The “total” system for design and fabrication of steel structures by means of electronic digital computer

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The "Total" System for Design and Fabrication of Steel Structures by Means of Electronic Digital Computer

Le système "Total" pour le projet et la fabrication de structures en acier à l'aide de calculatrices électroniques

Das System "Total" beim Entwurf und bei der Fabrikation von Stahlbauten mittels Elektronenrechnern

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I. Total system

Many automated design and drafting systems for steel structures have been recently developed. In addition to that, the introduction of automated fabrication methods has been made possible with progress of N/C machines. But, we can not expect an economic effect because of the large variety of members of steel structures, if the part programs are prepared for all these members. We have our opinion that it becomes possible to automate the fabrication and to rationalize extensively the production system by adopting the total system in combination of automated design and drafting systems and fabrication system making use of an electronic computer and N/C machines.

Now, we are developing our total system. By this system, we can not only automate the design, drafting and fabrication, but also abolish the templete shop and marking-off works.

Merits given by this system are as follows:

Saving of labor,

Improvement of quality,

Shortening of manufacturing process,

Decrease of error, and

Cost down.

II. Automated design system

It is possible to design automatically various type of bridges and other steel structures.
We will explain automated design of simple composite girder already accomplished. The calculation method of composite girder are clear, but the programs have to be available for various pattern of bridges. Automated design of composite girder consists of basic design and detail design.

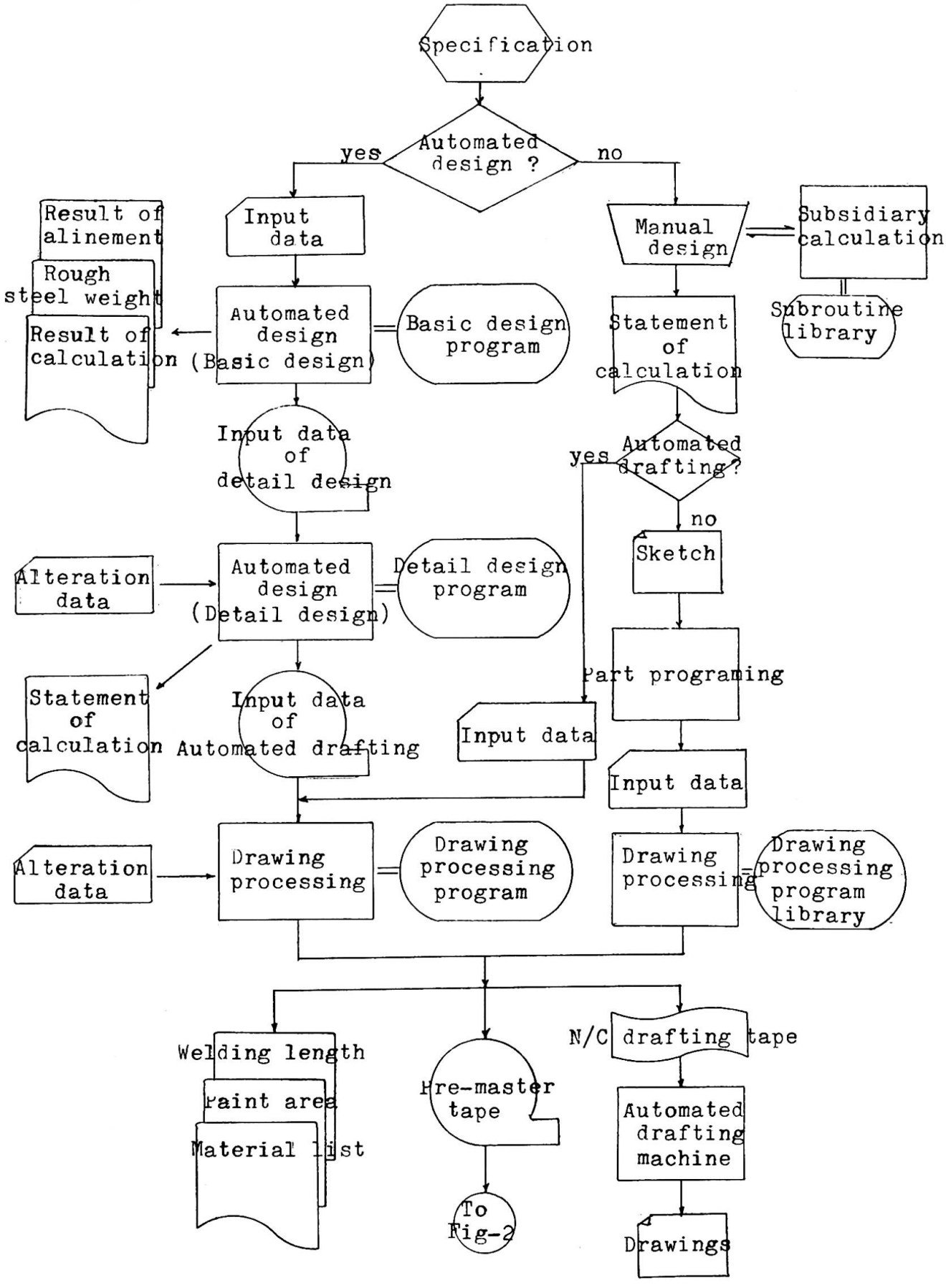

Fig.1 System flow chart of total system (1)

