The Analysis of Activity's durations, Precedence and Sequence of Work on Housebuilding Sites of Repetitive Nature:

Graphical Software to enhance the Printed Output from the Building Research Establishment Site Activity Analysis Package

L. F. Heineck

Department of Civil Engineering
University of Leeds

January 1982

Summary

This report initially describes the Site Activity Analysis Package developed by the Building Research Establishment. This package is designed to collect and organize production information on building sites using the activity sampling method.

The author relates his experience of using the package to obtain the information needed to analyse the following aspects of the production process on 3 house building sites:

a) activity durations;

b) precedence between activities;

c) flow of work.

A new set of computer programs producing mainly graphical output is presented. The set of programs were developed during the course of this research work in order to analyse the 3 production aspects given above. The programs are intended to complement the tabulated printed output of the Site Activity Analysis Package and to help overcome some of its shortcomings. They are fully described and documented in the appendix of this report.

The major findings related to the above production aspects stemming from the analyses of the 3 three different sites are reported. Suggestions are made for further work in the area.

Index

1. Introduction

1.1 Generalities

The initial aim of the present research work in programming techniques for building sites of a repetitive nature at the Department of Civil Engineering, University of Leeds was to observe the progress of work on construction sites. It was considered of fundamental importance to lay the foundations of the research work on practical experience, rather than to use only theoretical concepts. The review of the literature also indicated that there was a lot to be done in the area of construction programming in order to reconcile theoretical concepts with practical evidence obtained from building sites.

The author went to the Division of Production of the Building Research Establishment and during a period of 3 months extracted production data from the BRE files under the supervision of Mr. W. S. Forbes and Mr. I. Freeman. The opportunity is taken to acknowledge their great contribution to this work and to thank them for their encouragement.

Conclusions and remarks presented in this report express only the author's views. They should be taken as general ideas about the whole construction industry and building process and are not related to the particular design, construction, labour force or management of the sites analysed.

1.2 The Site Activity Analysis Package from the Building Research Establishment

The basic features of this package are given below. They were extracted from the BRE research notes No. 143/80 (12) and No. 13/81 (13).

The activity sampling approach is based on the assumption that a sample taken at random from a large group tends to have the same pattern of distribution as the large group. Thus, what operatives can be observed doing at times chosen at random will reflect how, on average, they spend the whole of their time. In practice, a record is kept of what each operative is observed to be doing at particular moments, randomly selected. These observations are known as 'snaps'. The distribution of observations between the choosen parameters (for example, working at task, relaxing, receiving instructions, etc.) is an approximation to the distribution of the operatives' time between these parameters. The greater the number of observations that are made, the greater the accuracy of the approximation, so that the frequency of 'snaps' may be arranged to give results of the required accuracy.

In the site studies carried out by BRE the need has generally been to determine time spent on tasks and the pattern of working - in time and in place - so that observations are required annotated in time-related operational and geographical terms. Because of the large amounts of data accumulated, automatic data processing techniques are essential. Therefore, observations on site are recorded on special forms, suitably coded, which can be fed directly into an optical reader which transcribes the recordings on to magnetic tape in a form suitable for direct input to a computer. The optical recording sheet can be seen on figure 01.

Activity sampling, as a means of obtaining accurate feedback of resources used during the progress of a construction project, has only been employed in the UK as a research tool; for example, to study the effects of a particular design factor on productivity. Because of the complexity of the analysis, production of results has been protracted. However, the speed and simplicity of the analysis available through the new BRE Analysis Package means that the role of activity sampling can now be reassessed. In particular, the potential of the approach as an aid to construction management is worth examination.

Normally the BRE employs 2 observers full time on site and experience has shown that they can control up to 100 operatives by going around the site at hourly intervals. But observations made only twice a day, at random, could still give data of sufficient accuracy for many contractors'requirements. Observing at this frequency should not prove an unreasonable expense in return for hard information on resource usage, the pattern of work on site, continuity of effort, performance of different gangs of sub-contractors, and realistic measures of the effect of design on productivity. Some simulation studies at BRE of the results which can be obtained with this frequency of observation are showing this to be practicable.

Snap observations should be made discreetly, so that the operatives are not disturbed. One of the majcr advantages of the activity sampling method compared with other production analyses techniques like work study is that operatives do not have the feeling of being observed, and hence are nct tempted to change their pattern of work.

Because all the men are not been observed all the time the results will be in error to a certain extent. The size of the error will depend on the frequency of the sampling and the labour content of the item being measured. Thus the sampling error effectively sets a limit on the level of detail that is measurable. There is no hope of ever measuring accurately small amounts of labour input that are not repeated.

In experimental work at the BRE it has been usual to design the observational system to be able to measure a unit of work estimated at 1% of the total man-hour requirement to an accuracy of plus or minus 5% with 95% confidence limits.

For 95% confidence limits, the formula giving the relationship between the degree of accuracy and the number of observations is (Stevens - 23):

$$A = 2 * \frac{(1-P)}{NP}$$

where:

N = total number of observations;

A = degree of accuracy (in decimal form);

P = percentage of occurence of activity (in decimal form).

The whole process of site analysis consists of 3 different phases. The first phase is concerned with the setting up of codes against which observations will be recorded. Two major families of codes are necessary: one defining the units to be constructed and the tasks considered to be observable on site, and another describing the operatives, their trades and skills. The second phase uses a package facility to check the observations consistency: such errors as non-existent operatives, dates and daily working hours and non-conformity to the codes previously set are singled out by the program; the user can correct or delete such observations. In the last phase instructions are given to the computer in order that the desired computer printout may be produced.

The system currently available at the BRE is very flexible and allows the user to specify the parameters (headings) under which the data is to be presented. Each individual snap observation contains 6 basic pieces of information:

a) date;

b) hour;

c) observer number;

d) operative number;

e) location (building units: blocks, houses, storeys, etc.);

f) task (stage of work, operation or activity);

Information contained in items "e" and "f" is in fact represented by several codes arranged in an hierarchical structure. For example, each site contains a number of blocks; each block contains a number of houses or storeys; each unit of construction requires several stages of work to be completed; each stage of work is formed by different operations and all observable work on site can be recorded against a set of activities (handling, working, being idle, walking, etc.). Operatives'numbers should be carefully selected to allow each range of numbers to represent particular characteristics of the work force. For example, it is possible to divide the work force by trade and then, inside each trade, by status (skilled, non skilled, foreman, etc.). Up to 8 different hierarchy levels can be set corresponding to items "e" and "f", and up to 3 different hierarchy levels can be set for the work force.

This maximum total of 14 pieces of information (item "d" could contribute with 3 different records and itens "e" and "f" together could collect up to 8 different records) are compared in pairs, giving a combinatorial total of at least 90 different types of data tabulation. Moreover it is possible to perform all these tabulations using a selected data bank; this data selection is again made using one of the basic pieces of information; it is possible, for example, to select data only for the carpenter trade or for work performed in the morning. Almost every aspect of the allocation of man-hours on site can be analysed using specific formats of the package output.

The package output comprises tables where row and column headings are taken from the 6 basic pieces of information. At the users choice, the tabulated values can be expressed in man-hours, man-days, percentages or averages. It is also possible to produce histograms.

Some tables are absolutely essential for any construction managerial system, like the ones aggregating the total number of man-hours spent in each house or stage of work; some other tables are useless due to the level of detail they imply and hence the innacuracy of results; some tables are useful under very specific requirements, like checking the performance of each individual observer on site concerning the possibility of optical reader sheets being filled in at the site office rather than on the rounds. A set of examples is given in figures 02, 03, 04, 05A, 05B, 06, 07 and 08.

Figure 02 gives a simple breakdown of the total number of hours spent at the Ladygate Lane site, according to the major stages of work. The information in this table can be used to estimate labour costs for each stage, to assess the stochastic variability in terms of man-hours required, or to check if any improvement due to learning phenomenon has ocurred, once the block's starting order is known.

Figure 03 shows the breakdown of man-hours spent at the level of activities by each one of the trades present on site. It could be used to check if subcontractor trades have different patterns of work, as far as non-productive time is concerned, compared to main contractor workers.

Figure 04 depicts the progress of work for the operation "water pipes, tanks and cisterns". It is possible to note at once the low number of hours worked each week (at least 40 man-hours per week can be expected, that is, at least one operative working full time in the operation in each block). The total operation's labour content in each block ranged from 61 to 217 man-hours, but the operation's duration was on average some 20 weeks, giving roughly an average of between 3 and 10 hours worked weekly in each block.

Figures 05A and 05B repeat the same type of table, but indicate how the wiring operation proceeded at 2 different sites. At the first, Ladygate Lane, the operation was in fact performed as 3 different and separate sub-operations. At the second site, Pitcoudie 1, design was rationalized in order to allow one single visit by the electrical trade. The table suggests that this was in part achieved.

Figures 06, 07, and 08 refer to the analyses of individual operatives'performance. Figure 06 shows the blocks where each worker has mainly devoted his activity. While it is apparent that each worker concentrated his effort in particular blocks, it is worth noting that practically all workers visited all blocks on site.

Figure 07 examines the performance of each operative in terms of productive and non-productive effort. For example, operatives No. 110 and No. 175 had low productive times (activities F1 = making the building grow physically and H1 = handling) and high non-productive times (activities W = walking, N = idle at the work place and A = absent).

Finally, figure 08 shows the operatives' attendance and turnover. At this site only 6 general labourers were required due to the nature of the work and the total work content, but 36 different general labours were employed, giving a very high turnover rate.

1.3 Data Retrieval for this Research Work - Objectives and Format -

Data from 3 building sites were readily available at the Building Research Establishment. This research work intends to use information obtained from these sites to analyse the following aspects of site programming:

a) stochastic duration of operations;

b) stochastic amounts of resources required by the operations;

c) progress pattern of operations (rate of progress);

d) precedence between operations.

The family of tables with time periods (months, weeks or days) as row headings and tasks (stages of work or operations) as column headings was found particularly useful, since it can provide data by which to examine the four items above.

First of all it was necessary to define the level of detail to which the tables would be built. At the 3 sites, each block contained a mix of dwelling types: 2 person, 4 person, 5 person, 7 person and 9 person houses, single, 2 and 3 storey houses, and even in one site, a small proportion of 3 and 4 storey flats. For each house some 30 to 40 stages of work were defined. Each stage of work was further subdivided into operations like:

stage of work	operations
electrical installation	- wiring and conduits; - socket outlets, switches and fittings; - conduit and meters; - apportionable to stage only (heading used when it was not possible to allocate the task being performed by the operative to one of the 3 preceding operations).

Operations were split in elemental activities like handling, cleaning tools, measuring, remedial work, working productively at the task itself, etc.

With a view to reduce the bulk of computer printouts, establishing a level of detail likely to be meaningful to management feedback information systems, and bearing in mind that the accuracy of any activity sampling method increases with data aggregation, it was decided to build tables at the level of blocks instead of houses, weeks instead of days or months, and stages of work rather than operations.

There was also the possibility of building the tables using a particular set of elemental tasks, that is, man-hours presented in each table will refer only to handling, making the building grow, etc.. It was decided, however, to use the aggregated value of all elemental tasks. As a result, man-hours recorded against each pair of row and column headings will contain productive, ancillary and non-productive time.

1.4 Output Shortcomings of the Site Activity Analisis Package

As already mentioned, in the past the BRE has used activity sampling computer programs on a specific basis, tailoring each program to the special requirements of each site and the research work being carried out. This new Site Activity Analysis Package (S.A.A.P. for short) is intended as a general package, applicable to any foreseable size and type of building site.

In order to simplify the commands to create the output files, a rather generous output layout was devised: for example, man-hours presented in the tables can vary from 0 to 99999 which implies that a maximum of 18 columns are produced in each computer page. Not more than 30 rows will appear on each page.

The result of this decision is that computer printouts are in general bulky, and it is necessary to do a lot of clerical work before the tables can be properly analysed. The largest of the 3 sites, Pitcoudie 2, involves 42 stages of work and 53 blocks. The whole work on site took 94 weeks to be completed. The author produced one table giving weeks as row headings and stages of work as column headings for each of the 53 blocks. The total number of computer pages output was:

94 weeks at a maximum of 32 weeks/page = 3 pages

42 stages at a maximum of 18 stages/page = 3 pages

Total number of pages = 53 blocks * 3 * 3 = 477 pages

If an analysis in terms of days rather than weeks was choosen the numbe of pages would be 7 * 477 = 3239 pages.

All the 477 pages were separated, cut and glued together in order to produce a clear picture of the progress of work in each block. Moreover, reductions using xerox or photography might be necessary in order to arrive at workable sizes of tables, with inevitable losses in printing clarity.

Whichever rows and colums are choosen, the information conveyed by the tables is always man-hours, man-days, percentages of man-hours or histograms representing one of these values. There is no facility to include a third variable in the tables. For example, if it is intended to follow the movement of operatives from one block to another during the construction period, 3 variables are involved: time, location and operatives. Several tables would be required to conduct this analysis, each one corresponding to one block, to one operative or to one time period, with rows and columns corresponding to the remaining variables. It is not possible to include the 3 variables in one unique 2 dimensional table.

The BRE uses a photographic technique to analyse the precedence relationship between operations: the computer printouts of each operation are reproduced on a translucid sheet of plastic and superimposed one on the top of the other.

The author intended to simplify the analysis of the data relating to the stage durations, precedence, and sequence of work from block to block by creating a number of computer programs to drive the plotting facilities at the University of Leeds. The programs were specially developed to make it easier to compare a greater number of variables at the same time, mainly when examining the progress pattern of different stages of work. The information made available by the Site Activity Analysis Package is rearranged by the user on a interactive basis and displayed in the form of graphical output using either Video Display Unit terminals, or Calcoomp 1012, or Calcoomp 1039 hard copy plotters.

The remainder of this report describes the set of computer programs developed, and puts forward a series of conclusions based on the graphs obtained so far. The complete set of computer programs anc their documentation is provided in the Appendix to this report.

Before proceeding further, the literature on the pattern of progress on building and civil engineering sites is reviewed. The review will be seen to support some of the conclusions reached at the end of this report.

2. Building Progress Patterns

- Review of the Literature -

Several authors, after investigating the duration, precedence and the progress pattern of operations on site, have come to conclusions substantially suported by the results of the analyses carried out during the course of this present research work.

A report by the United Nations (6), while studying the effect of repetition on building productivity, found that some operations were performed in a discontinuous manner. Figure 09 extracted from the report shows that operations number 3 and 6 were performed discontinuously in the regions labelled A and B.

Forbes (9) produced a picture of the progress of work on site depicting the increasing confusion in the pattern of work as the final stages of construction were reached (fig. 10). The first 3 stages of work, substructure beams, floor slabs and the housing shell erection, were done continuously, with few working places being tackled each week. The progress lines of these stages are clear and do not overlap. The remaining stages of work, dry-linings, joisting, joinery, plumbing, electrical fittings and decoration, were performed under a confused pattern of work.

Figure 10 was originally drawn in colour; 172 houses are plotted in the y axis; each weekly ocurrence of a particular stage of work was represented by a coloured rectangle with length ecual to 1 week and height inversely proportional to the number of stages executed simultaneously in each house in that week.

According to the line of balance principles (see Lumsden - 15), all stages of work should produce a progress pattern similar to the ones presented by the initial stages in this figure (substructure beams, floor slabs and housing shell). Forbes observed that this was not so because the final stages of work were done with a great number of interruptions over a very long period of time.

The unusual form of the progress lines may be criticized because they were obtained using stages of work rather than activities or operations; the stage "electrical fittings" should at least comprise the operations "first fixings" and "second fixings", as it is normally considered to do in building construction network programming (8).

In this particular research exercise, known as the Finchampsteadt project, the first stages of work were carefully designed bearing in mind construction methods on site. The final stages were not so designed. Reflecting upon this experience and considering other studies done at the Building Research Establishment, Forbes (10) concluded that design which takes into account constructional aspects is the key factor if continuity of work and clear patterns of progress are to be attained.

A report by Ann Foras Forbartha (22) corroborates the hypothesis that continuity of work is difficult to find in house building construction. Figure 11 was taken from their study based on observations made on a site with 17 blocks of 2 storey semi-detached houses.

Pigott (16,17), also from Ann Foras Forbartha, detected a great number of visits by each trade to complete the stages of work on a house building site (see table 01). He related this large number of work interruptions to the way subcontractors undertake their tasks on a number of different sites simultaneously; whenever there is a potential disruption to their smooth flow of work they tend to leave the site. Shortage of materials and design-related problems caused less than 10% of the interruptions. Repair work and organizational problems (mainly related to subcontractors) caused more than 88% of the interruptions observed on 3 sites. The majority of the work was subcontracted, even for the initial stages like ground floor slab and blockwork.

An operation can be defined as a subdivision of the total work content of a project that is performed by a specific trade in a continuous manner, that is, without interruptions other than weekends, holidays and strictly unavoidable ones (8). It can be defined also as the smallest practical unit of construction work in the sense of being measurable (12). According to the former definition, BRE studies have identified as many as 300 operations on a typical site were theoretically only 100 were needed and expected to ocurr.

Fine (7) stated in a paper dealing with tendering and estimating problems that:

> "Some part of almost every job lies outside the experience of the estimator or of other people whom he may consult. In these circumstances a guess must be made and the major guess is nearly always the one which purports to define the subtasks out of which the project is to be built".

The fact that operátions are not easily identified and classified suggests that the observable progress patterns of some operations might in reality correspond to the progress pattern of sets of sub-operations. If this is true, it is not surprising that these so called operations are interrupted several times, take a long time period to be completed and are done in parallel with, rather in sequence to, their technically precedent operations.

