels, but also supports documents for shop assembly checkings.

(6) It prepares a variety of output formats, such as lists, drawings, rulers, templates, and NC-data. One can choose any format according to the needs in the factory.

(7) It can be used on almost all computers, because it is entirely programed in FORTRAN77.

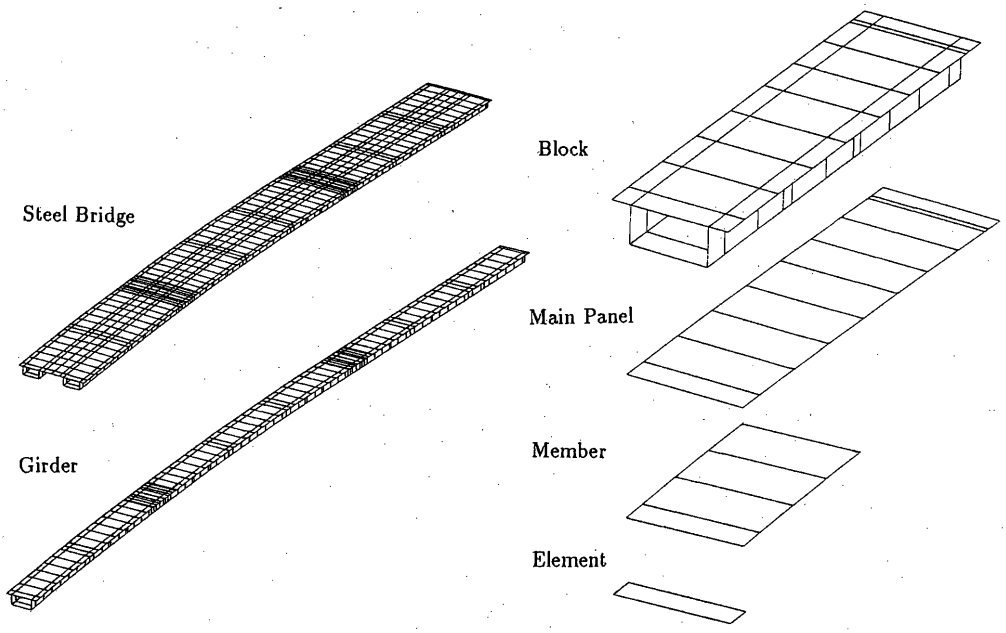


Fig.1 Mesh of steel bridge

3. FUNCTIONS

The functions of this system are as mentioned below.

(1) The four types of spline are applicable to define a shape of a bridge.

(2) The four stages of camber values are applicable.

(3) The three deflections and three rotations are applicable.

(4) The detailed processing dimensions of secondary members are defined automatically.

(5) Grouping gives the same number to the same members after the calculations are done.

(6) With the initial file register function, one can use any block names, and head marks on the output drawings and templates.

(7) It is not necessary to make all the input data to get a partial results.

(8) One can use NC cutting, drilling, and welding machinery by the output NC-data.

(9) One can use other CAD/CAM system by the output NC-data.

4. APPLICABLE MEMBERS

The types and the number of stiffened panels which compose I-girder and box-girder bridges are fixed. However, they are not constant in deck-girder and other types of bridges. Therefore, We classified the members of bridges into common groups listed below and constructed logics which define their shapes.

(1) Main panel : is a stiffened panel which forms a girder block.
(2) Sub-block : is a floor framing or a floor beam.
(3) Stiffner : is a plate which stiffens the main panel or the sub-block.
(4) Splice : is a plates which connect the main panels or the sub-blocks.
(5) Bracing : is a lateral bracing or a sway bracing.

5. STRUCTURE OF SYSTEM

This system is composed of seven sub-systems and four types of file as shown in Fig.2. The sub-systems are classified into three groups. They are the input generator system, the processing system and the output system.