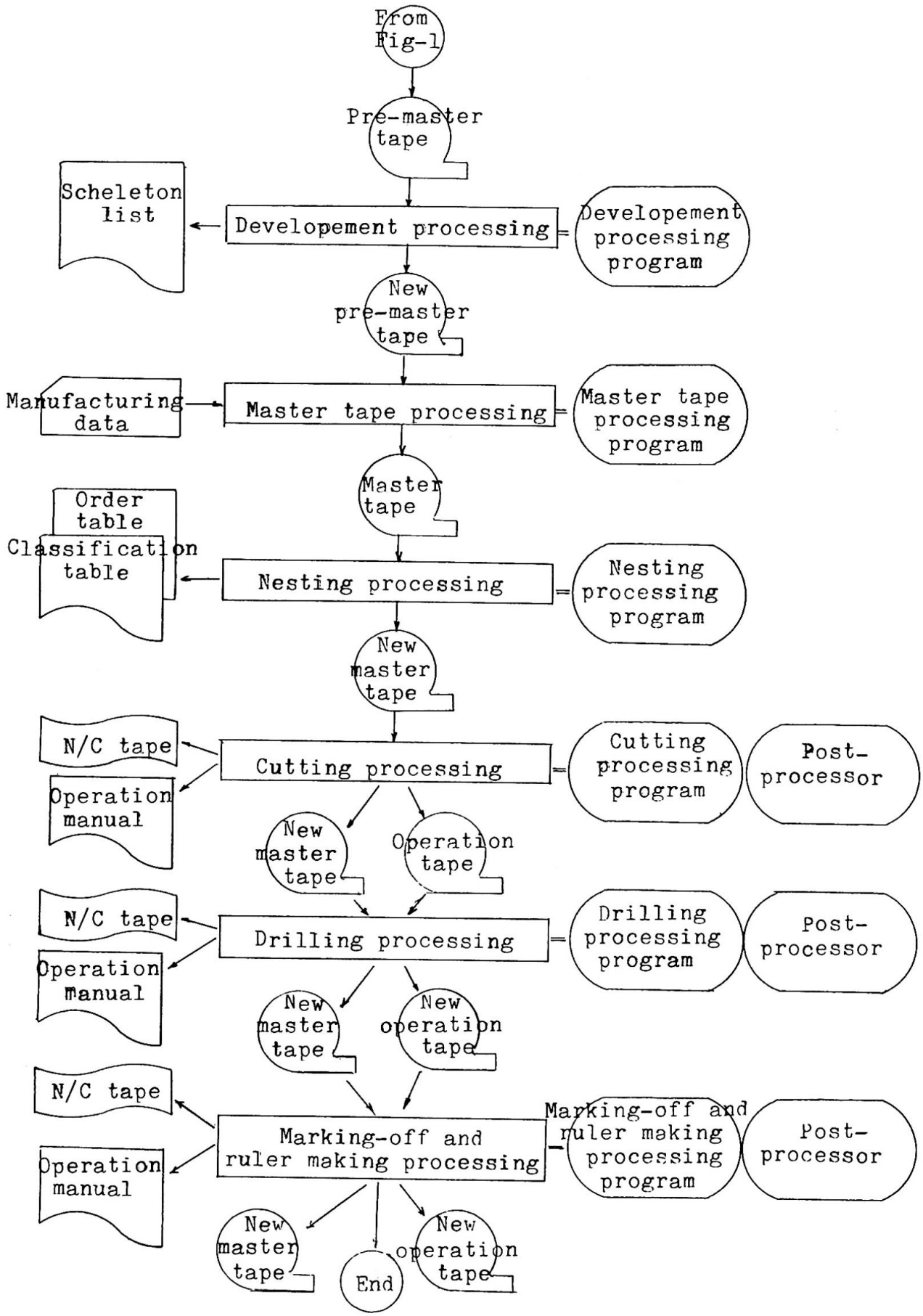

Fig.2 System flow chart of total system (2)

1. The basic design of composite girder

In accordance with the specification the most appropriate arrangement of structure is determined and preliminary calculation of the detail design is executed. The contents of this program are as follows:

Determination of arrangement type of main girder,
Determination of the optimum number of main girder,
Determination of interval between main girders and cantilever length of slab,
Determination of formation of cross section, haunch height and thickness of slab,
Arrangement of cross beams, sway bracings and lateral bracings,
Determination of the optimum height of girder, arrangement of sections and splices,
Estimation of rough steel weight.