Roderick (19) compared the network drawn by the contractor for a particular site with what really happened during construction. He found that not only did discontinuity of work give rise to activity's durations far greater than initially planned, but also that activities like ground floor slab, brickwork, first fixings, plastering and ceiling were done in parallel (fig. 12 and 13).

Hall and Ball (14) were able to find the same discontinuity of effort and overlapping of operations in civil engineering bridge construction.

To the best of the author's knowledge there is no research paper based on practical observations on site, to support conventional ideas used in building programming, such as:

- continuity of work in each operation from practical start to completion;

- rigid technical precedence constraints between operations determining that they are performed in sequential chains;

- constant levels of resources deployed to each operation; to the contrary, Roderick (10) found that resources were deployed to each individual operation according to a "S" shaped curve (fig. 14);

- durations of operations given by the quotient labour content/number of men assigned to the job.

It is with this background in mind that the following chapters should be read.

3. The Graphical Analyses of Building Process of the Pitcoudie 2 Site

3.1 Generalities

The programs herein introduced use the graphical subroutines contained in the Ghost Graphical System developed by Culham Laboratory (4). The reader should consult the Ghost Manual if an in depth appreciation of the computer software is required.

Software output is briefly commented on in this section, and examples are given to show the type of information that can be derived from their analyses. The major research findings so far arrived at using this graphical technique of analysis are presented in the following chapter, which is devoted to a summary of results and conclusions. Further examples of output are also introduced in the following chapter.

Production data released by the Building Research Establishment comprises information about 3 differert sites:

Site Name	Number of Houses	Number of Blocks
Ladygate Lane	72	10
Pitcoudie 1	112	29
Pitcoudie 2	283	53

The following programs are specially designed for the largest of the 3 sites, Pitcoudie 2. Minor alterations are required before using these programs with data from the other sites, mainly in the area cf size of arrays and limits to the Fortran loop functions. Graphical output generally requires attention to aesthetic aspects and clarity requirements. Any modification to the present programs, while keeping their main structure and logical sequence, should be made in accordance with the above requirements. The author has found that programs specially designed to take into account the characteristics of each particular site are more flexible than generalized programs in terms of computer graphics lay-out. Modifications to suit a particular site have been completed curing a 2 hour session in an on-line computer terminal.

The same types of graphs were produced for the 3 sites and the following examples could have been taken from any of the 3 separate studies conducted. Likewise, the conclusions presented in the last section of this report are based not only on the Pitcoudie 2 graphs but on the total set of graphs produced for the sites.

3.2 Description of the Pitcoudie 2 Project

This housing scheme had been developed in consultation with architects and engineers in the Scottish Development Department responsible for Housing Standards, engineers in the Fife region, and the Department of Engineering in the Glenrothes Development Corporation. The information reproduced in the next paragraphs was taken from an internal project report (23).

Pitcoudie 2 is a continuation scheme from Pitcoudie 1, on a bigger scale of operations. The objectives of the Pitcoudie 1 and 2 projects are to study possible savings of time and money due to rationalizing the process of traditional house building construction. These objectives were to be achieved by:

a) the sequence of operations being identical in each house;

b) the standardization of building components (windows, floor joists, partitions, etc.);

c) the use of a simplified form of construction: concrete floors, which are not common in Scotland, are finished to receive thermoplastic tiles without the use of an intermediate screed; walls are of a thick single concrete block and internal plasterboard lining in Pitcoudie 1, and the traditional cavity brick/block wall with a thermal liningboard in Pitcoudie 2;

d) the coordination of dimensions;

e) the careful attention to plumbing, electrical and joinery work to require fewer, larger and more independent trade operations;

f) the contract documents and drawings allowing improved communications between design and building teams.

A special consideration in Pitcoudie 2 is the re-examination of the relationship between houses, roads, footpaths and courtyards.

Seven different house types are used:

- 2 persons single-storey south aspect;
- 2 persons single-storey north aspect;
- 4 persons two-storey;
- 5 persons two-storey south aspect;
- 5 persons two-storey north aspect;
- 7 persons three-storey;
- 9 persons three-storey.

The 7 person and 9 person house are 4 person houses with an additional storey, 9 person house having an additional annexed room on the first and second floors. There are also 2 three-storey and 2 four-storey blocks of flats providing mixed accomodation for 2 persons, 3 persons (one disabled) and 4 persons.

Some special houses and flats for the disabled are provided. The differences between south aspect, north aspect, and disabled houses are mainly in the positions of doors and windows and in increased sanitary facilities for the latter.

Single and two-storey houses have ducted warm air systems (equally divided between houses with gas and electric systems). Three-storey houses have either wet radiator gas systems or electric storage heaters. Flats use electric warm air ducted partial systems, with bedrooms heated by electric storage heaters in 3 person disabled flats.

Apart from these differences in heating systems, positions of doors and windows, and increased facilities in disabled houses, the houses can be considered identical as far as the construction process is concerned. Obviously the blocks of houses differ in size because each one has a particular mix of housing types. Flats employ a different construction method involving intermediate precast floors.

Pitcoudie 2 specifications are given in table 02. A schematic representation of the internal layout of each type of house is given in figure 15. A general site layout is given in figure 16 together with the housing mix of each block. Figure 17 reproduces the planned flow of work for each house type; as noted by the Pitcoudie 2 promoters, the flow of work is basically the same for single, two and three-storey houses.

The Building Research Establishment's production analyst used the following hierarchy of headings to record the snap observations;

- Level 1 :

  55 blocks of houses, corresponding to 49 blocks numbered from 1 to 49 comprising houses only, 4 blocks numbered from 50 to 53 comprising 2 three-storey and 2 four-storey blocks, and 2 artificial blocks; block 60 is used to record all stage-related external work that cannot be associated with any particular block; block 0 is used to record observations that can neither be assigned to particular blocks nor to particular stages of work;

- Level 2 :

  houses within each block; some blocks (like No. 15) are very small containing only 2 dwellings for 2 persons, others (like block No. 31) have

10 dwellings; when it is not possible to relate information to any particular house inside the block the heading "apportionable to block only" is used; the mix of houses in each block may be better appreciated after consulting figure 16 and table 03, where the total internal area of each block is given.

- Levels 3 and 4 :

stages of work and operations; each house building process is divided into 42 stages of work and each stage of work is further divided into operations; whenever it is not possible to relate an observation to a particular operation within a stage of work, the heading "apportionable to stage only" is used; a complete listing of the stages and respective operations is given below, exaclty as set out by the Building Research Establishment's production analyst:

Stages of Work	Operations
1) Foundation	A - excavate trenches B - concrete C - shuttering D - reinforcement K - apportionable to stage only
2) Substructure	A - brickwork B - blockwork C - lintols and service entry ducts K - apportionable to stage only

3) Ground floor slab	A - fill, hardcore and blinding B - slab, dpn, edge insulation and reinforcement C - flooring D - precast concrete floor units E - precast concrete stair units F - machine guide and shuttering G - slip steps K - apportionable to stage only
4) First-storey superstructure and also: 6) Second-storey 8) Third-storey 10) Fourth-storey superstructure	A - brickwork to external walls B - blockwork to external walls C - blockwork to party walls D - door and window frames E - dpc, lintols and window cills F - stud partitions G - rendering to party walls anc stair wells H - temporary buttresses for brickowrk J - cavity wall insulation K - apportionable tc stage only
5) Second-storey flooring and also 7) Third-storey, 9) Fourth-storey floorings	A - floor joists and ties C - flooring D - precast concrete floor units E - precast concrete stair units K - apportionable tc stage only
11) Roof carcassing	A - trusses, wall plates, fascia, ties anc braces B - sarking C - asbestos cavity closers D - ceiling insulation K - apportionable to stage only
12) Eaves to apex superstructure	A - brickwork to flank walls B - blockwork to flank walls C - blockwork to party walls K - apportionable tc stage only
13) Roof covering	A - felt, battens, tiles and roof lights K - apporticnable to stage only
14) Scaffolding	A - bricklayers scaffolding B - external scaffolding K - apportionable to stage only L - carpenters scaffolding
15) Glazing	A - glaze doors and windows B - mastic pointing around doors and windows K - apportionable tc stage only

16) Harling	A - harling and metal trims B - expansion joint filler C - mastic pointing to expansion joints D - remove efflorescence K - apportionable to stage only
17) Stairs	A - timber stairs, balustrade, trim and soffit B - metal handrails and balcony balustrades K - apportionable to stage only
18) Dry-linings	A - plasterboard to external walls B - plasterboard to party walls and partitions C - plasterboard to ceilings D - paramount partitions K - apportionable to stage only
19) Doors	A - external doors B - internal doors sets C - door and window reveals D - ironmongery K - apportionable to stage only
20) Joinery	A - timber skirtings and door facings B - plastic skirtings C - kitchen units D - bath panels, trims, shelving and boxing pipes E - tiling showers K - apportionable to stage only
21) Plumbing	A - gutters, down pipes and roof flashings B - soil and ventilation pipes C - hot and cold water pipes, tank, cistern and lagging D - wash basin, bath and wc E - radiators and pipes F - gas pipes K - apportionable to stage only
22) Electrical	A - wiring B - socket outlets, switches and fittings C - conduit and meters K - apportionable to stage only
23) Heating and ventilating	A - gas heating unit and ducts B - electrical heating unit and ducts C - air extract unit and ducts K - apportionable to stage only

24) Decoration	A - artex B - tape and fill joints in plasterboard C - emulsion paint to walls D - gloss paint to internal surfaces E - gloss paint to external surfaces F - sigma coating (stairs, landings, etc.) K - apportionable to stage only
25) Floor finishes	A - screed B - floor tiles K - apportionable to stage only
26) Cleaning and snagging	A - clean out prior to execution B - snagging after occupation C - clean out during construction K - apportionable to stage only
27) Additional sound insulation	K - apportionable to stage only
28 and 29) not used, reserved for unexpected ocurrences of work	
30) Reduce levels	A - strip topsoil, reduce levels and cart away B - ticy earthworks around site C - cover up courtyard areas for protection D - clean off courtyard areas E - break up and cart away rock K - apportionable to stage only
31) Soil drains	A - excavate trenches and backfill B - lay pipes and granular material C - construct manholes K - apportionable to stage only
32) Surface water drains	A - excavate trenches and backfill B - lay pipes and granular material C - construct manholes K - apportionable to stage only
33) Gardens	A - garden paths and steps B - bin stores C - fencing D - screen and retaining walls E - vine supports F - replace topsoil

	G - rotary dryers - all work K - apportionable tc stage only
34) Landscaping	A - return topsoil and form mounds B - public seats and play equipment C - play areas - all work D - cobbled edging to courtyards E - fencing F - concrete blocks for fire paths K - apportionable to stage only
35) Roads and public footpaths	A - kerbs, base and surfaces to roads and courtyards B - kerbs, base and surfaces to footpaths K - apportionable to stage only
36) Site establishment	A - erect and maintain offices, sheds and compounds B - temporary fences, access and utilities C - visits to stores and offices D - plant maintenance, cleaning and refueling E - general cleaning up around site K - apportionable tc stage only
37) Gas and also 38) Water, 39) Electricity	A - excavate trenches for main cable/pipe and backfill B - lay main cable/pipe and fittings C - excavate trench for house connection and backfill D - lay house connection cable/pipe and meter K - apportionable to stage only
40) PO telephone	A - all work
41) TV relay	A - all work
42) Street lighting and name boards	A - street lighting, all work B - street name boards, all work

- Level 5:

all observations are recorded against one of the following activities, no matter what headings are used for higher levels in the hierarchy:

F1 - making the building grow (adding materials and componentes to the house in a productive way)
U1 - unloading
H1 - handling around the site
H2 - handling from stack to workplace
Su - supervision
T1 - setting out and measuring
T2 - testing hot water pipes, drains, etc.
P1 - preparation of materials
Cl - cleaning tools or clearing up
N - not working while at the workplace
I - not working while around site
W - walking
Bk - meal breaks
Ro - work stopped due to the weather
A - operative not seen during the round
Rt - work repeated
F2 - lay bricks/blocks to rule
F3 - lay bricks/blocks to line
F4 - spread mortar bed
P2 - cut bricks/blocks
P3 - prepare mortar
P4 - set up line

The setting up of the site hierarchy is entirely the responsability of the production analyst. It should be done in accordance with the objectives of the site analysis exercise to be conducted. The setting up of the site hierarchy is done previous to the start of the works on site; it follows from previous discussion in this report that it is not always easy to define this site hierarchy so as to make sure that it will match the actual building process on site. As a good guide, the production analyst should try to define each operation as broadly as possible in order to encompass a significant proportion of work on site, while ensuring that it will be performed by only one building trade and occur at a unique period of time during construction. Small proportions of man-hours are relativelly more innacurate due to the principles of activity sampling; this innacuracy can render useless the output tables produced by the Site Activity Analysis Package.

Due to small differences in the site hierarchies it is not possible to compare directly the analyses for the 3 different sites: in Ladygate Lane, ground floor panels correspond to one stage of work, while at Pitcoudie 2 the equivalent stage, first-storey superstructure, contains brick and blockwork to external walls, door and window frames, cavity insulation and stud partitions.

3.3 Graphical Software developed

3.3.1 Introduction

In this section each one of the programs developed is briefly described, graphical output is presented and the major findings that stem from each graph are discussed.

A complete documentation of each program, comprising the Fortran program itself, input files and a graphical example, is given in the appendix.

The computer programs developed for Pitcoudie 2 are designed to use information aggregated at the level of stage of work. Some conclusions taken from the graphs may be criticized because the lower level of detail - operations - was not investigated. However, for the Ladygate Lane site, analyses were carried out both at the level of stages of work and at the level of operations without significantly different results.

The production tables obtained from the Building Research Establishment contain both productive and non-productive allocations of man-hours. The graphs presented in this report can be redrawn using only productive hours.

The respective merits of using the total number of hours or only productive hours to investigate the pattern of progress of work on site is open to discussion. One of the major objectives of this Site Activity Analysis Package is to provide feedback information to estimating departments. Non-productive hours should be included in estimates whatever type of production feedback is obtained from site. Forbes (12) maintains that labour rates should not contain non-productive time, and suggests that this should be included as a global figure at the end of the estimating process; the fact that non-productive time is related to organizational aspects of construction sites and building companies rather than to physical quantities and type of work is given as the justification for this procedure. On the other hand, including non-productive time in estimates at the level of stage of work or operation simplifies the whole process of feedback and labour cost control.

3.3.2 Program P2NETJUN

Information obtained from the Building Research Establishment was in the form of tables showing weeks as the row headings, stages of work as the column headings and man-hours as the tabulated values, one table for each of the 53 blocks. This program simply plots the information contained in these tables; the program output is a graphical representation of the tables used as input. Stages of work are arranged in a bar chart format. Only stages 1 to 25 are included, because the remaining stages are mainly related to external work.

Weekly totals of man-hours allocated to each stage of work in each block are transformed into "colour densities" by the use of the subroutine 'Call Thick' (see 4); this subroutine draws n-1 parallel lines alongside a central line; the length of the lines drawn corresponds to one week of work on site; the value of "n" is given as a parameter for the subroutine; the greater the number of parallel lines drawn the wider and apparently the more colourful becomes the rectangle representing the number of weekly man-hours allocated to the stage of work; a suitable scale is choosen to relate man-hours to colour densities, for example:

Range of man-hours	n	Number of parallel lines drawn
From 1 to less than 5 man-hours	1	1
From 5 to less than 21 man-hours	2	3
From 21 to less than 41 man-hours	3	5
From 41 to less than 81 man-hours	4	7
From 81 to less than 121 man-hours	5	9
More than 120 man-hours	6	11

This scale corresponds roughly to half a man-day, half a man-week, one man-week, 2 man-weeks up to more than 3 man-weeks' work. The form of each graph will depend on the scale choosen and any scale can be rapidly implemented in the program.

Figures 18, 19, 20 and 21 are examples of the graphical output produced by this program. The figures convey a more concise and a clearer image of the progress of work in each block than the printed output tables from the BRE. Information on each block can be analysed in terms of stages of work duration, technical precedences and weekly intensity of work. For example, the stage "decoration" took nearly 20 weeks to be completed in block 1 (fig 18) and block 11 (fig 19) and was done in parallel with stages "doors", "joinery" and "stairs".

Figure 20 is a graphical representation of the week versus stage of work table for block 17. This block is a very small one, containing only 2 2-person houses. Nevertheless, the total duration of construction for this block is very similar to that for block 11, with 8 4-person houses and 2 2-person houses; this can only be so if the average intensity of work on block 17 is low compared with block 11.

Figure 21 shows that block 44 was done in 2 different periods; first, all substructure and carcassing, and then, 30 weeks later, dry-linings and finishings. The reason for this is probably that block 44 was used to accommodate site offices during the early stages of construction.

Four different periods of work can be identified in each graph (see figure 19). The first one corresponds to substructure (foundations, substructure and ground floor concrete slab); the second one relates to what can best be described as building carcassing (first, second and third-storey superstructures, floors, roof carcassing and covering); after that only the stage dry-linings is carried out; near the completion of this stage the finishing operations are started, including services (plumbing, heating and electrical work), woodwork (doors, joinery and stairs) and decoration.

This possibility of dividing the construction process into four broad areas is further investigated in the next program.