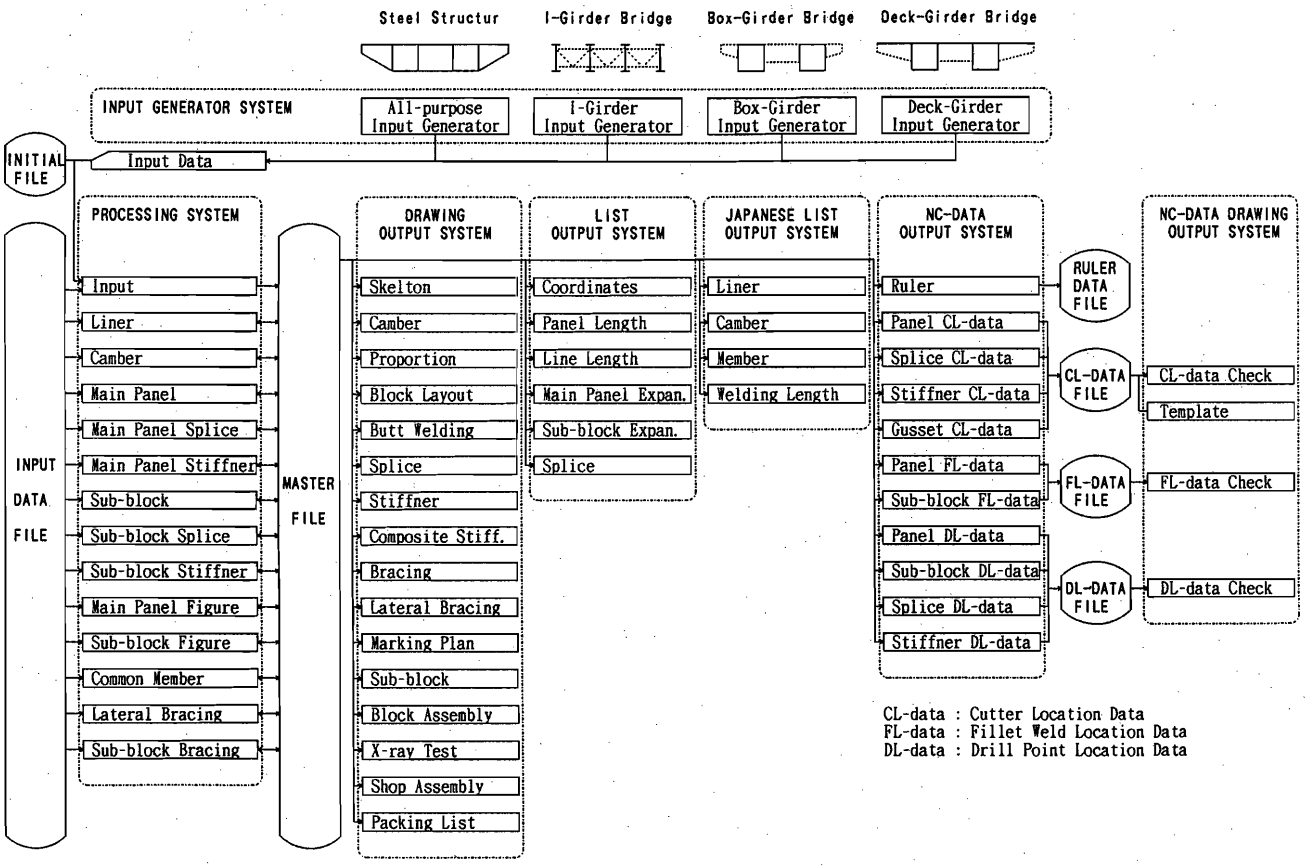


Fig.2 Structure of system

(1) Input generator system

The all-purpose input generator has been developed for processing a large volume of the original input data. Especially for I-girder, box-girder and deck-girder bridges, the exclusive input generator has been developed respectively to inprove efficiency of input work. The original input data has a fixed format, on the other hand, the input generator data has a free format composed of words and numerals.

(2) Processing system
The processing system consists of fourteen modules which process all the calculation necessary to define the shape of the members. The results of the culculation are stored in a master file which is a randam file of the index sequential access method.

(3) Drawing output system
The drawing output system suports all the information which is necessary for marking, cutting, drilling, welding, assembly and quality assurance, and outputs them in the form of drawings.

(4) List output system
The list output system prints out coordinates of solid and expanded shapes of stiffened panels for cheking of rusults.

(5) Japanese list output system
The member list and the welding length list are printed out in Japanese.

(6) NC-data output system
The fix formatted NC-data for marking, cutting, drilling and welding machinery, is produced.

(7) NC-data drawing output system
The drawing is output for checking of the NC-data.

6. PRODUCTION FLOW AND OUTPUT

The relationship between the production flow and the output is shown in Fig.3. The output drawings of a main panel and those of a sub-block are shown in Fig.4 and Fig.5.