2. Detail design of composite girder

In this process, details of structure are determined and calculated by use of the results of the calculation of the basic design. This system consists of alinement calculation program, structural analysis program, slab program, main girder program and cross beam and lateral bracing program.
Each program is processed sequentially being controlled by information in disk files.

III. Automated drafting system

N/C drafter's input tapes, pre-master tapes and material lists are offered by electronic drawing processing, using the parameters determined in the above system. The part program should be made for the complicated and particular structure to which the above system can't be applied.

1. Drawing language

We have uniquely developed the programing language for drafting. This language basis on ALGOL language, and consists of geometric and drawing variables in addition to ALGOL's reserved words.

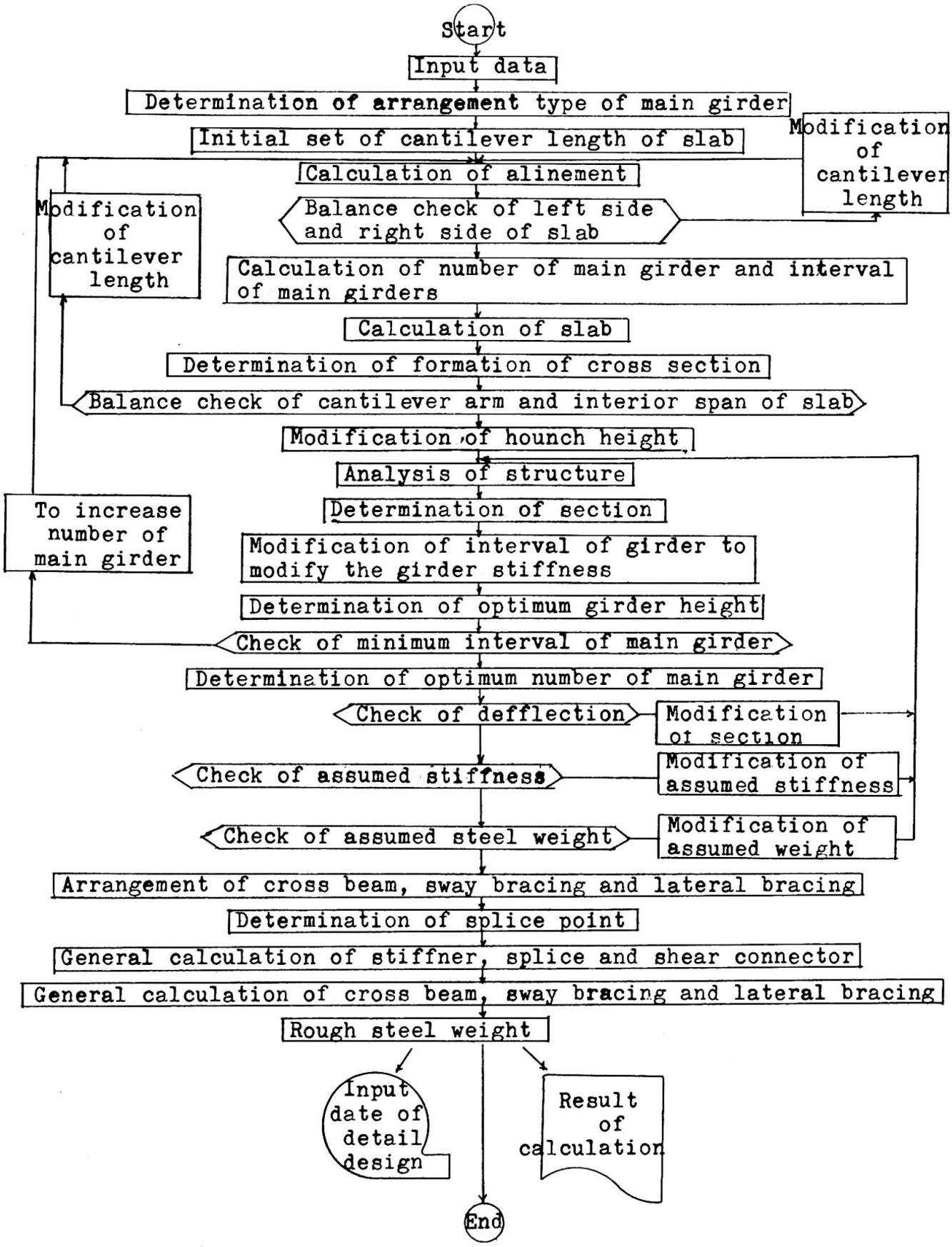

Fig.3 General flow chart of the basic design

In this language system, the patterns and members of a structure are directly processed, and the structure is built up by the electronic processing.