3.3.3 Program P2GRTO

This program allows the plotting of any number of stages from any number of blocks simultaneously. Different colours are assigned to each stage of work (up to a maximum of 4 colours - black, red, green and blue - according to the Calcoop 1012 device). Weekly allocations of man-hours to each stage of work in each block are represented by colours densities according to a user selected convention. Each range of values in this convention is associated with a paramater of the subroutine Call Thick, exactly as in the preceding program. The convention used in figure 22 is:

Range of man-hours	Paramater for the subroutine	Number of parallel lines drawn
From 1 to 20 man-hours	1	1
From 21 to 40 man-hours	2	3
More than 41 man-hours	3	5

This graph corroborates the idea that the stages of work were performed in four different groups with respect to time. Various combinations of colour assignments tc the stages of work were tried but the clearest picture emerged with the colour convention appearing in the right hand side of figure 22.

It is worthy of note that:

a) the stages of work foundation, substructure and ground floor slab were performed at a much quicker pace than the others;

b) the stages of work corresponding to carcassing and dry-linings were interrupted by holidays between the 40th and 45th week but the finishing stages were not so interrupted;

c) block No. 44 did not follow the building sequence after the carcassing period;

d) the y axis gives an approximate order for the starts and completions of the stages of work. In fact, in this figure the y axis was organized according to the starting order observed for the stage first-storey superstructure. This is not to say that all stages of work will have the same starting order as the first-storey superstructure. Any stage of work can be used to organize the y axis. Figure 23 depicts the approximate flow of work on this site using the same starting order as in figure 22.

This program can be used to reproduce figure 10 which was produced manually by Forbes for the Finchampstead project. The main feature is its capability of conveying at a glance the amount of interference between stages of work and the production characteristics (duration, precedence and intensity of work) of these newly identified groups of stages like substructure, carcassing, etc..

3.3.4 Program P2NGER

The basic idea behind program P2NGER was to obtain a pictorial representation of the average duration of each stage, its precedence relationships, and the intensity of effort by the operatives.

The program superimposes all 49 graphs produced by program P2NETJUN. This is not straightforward because each block has different total durations and different group of stages durations; for example, some stages of work took much longer for some blocks than for others because they were interrupted by holidays. Superimposition requires the bar charts of each block to be as similar as possible with respect to time in terms of group of stages durations and total durations.

From the previous graphs it became clear that it is possible to differentiate stages of work into well defined groups. The bar chart for each individual block from No. 1 to No. 49 (blocks Nos. 50 and 53 are flats with a different bar chart structure) was divided in four groups: substructure, carcassing, dry-linings and finishings.

The graphs produced by program P2NETJUN were used to determine the practical start and completion dates for each of these groups of stages within each block. An average duration for each group was calculated. This average group duration was then used to establish a standard bar chart framework. The standard bar chart framework developed for this particular graph shown has the following characteristics:

group of stages	duration	accumulated duration (milestones)
substructure	9 weeks	week 0 to the end of week 9
carcassing	13 weeks	week 10 to the end of week 22
dry-linings	11 weeks	week 23 to the end of week 33
finishings	-	week 34 onwards

Each group duration was compressed or decompressed to fit this time structure. Finishing stages were left unchanged, but in all blocks they were made to start in the 34th week. After this exercise of fitting each individual block bar chart into the standard bar chart framework, man-hours allocated to each block were aggregated and plotted, stage of work by stage of work and week by week. The exact procedure is fully explained in the source copy of the Fortran program P2NGER presented in the appendix.

A geometrical scale was used to represent the aggregated amount of man-hours allocated in each week. The scale below was used to provide the parameters for the subroutine Call Thick:

Range of man-hours	Parameter for the subroutine call thick	Number of parallel lines drawn
From 1 to 40 man-hours	1	1
From 41 to 80 man-hours	2	3
From 81 to 160 man-hours	3	5
From 161 to 320 man-hours	4	7
From 321 to 640 man-hours	5	9
From 641 to 1280 man-hours	6	11
From 1281 to 2560 man-hours	7	13
From 2561 to 5120 man-hours	8	15
From 5121 to 9999 man-hours	9	17

The absolute amount of aggregated man-hours has no special meaning because it is a function of the subjective standardization procedure used. It can be used only on a relative basis, comparing the allocation of effort within or between stages.

Figure 24 shows the aggregated bar chart drawn by this program. It gives a rough idea of the precedence relationships between stages of work, their durations and ocurrences during the construction process. This figure provides evidence that:

a) average durations in each block were very long; for example, doors and joinery work took more than 30 weeks to be completed; decoration took even more than this; the electrical stage of work that was carefully designed to require only one visit by the electrical trade took 15 weeks to be completed;

b) the technical precedence between stages did not require the completion of a supposedly preceding stage of work to allow the succeeding one to start. Stages of work overlapped, they were done in parallel rather than in sequence. The envisaged flow of work presented in figure 17 was not followed, and the sharp separation between the work of different trades did not occur;

c) on average each block took 60 weeks to be completed.

Any particular set of blocks and stages of work can be examined using this program. It could be used to investigate only one-storey blocks or only blocks containing 5 person houses, etc..

3.3.5 Program P2SER2

This program simply aggregates and plots the weekly total number of man-hours spent in each stage irrespective of block. Figure 25 is an example of the output this program is capable of producing. Not only blocks 1 to 53 are included in this case but also block 60. As mention earlier, whenever it is not possible to relate the stage of work being observed to a specific block the heading "block 60" is used. For the majority of internal stages of work, i.e., the ones with identification numbers between 1 to 26, the amount of hours recorded under this block 60 heading is not more than 12%, but for the external blocks, i.e., the ones with identification numbers between 30 to 42, the majority of the work was recorded under this heading.

In contrast to program P2NGER where man-hours allocated to each stage of work are transformed into man-hours allocated to standard stage durations, this program aggregates the individual amounts of man-hours exactly as they appear in the week versus stage tables obtained from the BRE. If the BRE tables are considered as a matrix, these stage man-hours form a band of values, roughly approximating the progress pattern band used with Line of Balance programming techniques. This is the reason why the aggregated bar chart picture in figure 25 is called "drawn from the Line of Balance".

The scale used to represent the intensity of effort applied to the stages is the same as in program P2NGER.

When used in conjunction with program P2GRTO, this computer software is useful for providing a general picture of the progress of work on site. The start and finish of each trade's work is clearly marked as also is its intensity of work (number of weekly hours worked).

The total duration of work on site, not considering the external works like gardens, landscaping, road and public footpaths, can be taken as 85 weeks. Comparatively speaking, this is not much greater than the 60 weeks observed in figure 24 depicting the average bar chart of individual blocks. This means that each block took on average 70% of the total time taken to complete the whole site, or in other words, it means that the time taken to complete the individual blocks and the whole site is of the same order of magnitude. Building work spreading over several blocks at the same time instead of being concentrated in a reduced number of blocks each week is one possible explanation for this.

3.3.6 Program P2GRAF

The programs so far described are useful to analyse the progress of work as a whole, and for studying groups of stages of work from subsets of building units (blocks, houses, etc.). Individual stages of work are analysed or compared using the next 2 programs. Both programs enable the user to choose any particular set of blocks for analysis using any particular "colour density convention".

The first program developed was P2GRAF. One initial difficulty was to find a suitable order for the y axis, to represent the sequence of work from block to block. As shown in figure 16 blocks were numbered from top to bottom and from left to right. The unique clue found in the drawings was that blocks 1, 6, 11, 15, 18, 19, 24, 28, 29 and 31 were situated in the "first area available for building". No other information was available about the sequence of work from block to block.

Therefore it was decided to investigate this aspect of the sequence of work using a block ordering from 1 to 49 as the y axis. Figure 26 is an example of the output generated by this program. Clearly stages of work did not follow the sequence 1 to 49 in terms of their starts and completions. The resulting confused progress pattern meant that this y axis block ordering was not useful for comparing the patterns of progress of 2 different stages of work, or for analysing single stage progress patterns.

A better procedure was introduced, which was capable of finding the order in which individual stages of work were started. Whenever the number of man-hours allocated to a stage of work is greater than a given amount, the work in this stage is considered to have started. There is no point in saying, for example, that a stage of work has started because one observation was made of an operative just, say, visiting the work place.

For the remainder of this report this minimun number of man-hours choosen by the user as indicative that the stage of work has really started will be called the starting parameter.

For each starting parameter a different block starting order and a different graphical representation of the progress of work on site could be obtained. Figures 27, 28, 29 and 30 refer to the same stage of work, first-storey superstructure, but different starting parameters were choosen in each case. Even with 1 man-hour as the starting parameter, the pattern of work is clearly set; the stage occupies a band of some 10 weeks from start to completion, with the majority of the effort concentrated in the 2 initial weeks. The aggregated total amount of man-hours allocated weekly to the stage in this particular set of blocks is plotted at the bottom of the figure.

Figures 31 to 45 refer to the stages joinery, plumbing and decoration. A completely different pattern of work emerges with each starting parameter. For example, no clear pattern of progress with respect to major effort in the joinery stage appears in figures 31 and 32 using 1 or 5 man-hours as the starting parameters, but with a 40 man-hours parameter (figure 35) it becomes apparent that this major concentration of effort took a relativelly small proportion of the total stage duration in each block (between 2 and 3 weeks). It is also apparent that this major concentration of effort followed a steady line of progress from block to block.

The same could be said about the plumbing stage although 2 well defined lines of progress appear using 1 man-hour as the starting parameter (figure 36) while a 10 man-hours starting parameter (figure 37) is not able to produce any clear line of progress.

Figure 46 shows that the stage second-storey flooring comprises in fact 3 operations. No useful information can be obtained using a y axis block order from 1 to 49 as in figure 47. The site hierarchy set by the Building Research Establishment analyst assumed that only 2 tasks would be performed under the heading second-storey flooring, that is, floor structure (ties and joists) and flooring (the other operations defined under this heading are related to the flats where concrete floors and concrete staircases were used).

Figure 48 depicts the interruption of work in the dry-linings stage due to holidays from week 40 to week 45. Figure 49 presents the same stage with a y axis block order from 1 to 49 emphasizing once more the importance of finding the correct order of starts when producing this type of graphs.

This program P2GRAF is useful for determining the progress pattern of single stages; it can also be used to give a rough idea about average stage durations, levels of resources available on site, and precedence relationships between different stages. Figure 50 proves that, in all but 3 blocks, ground floor slab precedes first-storey superstructure; furthermore, there is a large time buffer between these 2 stages of work. It is worth noting that the starting order is arranged according to the first stage - ground floor slab - , but that the second stage did not follow the same sequence.

The comparison between the progress of work in 2 stages can become confused when there is a certain degree of overlapping. Figure 51 compares the progress of work of second storey-flooring and second-storey superstructure; the first part of second-storey flooring precedes second-storey superstructure, but the last part of flooring comes just after the latter has finished. In this case, even if an apparent overlapping exists, the precedence analysis is straightforward, but in figure 52 it is not easy to assess the cegree of overlapping between the final part of roof covering and the initial work on dry-linings.

The next program evolved from this one. The author tried to develop a better way of qualitatively analysing the degree of overlapping between 2 stages of work.

3.3.7 Program P2NLOB

For a given stage of work this program aligns verticaly the stage of work starting dates of a number of blocks. In other words, it brings to the vertical the inclined band of progress that the stages of work normally show; all the blocks are shown to have that stage of work starting simultaneously. The starting order that appears on the y axis is given by a minimum number of man-hours allocated, the previously referred to starting parameter. When 2 stages are being compared, the starting order is given by the first stage input. Horizontal shifts to the left given to the first stage of work are equally given to the second stage of work, block by block.

This program is not able to show the progress of work throughout the project duration as program P2GRAF does, but it produces a clearer picture in terms of stage durations and precedence between stages. Figure 53 allows the reader to see that the stage roof covering unquestionably preceded joinery, as can be expected. It reveals that the overlapping between these stages indicated in figure 24 is limited to only a few blocks.

Figure 54 shows that the stage dry-linings took on average almost 13 weeks to be completed (at least the majority of work did, total duration was more than 30 weeks) and that it was preceded by second-storey superstructure. The pace of work in these 2 stages was different; the time gap between them increased when the final blocks were reached. The aggregated plots at the bottom of the figure give some rough qualitative indication about the precedence relationship between the 2 stages. This form of progress presentation makes it impossible to detect the interruption due to holidays as seem in figure 48 produced by program P2GRAF.

Figure 55 compares roof covering and dry-linings, improving upon figure 52 as far as clarity in depicting the overlapping between stages is concearned.

Figure 56 investigates the precedence relationship between first-storey superstructure and second-storey flooring; a small proportion of the second-storey flooring work was done just after the major proportion of first-storey superstructure work. Likewise, from figure 57 it is apparent that second-storey superstructure had started only after this small proportion of second-storey flooring work was done. Only block 41 did not follow this precedence arrangement. Both figures show that the majority of work in connection with second-storey flooring was done after first and second-storey superstructure were virtually completed.

This construction pattern is what can be expected in this type of house construction, where external first-storey and second-storey brickwork are operationally split by floor joisting. This dictates discontinuity of work, and Forbes (10) suggests modification of this traditional design t allow continuity of work to take place.

The reader is requested to compare figure 57 with figure 51, which was drawn using program P2GRAF, and which was also intended to assess the overlapping between second-storey superstructure and second-storey flooring.

It is possible to combine figures 56 and 57 into a unique one, thus comparing 3 stages of work at once. It is necessary to introduce only small modifications to the P2NLOB program. A different colour density scale should be used: the band thickness of the largest allocations of man-hours should be reduced, in order to allow 3 stages of work to be drawn within the slot reserved for each block.

Program P2NGER provides a rough indication of which stages of work should be compared using program P2NLOB in order to have better insight into the precedence relationships existing on each site; it is obvious that decoration should succeed foundations or first-storey superstructure but, unexpectedly, in this analysis of Pitcoudie 2 the author found that decoration was performed in parallel with stages like doors, joinery and services.

The uncertainity regarding the precedence relationships created by the observed tendency for overlapping between stages requires a large number of comparisons to be made. The maximum number of comparisons that can be made for this site with a total of 42 stages is 42 x 41 = 1722, or 861 if the user does not want to compare each pair of stages twice, each time with one of them as the leading stage determining the starting order. The author was able to cut down this number to some 150 comparisons using program P2NL08. Although this large number of graphs provided a very gooc qualitative understanding of the real precedence relationships between stages of work, it proved to be an expensive exercise in terms of computer time and plotting resources.

A useful set of graphs obtained using program P2NL08 is described below. Figure 58 shows again the first-storey superstructure stage; this stage took on average a maximum of 14 weeks to be completed, but the majority of the effort was allocated during the first 2 or 3 weeks.

Figures 59 and 60 refer to the same stage of work, joinery, but the first one uses as starting parameter 5 man-hours and the second 40 man-hours. The first graph suggests that this stage took on average some 23 weeks to be performed. The second one indicates that the major effort in this stage changed its relative position as new blocks were tackled. In the first blocks the major effort ocurred at the end of the stage duration while in the last blocks the major effort was applied right at the beginning of the duration. The same conclusion could have been obtained from figure 35 which was drawn using program P2GRAF.

The same change in the relative position of the major effort with respect to decoration can be noted in figure 61. Apparently, the total duration of this stage of work remains the same throughout the project construction, block after block. However figure 62 indicates that the practical duration of the decoration stage decreased as the operatives progressed through the site; the major effort occurs closer to the start of the stage and the remaining man-hours are less and less significant.

Figures 63 and 64 are used to demonstrate the capabilities of this program to illustrate total overlapping between stages of work. In figure 63 roof carcassing marginally precedes roof covering, but, apart from this initial lag, both stages proceed in parallel until their completion. The stage superstructure eaves to apex was mainly related to brickwork; it was done at the same time as brickwork for the second-storey superstructure (figure 64).

Figures 65 and 66 return to the analysis of the second-storey flooring stage of work, which is the object of several figures in this report. This stage in theory contained 2 operations, flooring-structure (ties and joists) and flooring. It is clear that the second operation of this stage of work, flooring, was performed under the same environmental conditions and at the same time as the first part of dry-linings. As expected, each block was covered anc partially glazed before flooring and dry-linings could start.

Figures 67, 68 and 69 refer to glazing. Generally this stage of work is a very important milestone in the building process because it marks the moment when dry processes substitute for wet ones. Glazing was done after second-storey superstructure (figure 67) but in parallel with roof covering (figure 68). Both glazing and roof covering were necessary to provide a waterproof environment for the succeeding dry trades. The dry-linings stage of work was started only after the first part of glazing was completed, as can be seen in figure 69.

When analysing this stage of work it becomes difficult to understand the reason behind the subdivision of the stage into a great number of small sub-tasks; on average glazing lasted more than 30 weeks and some 8 separate visits were necessary for each block.

Figures 70 and 71 are presented in support of the idea that the dry-linings stage of work can be taken on its own as one of the four major groups into which the stages of work were divided (substructure, carcassing, dry-linings and finishings). Here joinery and decoration are shown to start after the major effort by the dry-linings trade was allocated. Similar precedence relationships would be seen if graphs depicting dry-linings versus heating and ventilation, doors and windows, electrical installation, or plumbing were produced.

Figures 72, 73 and 74 exemplify the overlapping tendency found within the finishing stages. Decoration is compared with heating and ventilation, electrical installation, and joinery. Only the electrical installation stage seems to occupy a well defined position in time, always before the major effort in the decoration stage.

The floor finishes stage was considered to be the last stage according to the planned flow of work in figure 17. This held good for some blocks, but for the majority of them work on decoration continued well after the floor tiles were laid (figure 75). It is interesting to observe the different pace of work in these 2 stages; as floor finishes proceeded at a slower pace than decoration the time gap between them increased.