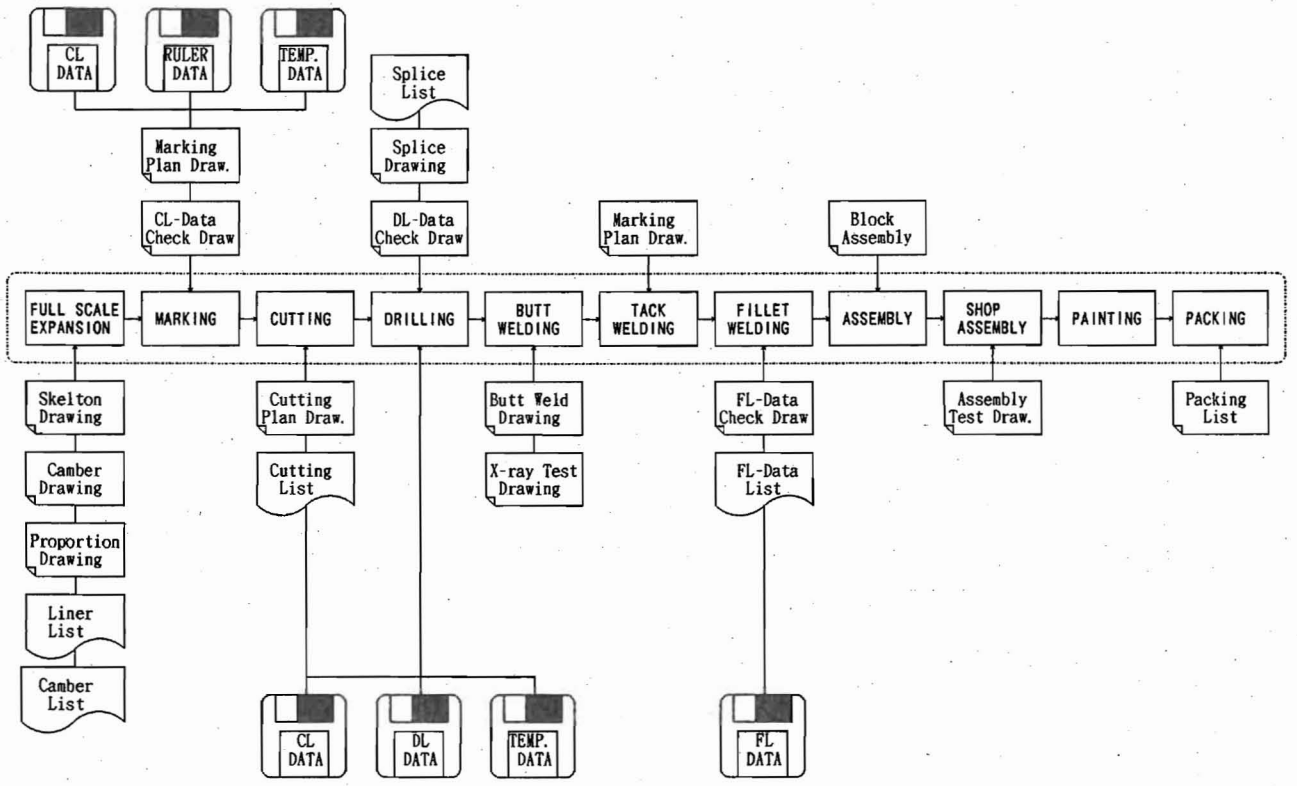
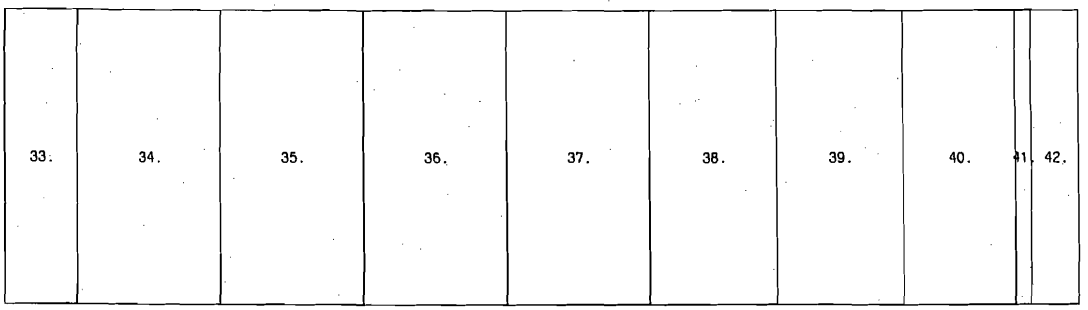
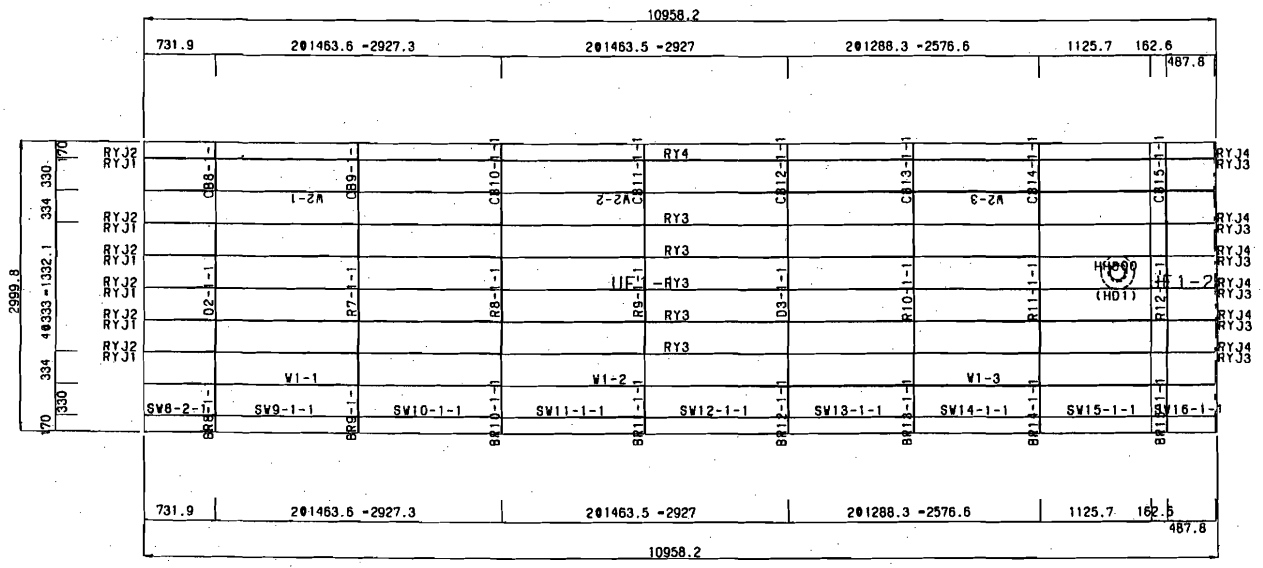