2. Master tape

Master tapes are equivalent to drawings, and consist of all basic information for shop fabrication. The contents of master tapes are separated to two types of data. The one is a set of member data, that is, figures or properties of each member, and the other is what means the relations between members.
The member data are as follows:

Original number of data,

Arrangement of member,

Number of members,

Dimension of member,

Quality of material,

Outline of elements,

Kind, number and co-ordinate of holes,

Bending, twisting, beleveling data,

Mark,

etc.

Relational data are link keys that indicate the connections of members, and form a "tree structure".

3. Automated drafting system of composite girder

This system consists of six programs, that is, for main girder, cross beam, sway bracing, lateral bracing, material and pre-master making.
In this paper only the general flow chart of main girder program is shown in Fig. 4.

IV. Automated fabrication system

Adopting this total system will help us to make N/C tape, and make the automatic fabrication possible. Furthermore, it will be possible to abolish the templete shop and marking-off works as auxiliary processes of production. Our plan is dealing with so-called pre-process, that is, cutting, drilling, marking-off and rule-making process. Consequently, the member assembling and welding process is out of our objects.

1. Development of full size drawing and addition of manufacturing data

We make a master tape from a pre-master tape by this electronic processing.
Practical measure is calculated automatically, modifying data in consideration of deformation of members due to dead load and developing the scheleton.

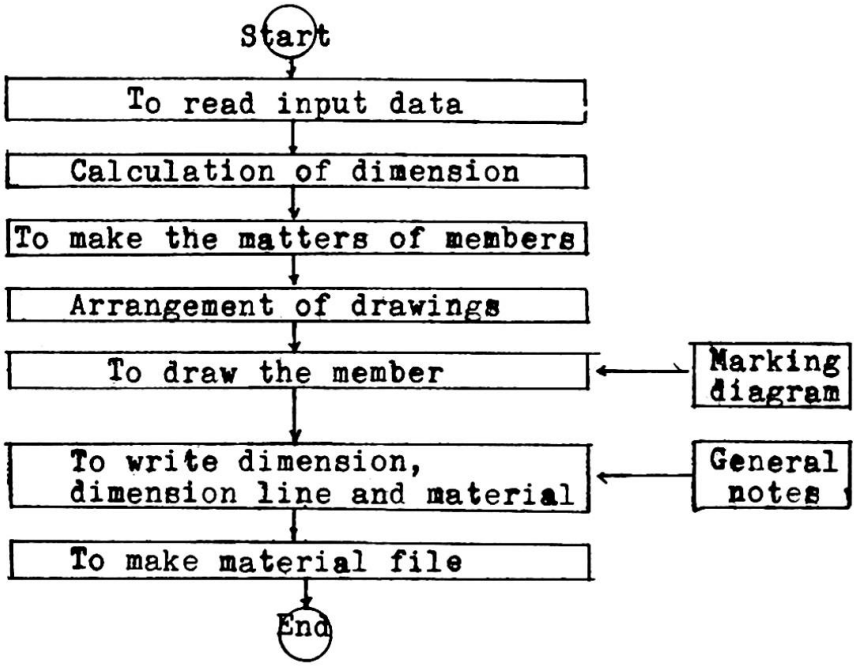

Fig.4 General flow chart of main girder program in automated drafting system

A person in charge of fabrication has to make data concerning the clearance for cutting, shrinkage and planing, and the deformation in accordance with fabrication condition, after examining drawings.

2. Nesting processing

The classification table showing qualities and thickness of material is make automatically by use of data in master tape, and the order table is done after determining optimum cutting stock with minimum loss.

3. Cutting processing

By use of data in a master tape, the form to be cut and sequence of cutting are determined in consideration of material deformation due to heat, and CL data is made. And then, using the CL data, N/C tape having a format

according to each N/C machines is made by use of post-processor. It is possible to make N/C-gas-cutter draw lines by use of paint instead of gas.

4. Drilling processing

In order to drill holes for joint, this processing supply the determination of drilling position, automatic drilling and automatic cleaning up of dust after drilling.

5. Marking-off and rule-making processing

At this step, marking-off and making templetes are processed automatically, when it is needed to draw post-marking-off because of deformation due to gas-cutting and welded joint.

Objects of rule making processing are post-marking-off, planing and so on.

Summary

We are developing our total system, from design to fabrication of steel structures making use of an electronic computer and N/C machines. This total system consists of automated design system, automated drafting system and automated fabrication system. By combination of these three systems, it is possible to fabricate the steel structure automatically without templete shop operation.