The P2NLOB software is also useful to point out circumstances in which expected precedence relationships did not occur. The Water Authority mains connections and the plumbing installation seem to bear no relationship at all either in terms of precedence or pace of work (figure 76); this could be considered to be unexpected because it is generally wiser to test the plumbing installation with the mains already connected; in such a case these 2 stages of work would bear some operational relationship. By contrast, figure 77 makes it clear that the electrical installation work and the Electricity Generation Board work had some relationship. Figure 78 shows that harling preceded dry-linings. The planned flow of work presented in figure 17 indicates exactly the opposite since mastic pointing to expansion joints (included in the harling stage) was scheduled to start after plasterboard to external walls (included in the dry-linings stage).

3.3.8 Program P2STJN

The various examples of graphs produced using program P2GRAF attest to the fact that each stage of work had a different starting order. Moreover, even the same stage of work could have different starting orders using different starting parameters. Program P2STJN was created to investigate starting orders, using a simpler approach than program P2GRAF.

Figure 79 studies the joinery stage of work. It can be seen that the lines of starts for the given starting parameters lay inside a band of 15 weeks. Figure 80 refers to first-storey superstructure: a much more stable set of lines of starts is presented; choosing different starting parameters would not determine very different dates for the start of work in each block.

Figures 81 and 82 are used to plot the line of starts of 6 major stages of work on site, namely first-storey superstructure, roof covering, dry-linings, joinery, electrical installation and decoration. It seems that each stage had its own starting order and neither the selection of a particular stage as the leading stage (i.e., the one that provides the starting order in the y axis), nor the selection of a specific set of starting parameters is capable of producing a better agreement between the starting lines of the various stages. Nevertheless the general trend of the pace of starts is similar for all stages, whichever leading stage and set of starting parameters is choosen.

Figure 83 shows that even for 2 very related stages of work like roof carcassing and roof covering the starting order was not the same.

Several papers dealing with line of balance programming technique like the works by the Building Research Establishment (3) and Lumsden (17), emphasize the use of graphical methods to control the progress of work on sites of a repetitive nature. Figure 84 presents the starting lines of the 25 stages of work comprising the majority of the internal work in Pitcoudie 2. The graph is very confusing due to the lack of a rigid sequence of starts, and because several stages of work started almost simultaneously.

The usefulness of controlling progress on site using line of balance graphical methods is challenged by figures 84 and 85: a National Building Agency report (19) suggests the selection of only a suitable set of stages of work for site progress control; only the 9 most important stages of work (in terms of the number of man-hours allocated to them) are plotted in figure 85 but still the graph remains confusing and not useful for site progress monitoring.

3.3.9 Program P2STAJUN

Difficulties with monitoring site progress resulting from the unique starting order of each stage of work, as highlighted by the last program, led to the creation of this program P2STAJUN. Each stage of work is plotted according to its own starting order. No y axis annotation is given, because each stage of work would determine a particular one.

Figure 86 shows various lines of starts for the dry-linings stage of work, each one obtained with a different starting parameter. A decreasing number of blocks is plotted with increasing minimum parameters because the maximum weekly allocation of man-hours in some blocks was not as high as the starting parameter choosen. Compared with the previous program output, this form of progress display has 2 major advantages;

a) graphical control of progress on site is easier due to the improved clarity;

b) information is provided concerning the pool of work available ahead of each trade; it is possible to know the number of blocks started by the preceding trades. It is necessary to ascertain that the number of blocks started (and here started can be understood as implying a major effort in the stage started) is a good indicator of the work being mace available by the preceding crews.

The major shortcoming of this form of presentation is that precedence bottlenecks in the work flow of individual blocks are not detected.

Ideally the line of balance technique gives information not only about precedence bottlenecks but also about pool of work available ahead of each trade. Due to the uniqueness of the starting order of each stage of work, these important features of the line of balance progress control method are lost and can only be partially restored by programs P2STJN and P2STAJUN.

The pace of starts of the 21 most important internal stages of work (excluding cleaning and snagging) is given in figure 87. The reader is requested to compare it with figure 84 in terms of clarity and usefulness for site progress control.

4. Summary of Results and Conclusions

4.1 The Graphical Software as an Analysis Tool

The graphical software was developed because the author felt that the output provided by the Site Activity Analysis Package was not sufficiently quick, flexible or economical to analyse the wealth of information stored after the use of the powerful Building Research Establishment activity sampling method. The extraction of information from the computer files is made easy by the simple set of instructions contained in the package manual (22), but the computer printouts are bulky, more often than not needing a lot of handling and rearrangement of the individual pages (including cutting and glueing) to allow a better appreciation of the information conveyed.

The graphs developed are a step forward in terms of clarity and conciseness; the use of colour density instead of the number of hours allocated weekly to each stage of work could be more meaningful when a general appreciation of how man-hours were spent on site is desired. With small modifications to the programs it is possible to provide numbers instead of colour densities, exactly as with the computer printouts tables, but using a smaller size of paper due to the flexibility in plotting character sizes.

The graphs add to the usefulness of the Site Activity Analysis Package output because they can handle a greater number of variables than the tables, which are usually restricted to 2 variables, one for the row heading and one for the column heading. The graphs are not a substitute for the tables, but should be used in conjuction with them. Numerical and graphical analyses are equally important to study the progress of work cn building sites.

Some of the disadvantages associated with the use of graphs are:

a) they rely on scales and conventions to transmit the information; in this report the scales and conventions were set on a subjective basis;

b) they make use of plotting devices rather than line printer ones; experience gained using the computing facilities at the University of Leeds indicates that plotter devices are slower, more expensive to run and more prone to breakdowns than line printers. For example, comparing the progress of work on different stages taking only 2 stages at the time requires a very large number of graphs (some 150 as in Pitcoudie 2), representing a costly and time consuming exercise in terms of plotting resources.

At the beginning of the computer software development the author was hoping that graphical output on its own would be able to provide the necessary information about the sequence of work, the durations of stages of work and the precedence between them for the 3 sites for which data was obtained at the Building

Research Establishment. The author now feels that the analysis of production data using mainly graphical methods is lenghty and impractical. Statistical and regression analysis techniques will be used to help obtain data necessary for the research work in programming techniques now being uncertaken at the Department of Civil Engineering of the University of Leeds.

Some examples of graphs were produced in the preceding chapter in order to make the reader aware cf the graphical software capabilities. In this section conclusicns are drawn from the complete set of graphs developed by the author, encompassing not only the Pitcoudie 2 site but also the Pitcoudie 1 and Ladygate Lane sites. As no numerical analysis has been applied so far, conclusions stem directly from the information the graphs are capable of conveying.

4.2 Graph Analyses - Findings and Suggestions -

The more important conclusions obtained so far are given below. The reader is requested to bear the review of literature in mind, comparing the major findings here presented with those of other authors.

4.2.1 The Durations of the Stages of Work

The durations of the stages of work are greater than could be expected from the division of average labour content by the number of workers assigned to each job. Figure 58 shows that first-storey superstructure took on average 10-12 weeks to be completed. The total number of man-hours spent in each block ranged from 106 to 532, with an average of 275 man-hours.

The Site Analysis Activity Package allows the user to know exactly the size of gangs, operatives' identification numbers, and gang composition (proportion of unskilled to skilled workers) allocated to each stage of work. Unfortunately the author was not able to get those tables from the BRE. Assuming several gang compositions with each operative working 40 hours per week, the expected durations of the first-storey superstructure stage would be:

		Total number of men in the gang				
		1	2	3	4	5
Number of hours taken by the stage	532	13.3	6.7	4.4	3.3	2.7
	275	6.9	3.4	2.3	1.7	1.4
	106	2.7	1.3	0.9	0.7	0.5

Only in the worst case , that is, stage labour content equals to the maximum number of man-hours allocated to any one of the 49 blocks and only 1 man assigned to the job, is the calculated duration greater than the real one. It is reasonable to assume that in this stage, involving mainly brickwork, the gang was formed of at least 2 men; under this assumption each man will be working only 12 hours each week on this stage.

Forbes (10) found that houses with a total labour content of 800 man-hours were built in 40 weeks, giving an average of only 20 hours worked per week on each house, irrespective of trade or stage of work. Both figures include productive and non-productive time.

Figure 88 deals with the plumbing stage of work. The actual number of man-hours allocated to each block was between 55 and 407 with an average of 138 man-hours. The graph indicates that the average duration can be taken as 45 weeks. The following operations were recorded under the plumbing heading:

a) gutters, downpipes and roof flashings;

b) soil and ventilation pipe;

c) hot and cold water pipes, tank, cistern and lagging;

d) basin, bath and w.c.;

e) radiators and pipes;

f) gas pipes.

The dispersed aspect of the figure coulc have been determined by the fact that it actually represents 6 different operations; each operation coulc have been performed in a shorter duraticn with a higher relative density of man-hours applied to it. Only analysis at the level of operaticn rather than stage will show if this is so. For the moment it is worth mentioning that the intended flow of work (fig. 17) shows only 2 visits by the plumber trade and that the notes and specifications about Pitcoudie 2 (23) says that:

"Rationalization of house bulding construction is achieved by careful attention to plumbing, electrical and joinery work, forming fewer, larger and more independent trade operations".

It is possible to count on average 8 interruptions of work for each block in figure 88.

The electrical installation had been the object of special concearn in projects Pitcoudie 1 and 2. Previous experience with the Ladygate Lane site (see 11) was applied to these projects to modify the design and construction methods to make the stage electrical installation a one visit job. This stage was divided in 3 operations:

a) wiring;

b) socket outlets, switches and fittings;

c) conduit and meters.

Under traditional design practices this stage would correspond to at least 2 visits, first fixings and second fixings. The one visit job intention was partially achieved according to figure 89 and figure 90; both figures are here presented just to compare once more the output of programs P2NLDB and P2GRAF. The greater part of the work was done in the 2 or 3 initial weeks, but the actual total duration was still in the region of 10 to 12 weeks. The number of man-hours allocated to each block ranged from 36 to 482 with an average of 164 hours.

Figure 91, obtained using program P2GRAF with an 1 to 49 order of blocks as the y axis, and figure 92 obtained using program P2NLOB and a starting parameter equal to 1 man-hour, are also presented here; they illustrate that the apparent duration of the electrical stage conveyed by the graphs can be misleading if the proper starting sequence is not used.

Real concentration of work was found only in the initial stages corresponding to substruture (foundations, substructure proper and ground floor slab), harling and floor finishes.

The average number of man-hours allocated, the standard deviation of the number of man-hours allocated, the average duration and the average intensity of work (number of man-hours per week) for these and other stages of work at Pitcoudie 2 are listed in table 04. It is worth remembering that stage durations are taken roughly from P2NLOB graphs, they do not represent an accurately calculated value.

Figures 93, 94 and 95 refer to the harling and floor finishing stages. Figure 94 is included to demonstrate once more the importance of finding the correct starting order of blocks.

In the light of these findings it is suggested that the concept of stage durations should be reviewed; instead of talking in terms of an absolute duration, from the start of a stage to its finish, it would be better to talk in terms of time taken to reach a determined level of effort, or time taken at a sustained level of effort, or, finally, in terms of a set of durations describing more accurately the various phases of the allocation of resources to a stage.

4.2.2 The Precedence between Stages of Work

Due to the fact that the various stages of work took a long time to be completed at these 3 sites analysed, it might be expected that the precedence relationships between stages was not of a head and tail type , but of an overlapping type. Figures 24, 56 and 57 confirm this; proportions of the work of one stage are preceded or succeeded by proportions of the work of the other stages. This is not a new concept: reported research work by Carr (5) and even commercially available network planning software (15) allow the introduction of lead/lag factors (overlapping factors) between activities or stages of work.

More analytical effort should be directed to the study of the overlapping between stages of work. Lead/lag factors should be obtained from practical observation. The author was not able to find any research work giving quantitative guidance on these factors. The graphical analysis of these 3 sites did not make it clear if the overlapping factors remain constant throughout the construction process.

The conclusions relating to the durations of tasks on site suggested a new concept: we should talk in terms of the duration of each phase of the resource allocation process for a stage; for example, it could be said that 60% of the stage was completed within "n1" weeks, and the remaining 40 % took "n2" weeks. Here again it is suggested that the precedence between stages should be defined in terms of proportions of work accomplished and thus allowing technically succeeding stages to start.

The derivation of such overlapping factors based on proportions of work would make it possible to draw quickly aggregated bar charts like the one shown in figure 25. This aggregated bar chart depicting the start and finish of work in each stage can be used as a master program of building works. Conversely, the overlapping factors can be obtained by the observation of these aggregated bar charts on a number of building projects.

4.2.3 The Sequence of Work

At the sites analysed each stage of work was performed with a slightly different starting order. In Pitcoudie 2 the work evolved from northwest to southeast, as can be seen in figure 23, but no 2 stages of work were done in the same sequence, block after block. Sequence of work here is defined as the order in which a specific trade tackles the various units under construction on a repetitive site; obviously it is not related to the precedence between stages within the same block or house.

This finding represents an additional difficulty to the planning and control of works on site using a Line of Balance chart. The actual sequence of work is not known in advance to the site programmer, and hence he cannot arrange the units of construction along the y axis. On the evidence of this research work it would only be possible to define strategically the desired trend of progress along the site.

The majority of building sites contain non-similar units, that is, blocks differing from each other in area, number of storeys and facilities. In these circumstances the sequence of work can be optimized taking into account not only equipment layout, site supervision and materials handling but also the labour content of each unit (Hareli - 15). The evidence of this present research work suggests that it would be worthwhile to employ this optimization technique only when it could be assured that site control would be sufficiently tight to force the pre-planned sequence of work to be followed.

Bishop (1) and Forbes (10) found that the work tends to spread over the whole site instead of concentrating on particular units. The former suggested that site programming and control should compromise between the adoption of a rigid sequence of work and the possibility of diverting work to different blocks whenever production snags occur with the present blocks being undertaken. According to him, working simultaneously in various units allows greater flexibility in the daily allocation of workers; this contributes to reduce idle time on site, at the expense of efficiency (more time is spent setting up, clearing out and walking from work place to work place).

Forbes believes that the key to productivity on site is design taking into account production methods. This would allow concentration of work on the building units and hence a shorter time to complete them. At first sight it is not possible to understand why concentration of work on its own could ensure better productivity; putting it in a different way, why should it be more advantageous to tackle the work unit by unit than to undertake a battery of units simultaneously?

Pigott (18,19) found some correlation between discontinuity of work and the total number of man-hours taken by the operations. He proposed that the key issue to increase productivity on site is to provide a large work pool ahead of each trade, mainly subcontracted ones, thus avoiding their constant movement between a series of different sites in search of "snags-free" runs of work. Under this premise, sticking to a fixed sequence of work does not produce greater work pools than tackling the tasks at random.

This research work suggests that the more important elements in site programming and control should be researched in close contact with contractors, site managers, foremen and subcontractors before the concept of concentration and rigid sequence of work are taken as the main features of well organized sites. Meanwhile the concept of working pools ahead of each trade could be used. In fact, the fixed sequence of work approach is a particular case of the pools of work ahead of each trade programming strategy.

4.2.4 The Time taken to complete each Building Unit

The consequence of stage durations exceeding expectations, and the spreading of work to the entire site is that blocks took a long time to be completed (of the same magnitude as the time taken to complete the whole site).

This makes it difficult to control the progress on site based on number of blocks completed or even number of stages completed. The feedback of production information based on completed units or stages is not available till the last periods of work on site.

It is suggested that these absolute indicators of progress achieved on site should be substituted or complemented by others, relative and subjective in nature, like proportion of work completed, available work pools ahead of each trade, non-productive time achieved, etc..

4.3 Recommendations for further Work

Two major suggestions stemming from the work developed so far are made below.

a) More research work should be devoted to the analysis of the progress of work on building sites. Theoretical developments in this area should be welcomed only after the concepts of precedence, estimation of task durations and sequence of work are exhaustively reviewed based on practical experience. It is not recommended to proceed with theoretical works in the area using the traditional CPM, PERT or Line of Balance approaches to the aforementioned basic aspects of the building programming issue. Neither the review of the literature nor the analyses conducted during this research work give support to the traditional concepts of task duration estimation, precedence, or sequence of work.

Both the Site Activity Analysis Package and the graphical software here presented are capable of producing and organizing a huge amount of feedback information. The author feels that the production of this wealth of data is expensive and time consuming when applications at the level of the average building company are envisaged. More research work is needed to define which tables, graphs or numerical parameters are important, in order to make only these available to site managers and programmers. The overloading of staff with feedback information should be avoided.

In this sense the graphical software here produced does not help, unfortunately, in selecting fundamental feedback data or to reduce the amount of information produced. It is able to improve the output of the Site Activity Analysis Package, mainly by condensing information in a pictorial form, at the cost of using slower and more expensive equipment.

Neither can the tables produced be completely substituted nor can the graphical software entirely complement information previously available. More research work is needed in this area to derive simple numerical indicators capable of summarizing the status of the progress of work on site.

b) New planning techniques should be devised to overcome the problems that traditional techniques face when trying to model the work on repetitive building sites like the ones studied here. Discontinuity of work, parallel instead of sequential precedence relationships between stages, lack of a fixed work sequence from block to block, and difficulties in controlling a great number of stages of work by graphical means, should all be taken into account when developing a new technique or modifying the existing ones.