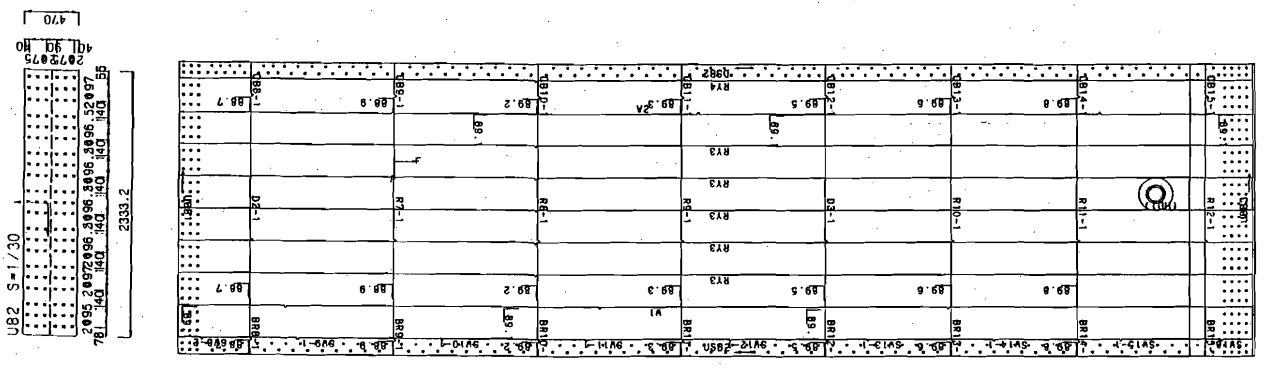
Fig.3 Relationship between production flow and output