The author feels that a technique which could overcome above difficulties would be based on:

I) the use of strategic milestones: these milestones could be represented by special dates, specific percentages of work achieved or specific buildings units completed. As a suggestion, these milestones could be obtained using the same procedure adopted to produce figure 22; several stages of work are grouped according to common characteristics and the completion dates of these groups of stages are taken as milestones, both for site programming and site control.

Milestones could also be set using information derived from progress "s" curves. These progress curves can be obtained by several methods, for example, historical records, optimization of resource mobilization costs, contractual requirements or management decisions.

In essence, these strategic milestones should be used instead of a detailed programming of works at the level of blocks and operations.

II) the use of percentage of work as the major measuring unit when planning and controlling building work. The same approach and graphical presentation of the Line of Balance method could be used, but instead of depicting units (blocks, houses) on the y axis, percentage of work would be displayed. Buffers between stages of work measured in physical units are replaced by percentage of work made available by the preceding trades. This presentation is not new (see 2) but it has not been sufficiently reported and investigated in the literature.

This report has shown that the percentage of work approach could also be extended to the concepts of single stages of work duration and precedence between stages. Bar charts are easily drawn when the relative position of each stage of work bar is determined by the percentage lead or lag factors of the other stages of work. The existing methods of relating production rates and factors affecting productivity like the learning phenomenon, weather and overtime, could be easily extended to accommodate this percentage approach.

It was suggested that milestones could be provided by the project progress "s" curves; conversely percentage progress curves of individual stages or groups of stages can be added to produce the entire project "s" curve. In this sense, this new approach improves the speed with which cash-flow analyses may be performed.

The underlying assumption of this new proposed method is that the precedence relationship between stages of work within each unit being contructed is not the most important factor in assuring a continuous flow of work on site, and hence good productivity. This hypothesis can only be proved by further research.

Tables

Table 01

Number of Visits to Blocks to complete Operations

OPERATION	MAXIMUM	MINIMUM	AVERAGE
Ground Floor Slab	6	2	3.4
Blockwork 1st. Lift	8	1	3.6
Blockwork 2nd. Lift	7	1	2.7
Roof Trusses and Timbers	10	3	5.4
Roof Finishings	11	3	6.4
Ext. Infill Panels	17	4	8.1
Floor Joists and Flooring	8	3	4.5
Ext. Plastering	16	4	8.8
Int. Dry-Lining	16	4	8.9
Joinery	28	4	11.4
Cellular Partitions	6	1	2.6
Plumbing	22	6	14.2
Electrical	13	3	6.9
Floor Tiling	10	1	3.6
Internal Painting	22	3	11.0
External Painting	14	5	8.3
Total	226	50	117.0

Table taken from reference number 19:
Pigott, P.T. <u>A Productivity Study of House Building</u>, 2nd. Impression, Dublin, An Foras Forbartha - The National Institute for Physical Planning and Construction Research - , December 1974.

Table 02

Pitcoudie 2

General Specification Notes

Foundations:	houses generally 570 x 190 mm.; flats generally 750 - 800 x 230 mm. concrete strip foundations (1:2:4) with 450 mm. minimum ground cover at all external and party walls. Foundations to flats have bottom mesh reinforcement.
Sub-Floor:	consolidated site fill to within 350 mm of floor level, thereafter 175 mm. well consolidated hardcore with 50 mm. sanc blinding finished smooth to receive dpm.
DPM:	"Visqueen 1200" damp-proof membrane in sub-floor.
Ground Floor Slab:	125 mm. concrete slab with mesh reinforcement; 600 mm perimeter insulation 25 mm. thick; surface cf slab floated to a smooth surface and finished with pvc floor tiles on "Dunlop Smoothfloor" latex screed.
DPC:	"Nurlene" damp-proof ccurses in walls.
Underbuilding:	Houses - 255 mm. thick "Thermalite" concrete blocks laid with 50 mm. vertical coursing and 1/3 bond horizontally; Flats - non-loadbearing 255 mm. overall thickness with 102.5 mm. outer skin, 52.5 mm. cavity concrete filled up to dpc and 100 mm. "Russlite" concrete blocks (7.0 N/sq mm.) inner skin; for loadbearing walls the inner skin is 140 mm. "Russlite" concrete blocks (7.0 N/sq mm.) and overall thickness thus 295 mm.
External Walls:	Houses: 255 mm. overall with 102.5 mm. brick, 52.5 mm. cavity and 100 mm. "Russlite" concrete block (4.12 N/sq mm.) inner skin; Flats: non-loadbearing 255 mm thick overall with 102.5 mm brick, 52.5 mm. cavity and 100 mm. "Russlite" concrete block inner skin (7.0 N/sq mm. on ground floor of 3 storey floors and ground floor plus first floor cf 4 storey flats; 4.12 N/sq mm. blocks on first and (to be continued on next page) ...

... (continued from last page)

second floor of 3 storey flats and second plus third floor of 4 storey flats); for loadbearing walls the inner skin is 140 mm. "Russlite" concrete blocks (strengths as for non-loadbearing walls) and overall thickness thus 295 mm.; finished externally with 20 mm. dry dash render; internal lining in "British Gypsum Vapourcheck Thermal Lining" fixed by modified "Thistlebond" method (25mm thick board) and nailed with 3 rows of 3 nails per sheet; U value of 0.67 W/sq M deg C for 255 mm. wall; 2 person houses only have Cape "U Foam Plus" cavity insulation.

Party Walls: two skins of 100 mm. "Russlite" concrete block (4.12 N/sq mm., 1250 kg/c. m. density) generally with 55 mm. cavity; both sides of wall with 8 - 12 mm. render and 12.5 mm. plasterboard fixed by "thistlebond" method; party walls between flats and houses will in some instances have higher density and thicker blocks (see above).

Intermediate Floors: Houses: 200 x 50 mm. joists at 450 mm. centres, built into walls; where built into party-walls, joists are fire-stopped with 12.5 mm. "Asbestolux" plates; 19 mm. chipboard flooring with higher density grade in bathrooms; 9.7 mm. plasterboard ceilings for 2 storey houses and 12.5 mm. plasterboard for 3-storey houses;
Flats: prestressed precast concrete units, 200 mm thick; design certificate to be supplied by manufacturers; 22 mm. T. and G. flooring on 50 x 50 mm. battens on sound insulating quilt (battens not fixed to floor units); 12.5 mm. plasterboard ceilings on 50 x 38 mm. battens fixed to timber inserts in concrete floor units.

Roof: "Redland Delta" tiles on 50 x 25 mm. impregnated battens, breather felt type 1A on 12.5 mm. bitumen impregnated black top fibreboard sarking on "Fink" type roof trusses at 600 mm. centres generally; 100 mm. fibreglass roof insulation immediately above ceiling; top floor ceiling to be 12.5 mm vapour-checked plasterboard.

(to be continued on next page) ...

... (continued from last page)

Internal Partitions:	50 mm. "Paramount" partitions.
Loadbearing Partitions:	75 x 50 mm studs at 400 mm centres lined with 12.5 mm. plasterboard.
Glazing:	2 person house type only to be double glazed with "Pilkington's "Plyglass" sealed units; all other house types to be single glazed.
Water Storage:	7 person and 9 person house types (3 storeys) to have 180 litres capacity combination "Elson" tanks; all other dwellings to have 135 litre capacity "Elson" tanks.
Heating:	single and two-storey housesto have ducted warm air SYSTEM (APPROXIMATELY 50% SPLIT BETWEEN GAS AND and electric); three-storey houses to be either wet radiator gas system or electric storage heaters; flats (all electric), to have warm air ducted partial system plus bedrooms heated in 3 person disabled flat by electric storage heaters.

Table taken from reference n 23:
Scottish Development Department, Urban Design and Research Division, Pitcoudie Housing Development for Glenrothes Development Corporation, Edinburgh, Scottish Development Department, March 1979.

Table 03

Mix of Dwellings Types in each Block anc

Blocks Total Internal Area

Block	Number of Houses of each Dwelling Type					Total Internal Area
	2 Person	4 Person	5 Person	7 Person	9 Person	
	Area 49.5 sq. m.	Area 79.2 sq. m.	Area 90.0 sq. m.	Area 118.8 sq. m.	Area 142.2 sq. m.	sq. m.
Housing Blocks						
1	2		4			459
2			5			450
3			5			450
4			3	2		508
5			5			450
6		7				554
7		4				317
8		4				317
9		4				317
10			7			630
11	2		8			819
12	2		6			639
13	2		3			369
14			4			360
15	2					99
16	3					148
17	2					99
18		5				396
19			5			450
20		5				396
21			3	2		508
22		4				317
23		5				396
24	2		6			639
25	3		5			599
26			4			360
27			8			720
28	2					99
29	4					198
30	2					99
31		5	3	2		904
32		5				396
33		4				317
34		3		2		475
35		4				317

(to be continued on next page) ...

... (continued from last page)

36	4		6			738
37			7			630
38	2		3			369
39	2		4			459
40	3		2			328
41			3			270
42		6		2		713
43		3		1	1	499
44	5					247
45		4				317
46		5		1	1	657
47			3	1	1	531
48	2	2				257
49			2			180
Number of Houses	46	79	114	13	3	255 Houses
Total area of Housing Blocks						20.766
Flats						
50	4 *	4 *				604
51	3 *	3 *				453
52	4 *	4 *				604
53	3 *	3 *				453
Number of Flats	14 *	14 *				28 Flats
Total Area of Flats						2.114
Total Number of Units	60	93	114	13	3	283 Units
Total Area of the Site						22.880

* - 2 person and 4 person flats have a different area than 2 person and 4 person houses.

Table 04

Stages of Work Average Total Allocation of Man-hours to the Blocks, Standard Deviation of this Allocation, Durations and Average Weekly Allocation of Man-hours

Stage	A	B	C	D	E	F	G	H
Foundation	41	24	2	8	8	20	32	248
Substructure	65	26	2	10	19	32	45	316
Gr. Floor Slab	100	40	4	9	15	25	35	544
First-Storey Superstructure	276	99	6	30	29	46	62	450
Second-storey Flooring	92	37	5	50	11	18	29	78
Second-storey Superstructure	235	88	5	31	29	47	65	317
Roof Carcassing	80	37	6	35	7	13	20	112
Superstructure Eaves to Apex	56	27	3	28	10	19	28	102
Roof Covering	87	48	5	38	8	17	27	112
Scaffolding	46	24	5	36	4	9	14	62
Glazing	32	17	8	60	2	4	6	26
Harling	127	62	2	38	32	63	94	163
Stairs	44	30	4	45	3	11	18	41
Dry-linings	367	176	9	50	21	41	60	356
Doors	114	55	7	68	8	16	24	82
Joinery	181	93	8	62	11	23	34	143
Plumbing	138	84	8	78	7	17	28	87
Electrical	165	100	3	35	22	55	88	230
Heating and Ventilation	64	37	5	56	5	13	20	56
Decoration	414	195	12	50	18	34	51	406
Floor Finishes	35	18	2	40	8	17	26	44

Convention:

A - average number of man-hours allocated to each one of the first 49 blocks;

B - standard ceviation of the number of man-hours allocated to each one of the first 49 blocks;

C - average net duration of the stage; this net duration is obtained considering the number of weeks which have more than 4 man-hours allocated to it; this net duration is substantially less than the total duration of each stage in each block (in this later case the work interruptions are included in the stage duraticn);

D - total number of weeks that the stage has been tackled on site irrespective of block;

(to be continued on next page) ...

... (continued from last page)

E - average number of man-hours weekly allocated to each block considering that the stage total allocation of man-hours to each block is the average allocation minus one standard deviation (units are man-hours/week);

F - average number of man-hours weekly allocated to each block considering that the stage total allocation of man-hours to each block is the average allocation (units are man-hours/week);

G - average number of man-hours weekly allocated to each block considering that the stage total allocation of man-hours to each block is the average allocation plus one standard deviation (units are man-hours/week);

H - average number of man-hours weekly allocated to the stage irrespective of block (units are man-hours/week).

Figures

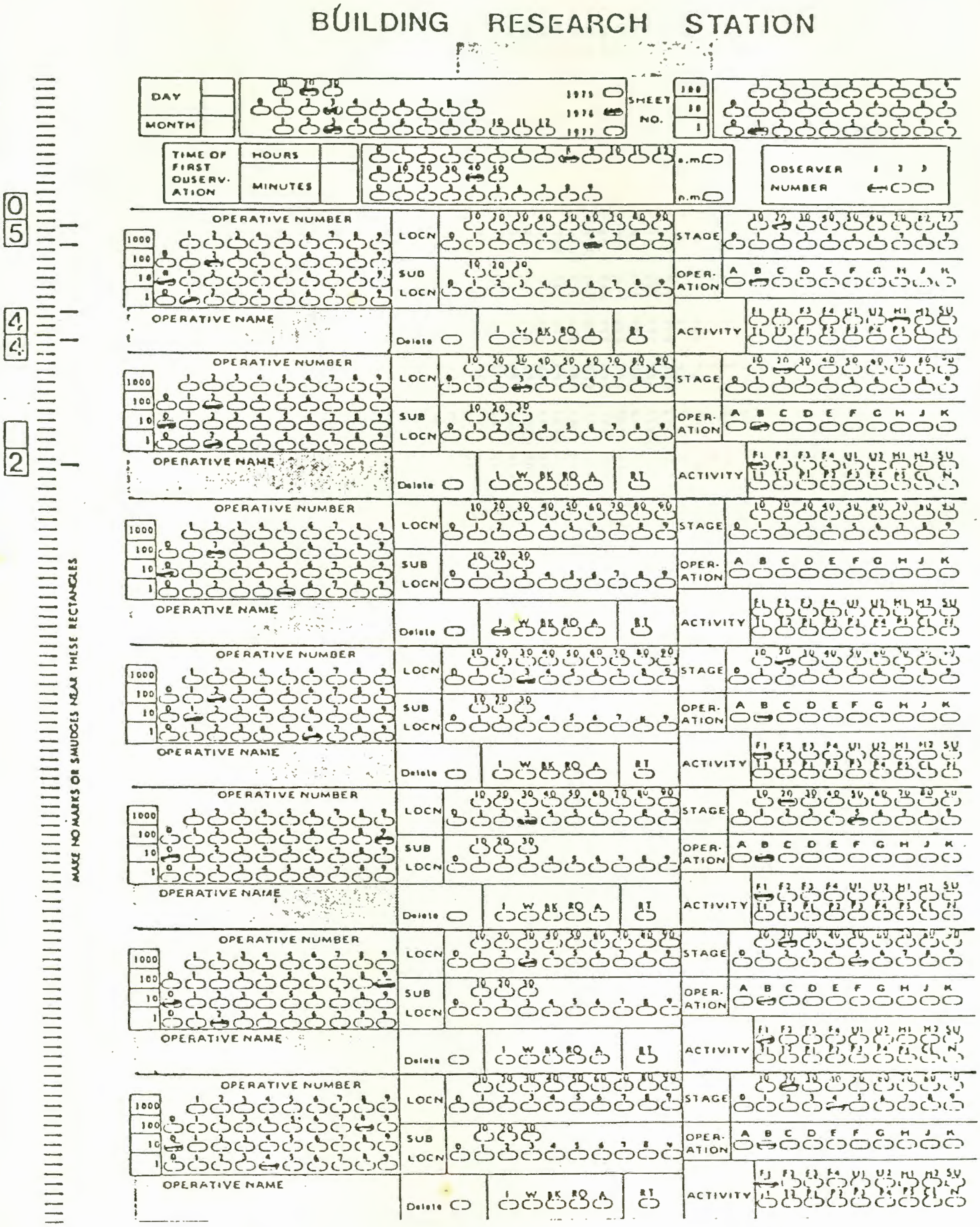


FIG. 1

Figure 1

Recording Form for the Optical Reader

Ref.:

Forbes, W.S. The BRE Site Activity Analysis Package, Building Research Establishment note n 13/81, Garston, BRE, January 1981.

FIGURE 2

Man-hours allocated to the Stages of Work on the Ladygate Lane Site, broken down by Blocks.

Ref.:

Forbes, W. S. House Building Productivity at Ladygate Lane, Hillindon, Building Research Establishment Internal Note, Garston, BRE, March 1980.

BRE SITE ACTIVITY ANALYSIS PACKAGE

ROW SELECTION NUMBER 5 STAGE
COLUMN SELECTION NUMBER 3 BLOCK

CLASS CODE	STAGE	BLOCK 0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B12	TOTAL
0		5504	65	77	168	75	64	105	133	69	95	140	670	7164
ST1	STRIP TOPSOIL		3	12	1	13	13	19	9	5	3	35	40	154
ST2	SET OUT		14	3	29	16	20	4	5	8	1	3	1	104
ST3	EXCAVATE		37	6	118	22	27	59	83	34	49	26	9	469
ST4	CONCRETE FOUNDATIONS		21	18	61	38	26	1	32	30	11	3	6	245
ST5	SHUTTERING		33	50	10	3	1	1	55				71	223
ST6	BRICK PADS		1	18	4	6	9		5			6		48
ST7	FOUNDATION WALLS		132	80	85	77	70	32	25	62		52	52	666
ST8	HARDCORE		94	74	100	32	64	42	129	18	66	46	25	689
ST9	REINFORCEMENT		4	3	6	10	4		36		3	4	5	76
ST10	FLOOR SLAB		60	20	65	25	50	24	15	25	6	15	60	362
ST11	SERVICES			8	16		18	5	54	14	17	1	4	138
ST13	GF PANELS		108	204	131	74	74	151	162	108	71	44	15	1143
ST14	BAND COURSE		4	64	12	3	5	32	7		1		1	128
ST15	FLOOR		104	173	136	109	98	127	193	121	59	119	38	1276
ST16	FF PANELS		123	256	195	163	91	78	183	140	73	80	36	1418
ST17	ROOF		65	138	140	112	131	108	150	68	92	90	28	1121
ST18	TILING		371	470	522	445	317	309	442	267	275	191	193	3800
ST19	SCAFFOLDING		154	151	226	158	149	131	123	98	109	121	336	1755
ST20	DOORS AND WINDOWS		595	818	848	627	510	927	1023	592	542	430	254	7164
ST21	BRICKWORK		308	252	360	181	272	235	294	181	259	140	1042	3524
ST23	PLASTERBOARD		361	487	702	460	408	476	716	410	348	432	115	4914
ST24	PLUMBING		272	384	414	448	252	463	466	299	356	240	87	3680
ST25	ELECTRICAL		269	397	300	234	342	367	505	193	208	195	46	3056
ST26	GAS		9	18	42	22		41	17	90	36	87	3	366
ST27	HEATING		188	194	331	272	296	388	355	284	264	137	46	2756
ST28	DECORATION		489	737	797	543	475	471	813	484	404	376	203	5793
ST29	GLAZING		17	16	18	10	12	9	5	21	11	13	71	203
ST30	FLOOR FINISHES		44	87	85	93	73	102	94	74	130	55	64	900
ST35	GARAGES		116	5	2	13		1		8	8	9	1519	1680
ST36	DRAINS		5	27	16	20	21	1	10	3	4	5	5342	5453
ST37	MAIN SERVICES				2		2		15				68	87
ST38	ROADWORKS			5	1					6	2	3	3277	3293
ST39	GARDENS		6	2	6	4	4	4		1	2		2589	2618
ST40	SITE ESTABLISHMENT		3	3	5	8	3	8	5	4	2	4	2308	2352
TOTAL:		5504	4076	5257	5953	4314	3898	4718	6155	3715	3506	3100	18621	68817

FIG. 2

FIGURE 3

Average Number of Man-hours spent by the Trades in each one of the 71 dwellings of the Ladygate Lane Site (broken down by the Activities listed at the bottom of the Table).

BRE SITE ACTIVITY ANALYSIS PACKAGE

ROW SELECTION NUMBER 11 TRADE
COLUMN SELECTION NUMBER 7 TECHNIQUE

**** OVERALL DIVISOR = 71 ****

TRADE CODE	TECHNIQUE A	I	N	W	BK	CL	F1	H1	P1	RO	RT	SU	T1+	TOTAL
	CLASS CODES													
GLAB GENERAL LABOURER	2	2	5	2	14	12	73	141	2	1	0	13	7	274
BRIK BRICKLAYER	1	0	1	0	2	1	41	14	2	1	0	0	0	63
CARP CARPENTER	3	4	4	2	11	5	456	38	5	1	3	2	2	237
OFFS OFFICE STAFF	0		0		0	0	0	0	0		0	1	0	2
SCAF SCAFFOLDER	0	0	0		0	0	2	1	0	0			0	3
ROOF ROOF TILER	1	2	1	1	3	1	54	5	1	1	0	0	1	70
PLAS PLASTERER	1	2	1	0	1	1	49	5	2		0		1	63
GLAZ GLAZIER	0	0					2	0					0	2
PLUM PLUMBER	1	1	0	1	4	1	39	9	2	0	0	0	0	57
ELEC ELECTRICIAN	1	0	0	0	4	1	39	3	1	0	0		0	49
GFIT GAS FITTER		0	0	0	0	0	3	1	0		0			5
HFIT HEAT AND VENT F	0	1	0	0	3	1	32	6	1		0	0	0	45
FLOR FLOORLAYER		0	0		0	0	6	1	0		0			7
DECR DECORATOR	0	1	0	0	4	2	64	9	3		0	0	0	85
LAND LANDSCAPING		0	0	0	0	0	4	2	0	0				7
TOTAL:	8	13	14	6	47	24	564	236	20	4	4	17	12	969

A - Absent
I - Non-productive around site
N - Relaxation at work-place
BK - Tea breaks and excess meal breaks
CL - Cleaning up
F1 - Making the building grow
H1 - Handling
P1 - Preparation
RO - Rained-off
RT - Repeat work
SU - Supervision
T1+ - Measuring (and includes unloading in this table)

Ref.:

Forbes, W. S. House Building Productivity at Ladygate Lane, Hillingdon, Building Research Establishment Internal Note, Garston, BRE, March 1980.

FIG. 3

BRE SITE ACTIVITY ANALYSIS PACKAGE

PAGE SELECTION NUMBER 6 OPERATION — CODE 0240 WATER PIPES TANKS CISTERNS

ROW SELECTION NUMBER 1 DATE
COLUMN SELECTION NUMBER 3 BLOCK

CODE	BLOCK CLASS CODES 0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	TOTAL
6 375												0
10 375												0
17 375												0
24 375												0
31 375												0
7 475												0
14 475												0
21 475												0
28 475												0
5 575												0
12 575												0
19 575												0
26 575												0
2 675												0
9 675			29									29
16 675		1	12									13
23 675		1	22	2	2							27
30 675		25	25	2	1							53
7 775		28	4									32
14 775		9	15	1								26
21 775			3	7		0						10
28 775												0
4 875												0
11 875		13	6									19
18 875			3									3
25 875												0
1 975												0
8 975			1									1
15 975				8				1				9
22 975			10	1	16							27
29 975				11	45	11						68
6 1075		4		16	6	1						26
13 1075		17		5								22
20 1075		4		7		2						13
27 1075				14	16							30
3 1175		1		4		6						11
10 1175				8	17	18	1	1				47
17 1175				32			24	1				57
24 1175				4	17	20	10			1		52
1 1275					4	4	5					13
8 1275			3		2	13	5					23
15 1275		2			5	1						8
22 1275					4	3						7
29 1275												0
5 176							11	20				31
12 176					1		6	19				26
19 176							3	18				21
26 176					4	5	10	26			1	45
2 276					17	8	3	5				33
9 276					1	6	8	13				28
16 276								25	27	4		56
23 276							4	17	7	14	4	46
1 376				2			17	26	2			47
8 376								17	37	3	3	60
15 376		1	2		1			3	3	25		35
22 376			1	1	1	1	2	6	4	27	3	46
29 376							1			5	9	15
5 476					1			3	1	18	12	35
12 476						1	3	1	7	14		26
19 476						1	3	2	3	25	4	38
26 476							4	15	4	4		27
3 576							10	6	2	1	14	33
10 576									7	9	2	18
17 576								2	2	6	7	17
24 576										2	3	5
-												
TOTAL	0	106	135	125	156	105	133	217	100	159	61	1297

FIG. 4

FIGURE 4

Man-hours allocated weekly to the Operation " Water Pipes, Tanks and Cisterns ", broken down by Blocks (Ladygate Lane Site).

Ref.:

Forbes, W. S. House Building Productivity at Ladygate Lane, Hillingdon, Building Research Establishment Internal Note, Garston, BRE, March 1980.

FIGURE 5A

Man-hours allocated weekly to the Operation " Wiring, Conduit and Boxes ", broken down by Blocks (Ladygate Lane Site).

Ref. :

Forbes, W. S. House Building Productivity at Ladygate Lane, Hillingdon, Building Research Establishment Internal Note, Garston, BRE, March 1980.

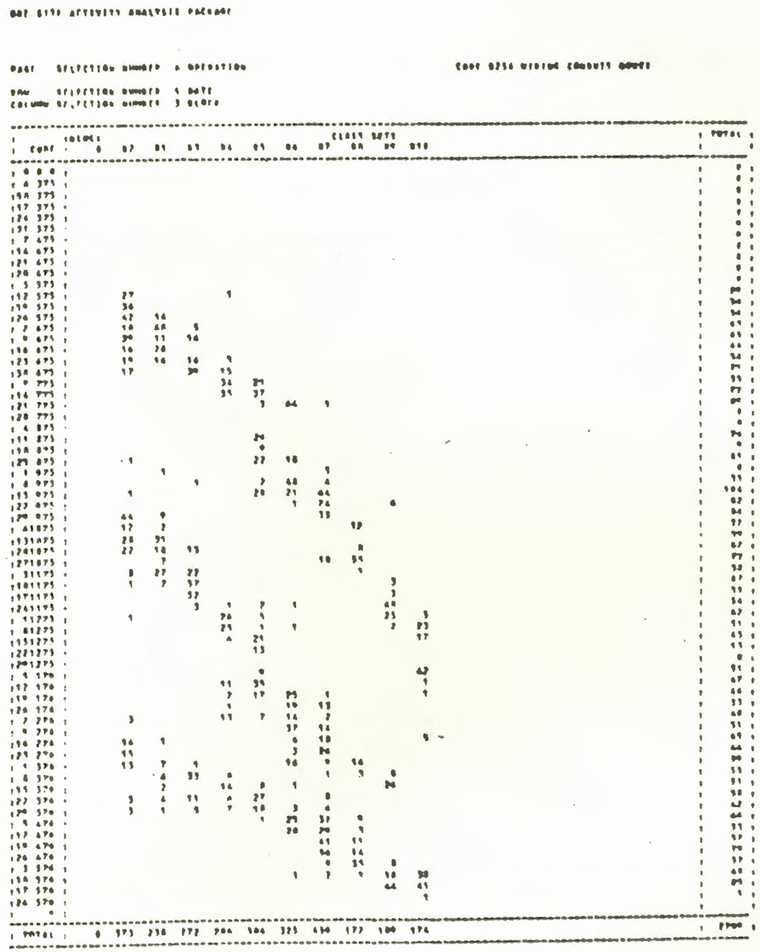
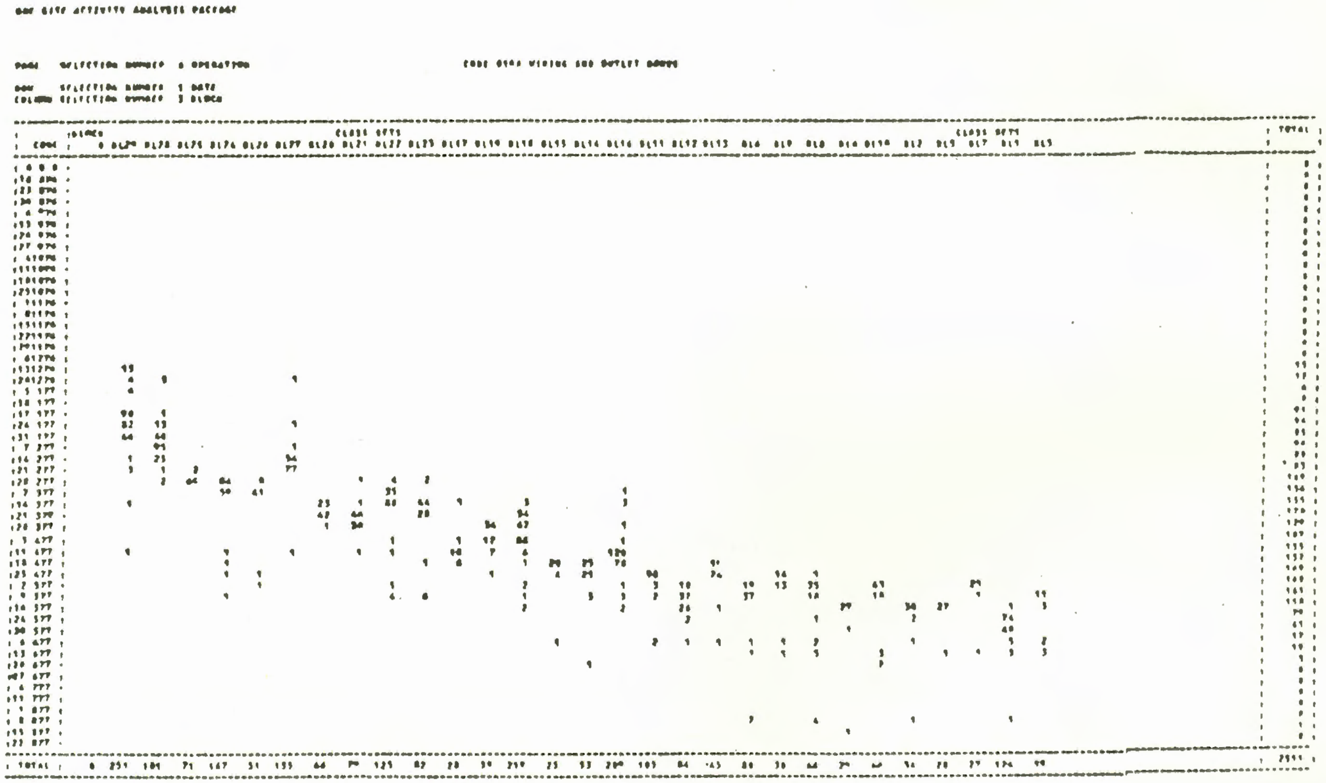


FIG. 5A

FIGURE 5B

Man-hours allocated weekly to the Operation " Wiring and Outlet Boxes ", broken down by Blocks (Pitcoudie 1 Site).



Ref.:

Forbes, W. S. The Relevance of the BRE Productivity Studies to Estimating, Building Research Establishment Note n. 143/80, Garston, BRE, November 1980.

FIG. 5B

FIGURE 6

Man-hours spent by the operatives n. 1350 to 1379 (painters) in the operation " Emulsion paint to Walls and Ceilings ", broken down by Blocks (Ladygate Lane Site).

Ref.:

Forbes, W. S. House Building Productivity at Ladygate Lane, Hillingdon, Building Research Establishment Internal Note, Garston, BRE, March 1980.

BRE SITE ACTIVITY ANALYSIS PACKAGE

CODE 0288 EMULSION PAINT TO WALLS AND CEILINGS

ROW SELECTION NUMBER 10 OPERATIVE
COLUMN SELECTION NUMBER 3 BLOCK

CODE	BLOCK 0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B12	TOTAL
1350													0
1351													0
1352													0
1353													0
1354												1	1
1355													0
1356													0
1357		1		1									1
1358													0
1359													0
1360													0
1361		13	53									2	68
1362		72	77	35	7							2	193
1363		81	63	48	12	6	14	16	22	7	17	3	290
1364													0
1365													0
1366		51	65	29	16	7						3	170
1367		52	61	47								2	161
1368													0
1369				8	1								9
1370				2	29	6			1			1	39
1371				1	10							2	13
1372													0
1373			1	2	8	6	18	30	11	13	11	2	102
1374				1	1	20	1	16	2	25	9	4	80
1375					2	11	11	7	10	3	14	1	59
1376			3	1	2			23	2			1	32
1377				1		2	32		17	14	6	1	73
1378													0
1379													0
TOTAL	0	269	324	176	88	58	76	92	66	63	56	23	1289

FIG. 6

FIGURE 7

Percentage breaking down of the Number of Man-hours spent by the Operatives n. 101 to 176 in the various Activities listed at the bottom of the Table (Ladygate Lane Site).

ROW. SELECTION NUMBER 10 OPERATIVE
COLUMN SELECTION NUMBER 7

PERCENTAGES

CODE	OHR CODES															TOTAL
	0	A	I	N	W	BK	CL	F1	H1	P1	P2	RO	RT	SU	T1	
9																0
101		0	1	3	0	3	1	57	4		0	16	5	0	1	14
102				1	5	1		67	2		0	23			1	7
103			0	1	3	2	0	69	2			23			0	7
104		1	0	2	5	3		63	3		1	22	1			7
105		2		5	8	1		60	5			16	1	3	0	5
106		4	1	8	5	1		67	2			13		0		5
107		0		6	7	1		65	4	1	0	15	0			5
108		10		5	6			61	4	0		13			1	5
110		1	3	7	13	5	0	11	5		2	17	6		0	13
151								24	19					48	9	0
171		0	0	2	6	3	2	4	64	1		18	0			7
172		1	9	3	4	1	3	1	44	25		18				7
173		3		3	9	0	1	2	51	19		13				4
174		2	9	3	0	1	0	4	63	1		17				5
175		12		14	13	2		12	47							0
176		0	0	2	5	1	3	2	67	1		19				7
TOTAL	0	1	1	4	7	2	1	41	21	3	0	18	2	0	0	100

A = Absent
I = Non-productive time on site
N = Non-productive time at work place
W = Walking
BK = Meal breaks

CL = Clearing up
F1 = Carrying out a task
H1 = Handling
P1 = Preparation
P2 = Cutting blocks

RO = Rained off
RT = Repeat work
SU = Supervision
T1 = Setting out

Ref.:

Forbes, W. S. The Relevance of the BRE Productivity Studies to Estimating, Building Research Establishment Note n. 143/80, Garston, BRE, November 1980.

FIG. 7

FIGURE 8

Man-hours spent weekly by Operatives n. 1 to 35 (General Labourers) in the Ruislip Site.

Ref.:

Forbes, W. S. The Relevance of the BRE Productivity Studies to Estimating, Building Research Establishment Note n. 143/80, Garston, BRE, November 1980.