Main panel mesh

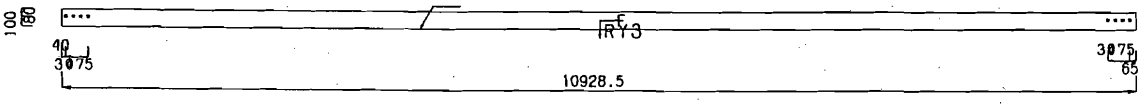


Marking plan drawing



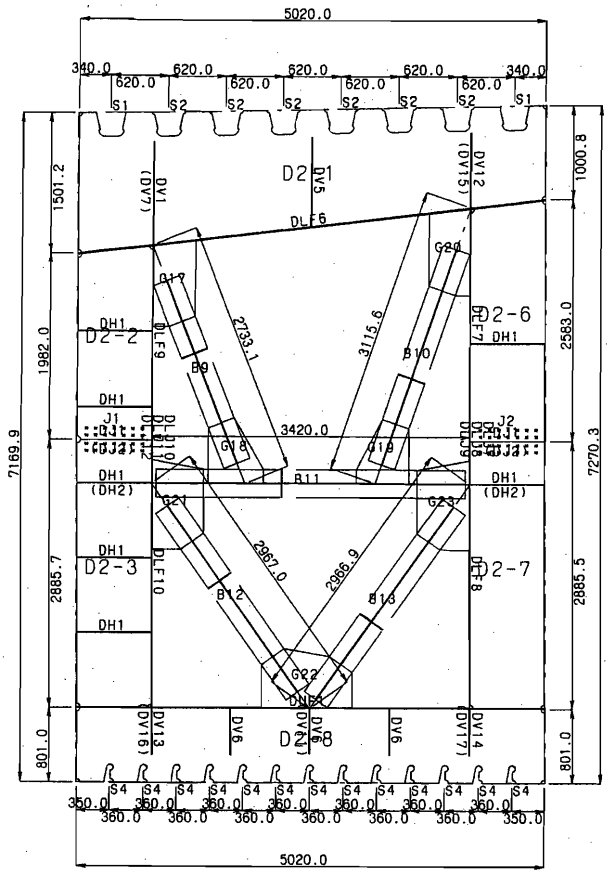
Splice

CL-data check drawing

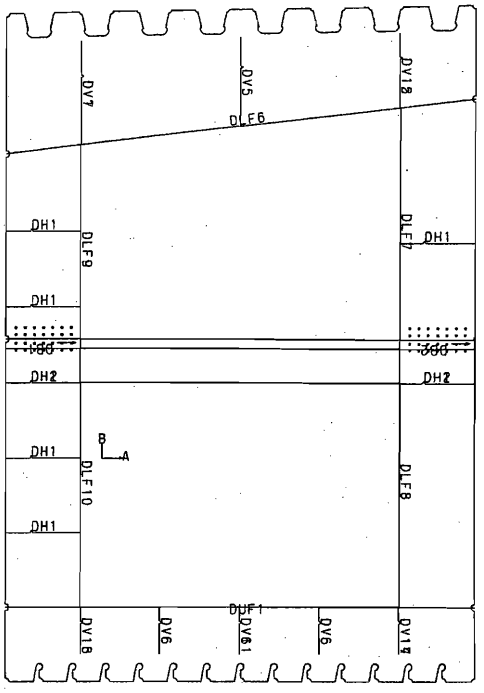


Stiffner

Fig.4 Output drawings of main panel



Marking plan drawing



CL-data check drawing

Fig.5 Output drawings of sub-block

7. CONCLUSION

The practice of MASTERSON system brings significant results in the reduction of the production costs, work time, and manpower, as well as in the betterment of production quality and labor environment. The following aspects show the direction that this system should proceed in further development.

(1) The input generator are batch type systems, intended for relatively simple I-girder, box-girder and deck-girder bridges. The batch system is capable of processing a large volume of data. However it is inferior in man-machine interface. Therefore, the new input generator which is aplicable for more complex bridge types, should be supplemented with computer graphics system.

(2) At the present time, this system does not share a common engineering data base with the design and drawing systems, except coordinates of lines. It is essential to share a common data base for integration of CAD and CAM systems.

(3) The NC-data links this system to NC machine tools and robots. Moreover, this system should be connected with a shop assembly simulation system which can skip the shop assembly, with quality assurance data.

8. REFERENCES

[1] Hanamura, Y., Namikawa, Y., and Tanabe, N., "CAD/CAM/CAT for Steel Bridges" The Fourth International Conference on Computing in Civil and Building Engineering, Tokyo, Japan, July, 1991.