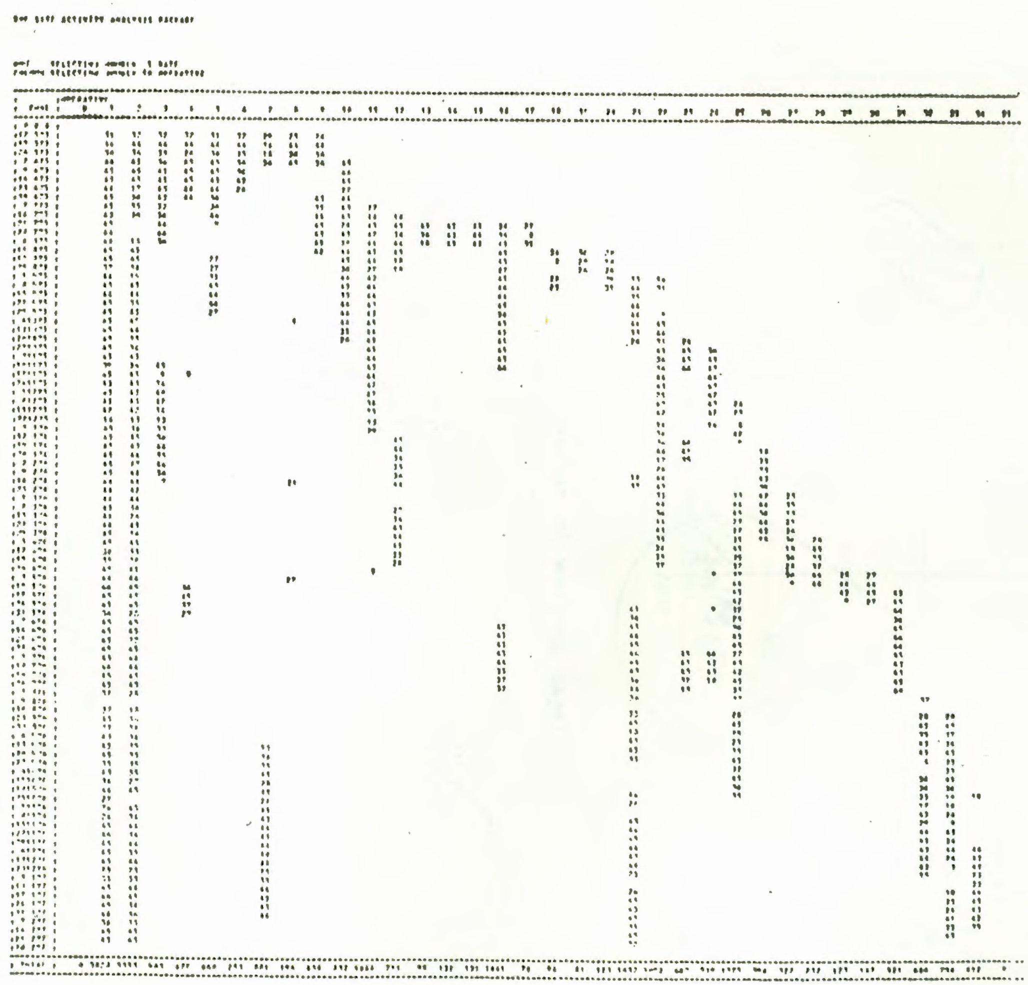
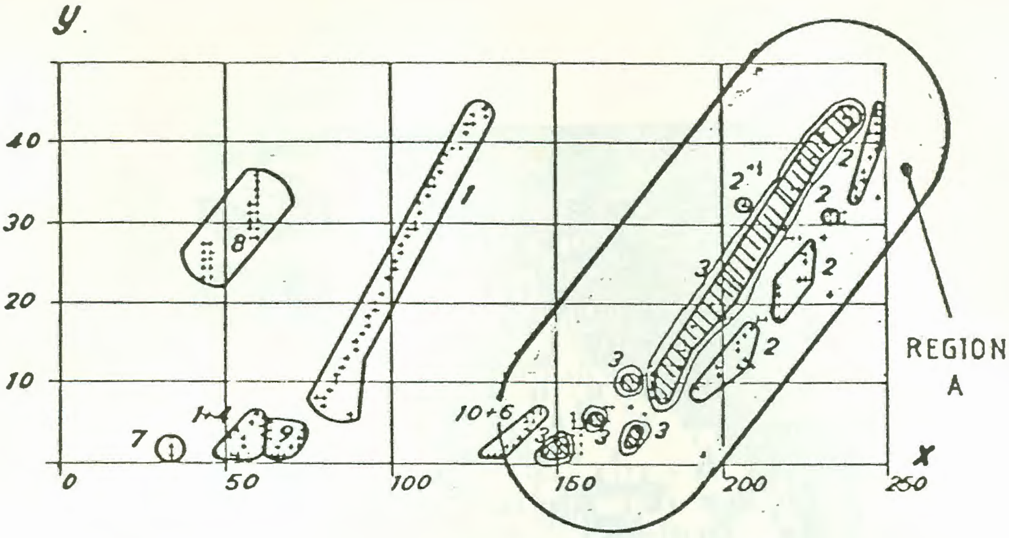
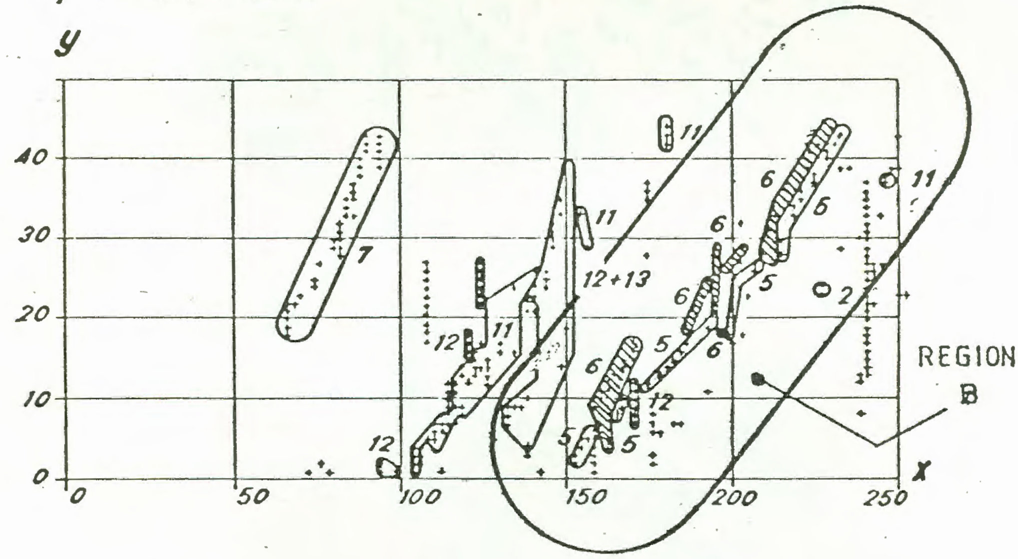


FIG. 8

FIG. 9



x = Date of execution (number of working days).
y = House number.



1 = Sawing and erection of load-bearing structure.
3 = Fitting of mouldings and window-sills.
6 = Support-pole setting for non-bearing walls.
2, 4, 5, 7, 8, 9, 11, 12 and 13 = Other operations.

Figure 9

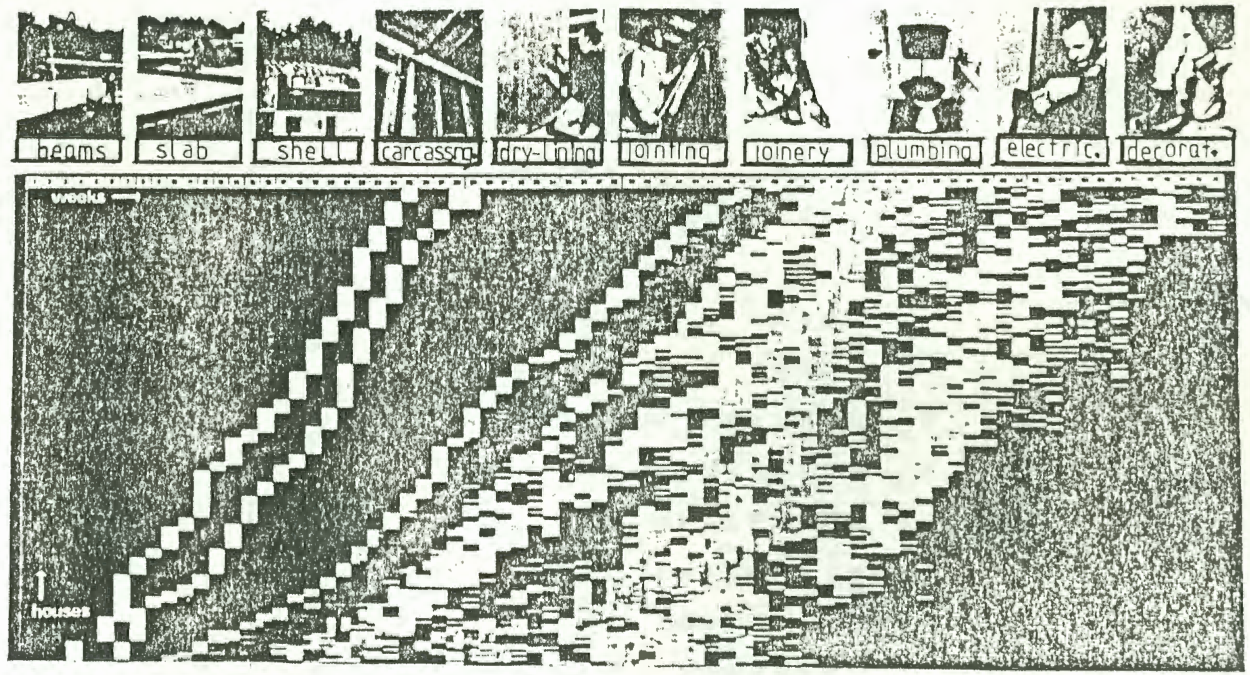
Observed Continuity of Work for different Building Operations (Sweden).

Ref.:

Committee on Housing, Building and Planning, Economic Comission for Europe, United Nations, Effect of Repetition on Building Operations and Processes on Site, Report of an Enquiry undertaken by the Committee on Housing, Building and Planning, New York, United Nations, 1965.

Figure 10

Observed Progress Pattern in the Finchampstead Project.



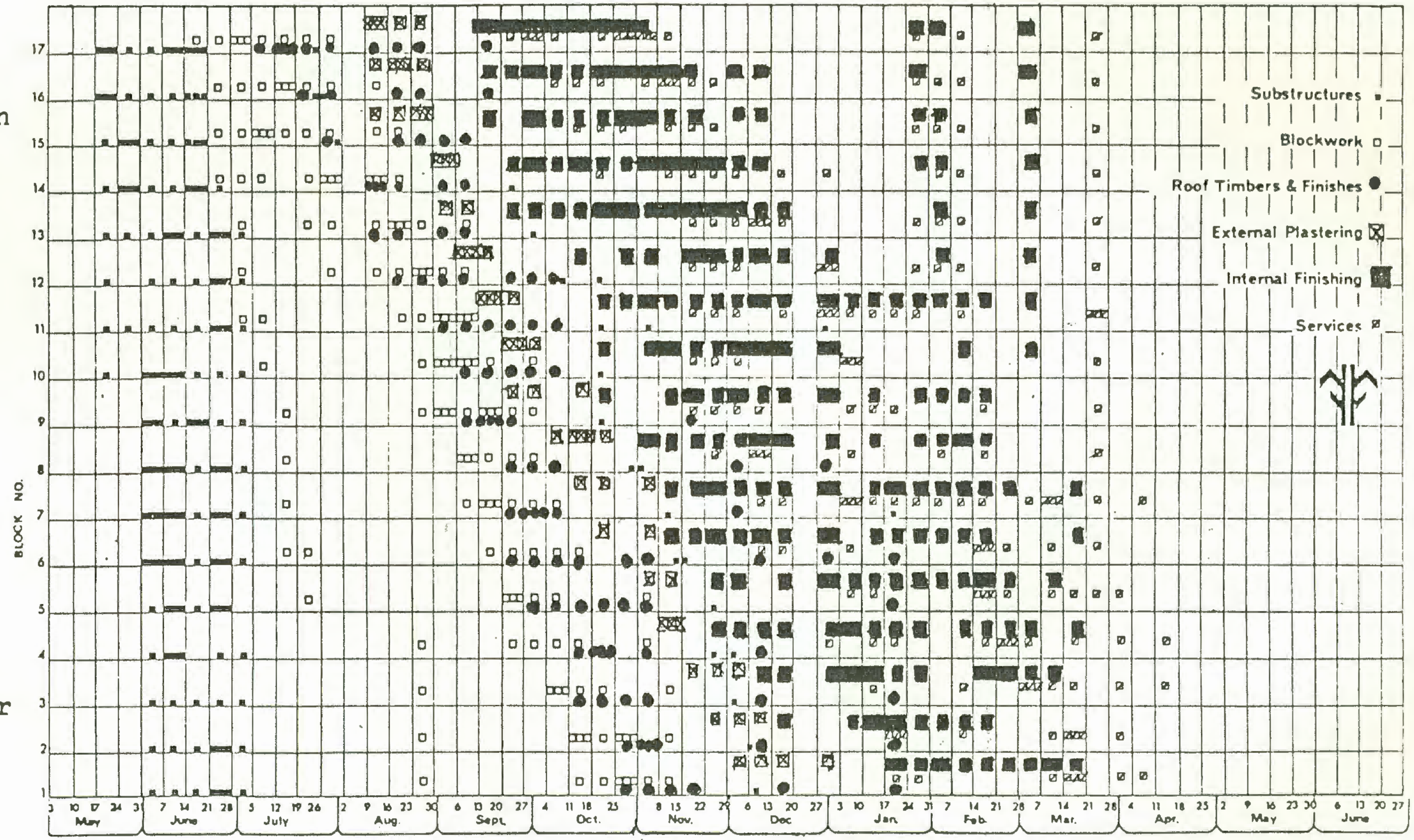
Ref.:

Forbes, W. S. The Rationalization of House Building, Building Research Establishment Current Paper CP 48/77, Garston, BRE, September 1977.

FIG. 10

Figure 11

Observed Progress Pattern on a Site with 17 Building Blocks in Ireland.



Ref.:

Shanley, L. F.; Keaney, B. J. An Examination of Labour Content in Housing, Dublin, Ann Foras Forbartha, May 1970.

FIG. 11

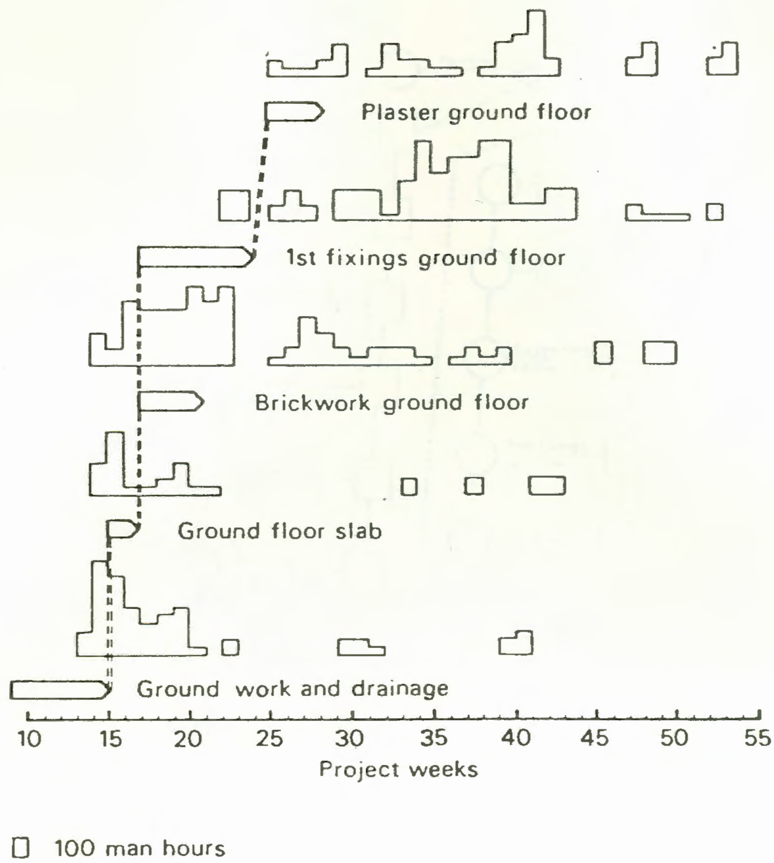


FIG. 12

Figure 12

Comparison of actual and estimated Stages of Work Durations in the Construction of a large Office Block and a central Warehouse for a Public Utility. Histogram of actual Resource Usage (Units are Man-hours per Week).

Ref.:

Roderick, I. F. Examination of the Use of Critical Path Methods in Building, Building Research Establishment Current Paper CP 12/77, Garston, BRE, March 1977.

FIG. 13

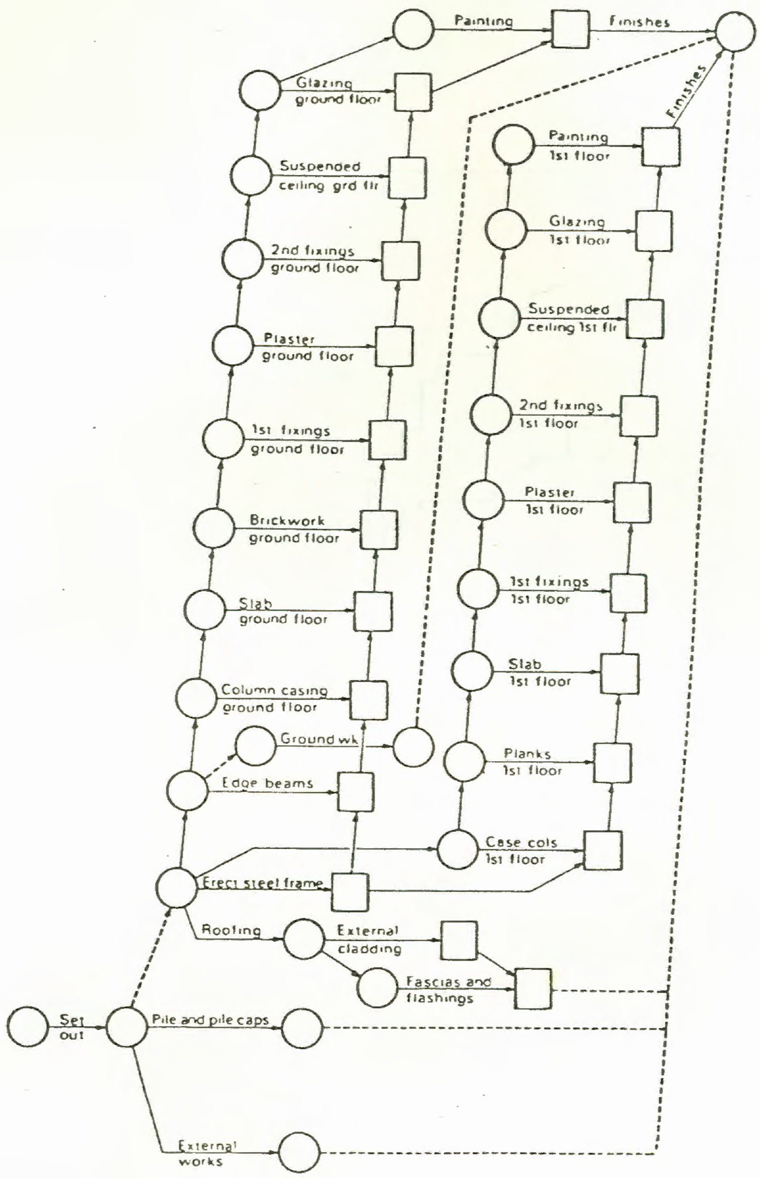


Figure 13

Actual Network of Operations observed in the Construction of a large Office Block and a central Warehouse for a Public Utility.

Ref.:

Roderick, I. F. Examination of the Use of Critical Path Methods in Building, Building Research Establishment Current Paper CP 12/77, Garston, BRE, March 1977.

FIG. 14

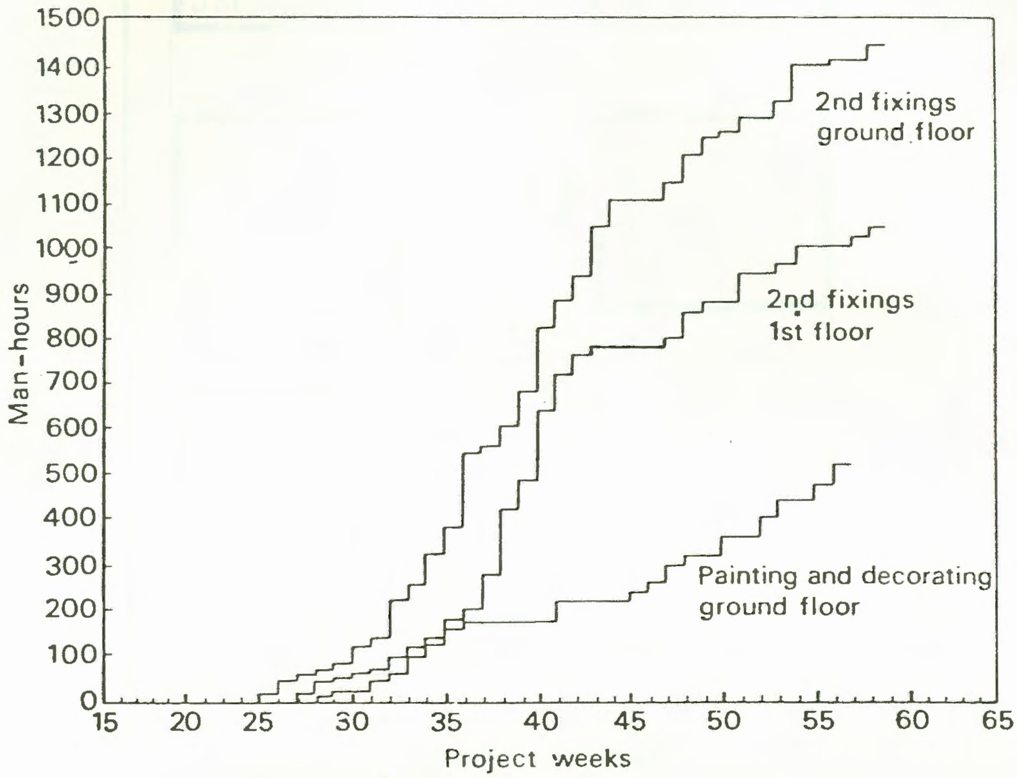


Figure 14

Cumulative Man-hour Graph for some Operations observed in the Construction of a large Office Block and a central Warehouse for a Public Utility.

Ref.:

Roderick, I. F. Examination of the Use of Critical Path Methods in Building, Building Research Establishment Current Paper CP 12/77, Garston, BRE, March 1977.

FIG. 15

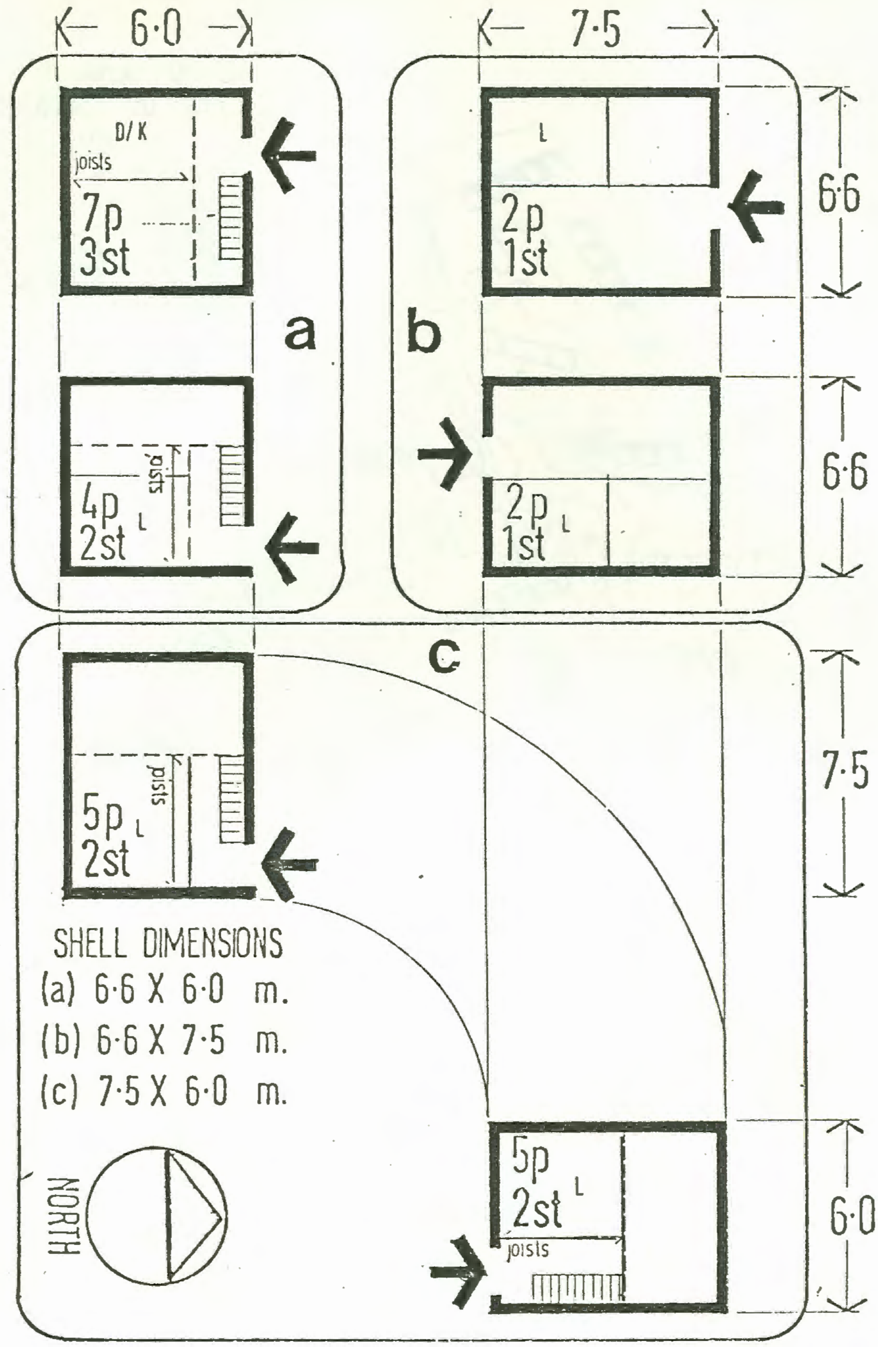


Figure 15

Rationalised Shell Dimensions for 2 person , 4 Person , 5 Person and 7 Person Houses in the Pitcoudie Project.

Ref.:

Scottish Development Department, Urban Design and Research Division, Pitcoudie Housing Development for Glenrothes Development Corporation, Edinburgh, Scottish Development Department, March 1979.

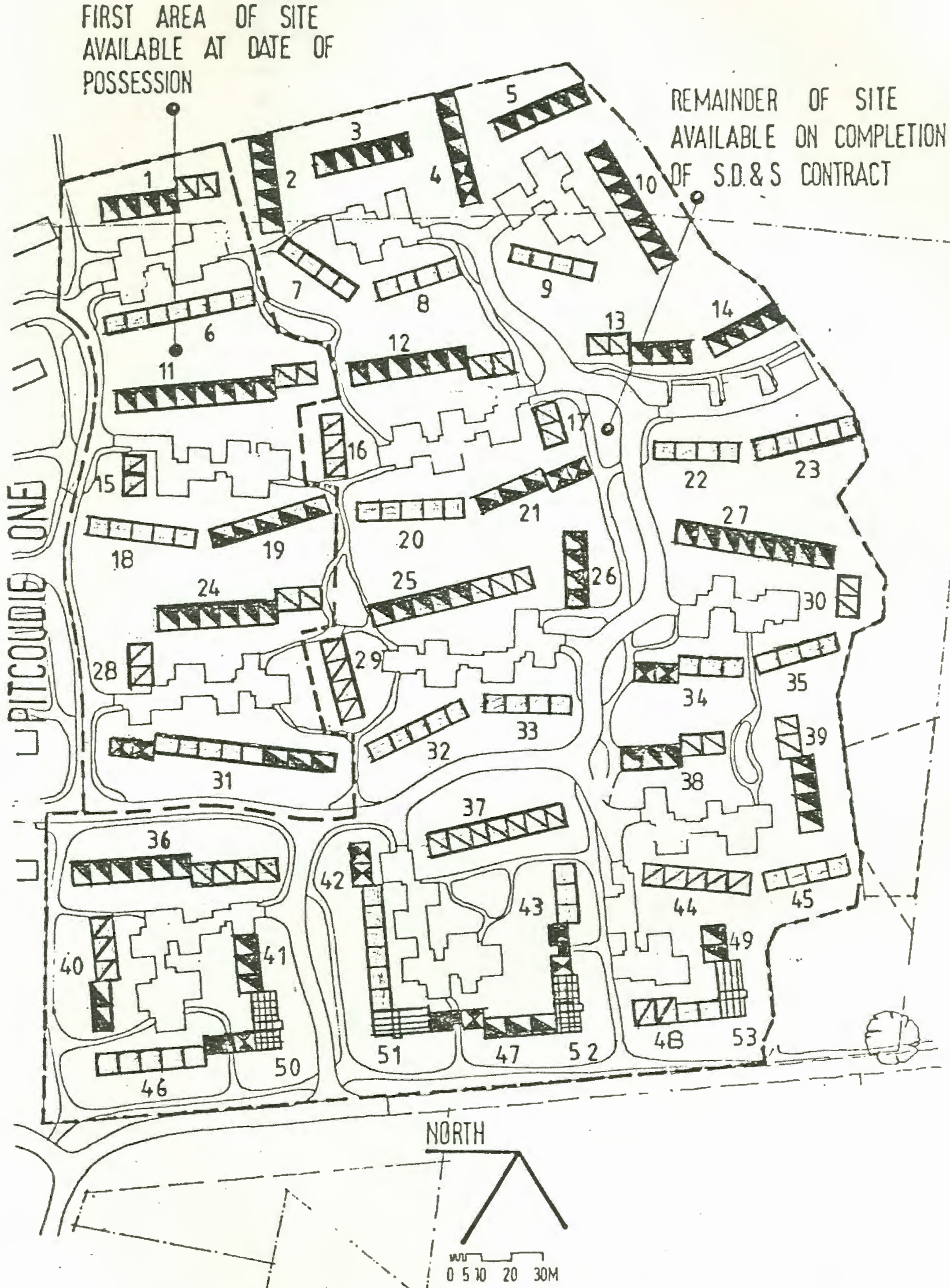


FIG. 16

Convention

- 2 Persons House South Aspect
- 2 Persons House North Aspect
- 4 Persons House
- 5 Persons House South Aspect
- 5 Persons House North Aspect
- 7 Persons House
- 9 Persons House
- 3 Storey Flats
- 4 Storey Flats

Figure 16

Pitcoudie 2 Site Layout and Housing Mix

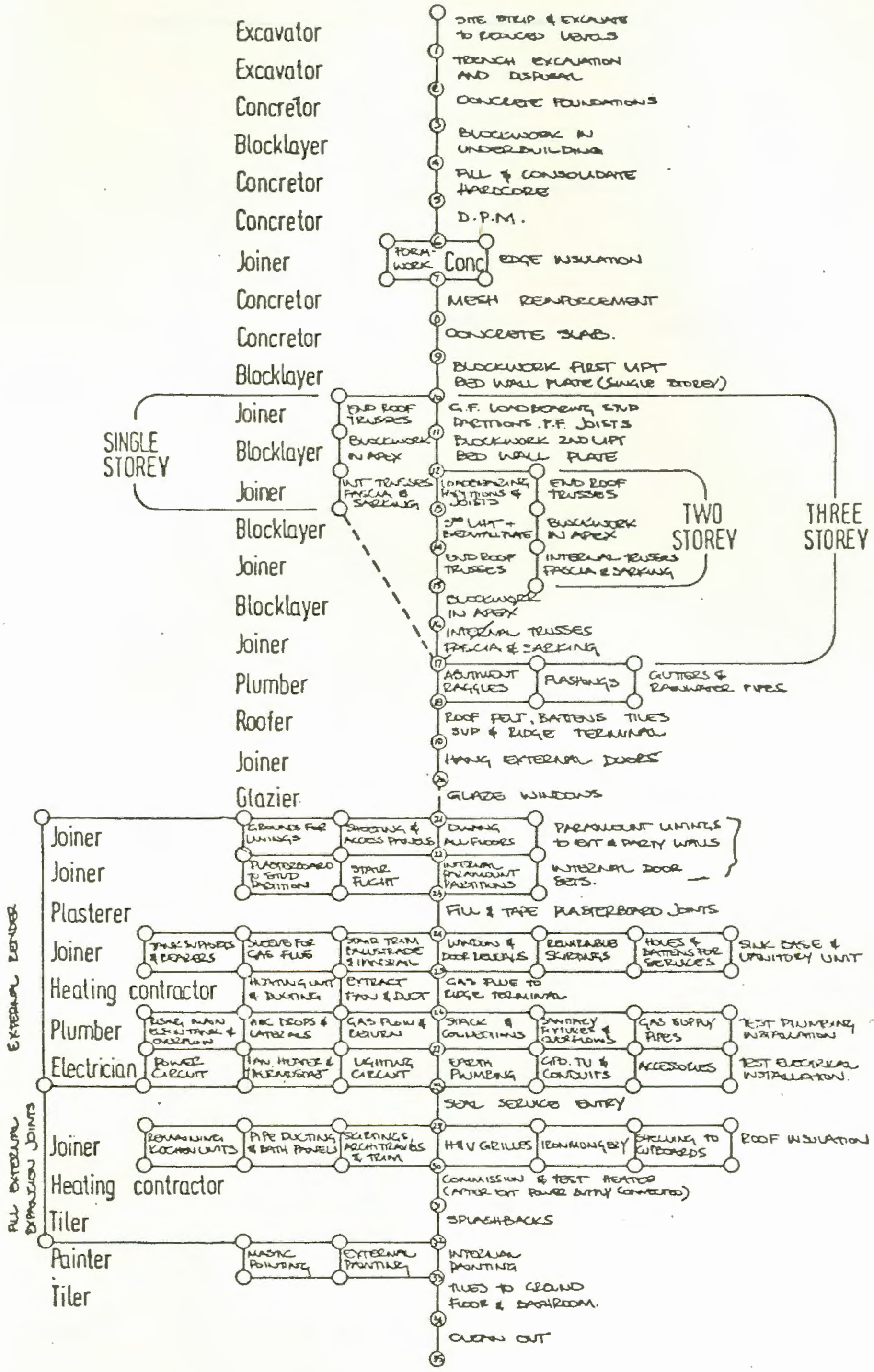


FIG. 17

Figure 17

Planned Network for the 1, 2 and 3 Storey Houses at Pitcoudie.

Ref.:

Scottish Development Department, Urban Design and Research Division, Pitcoudie Housing Development for Glenrothes Development Corporation, Edinburgh, Scottish Development Department, March 1979.

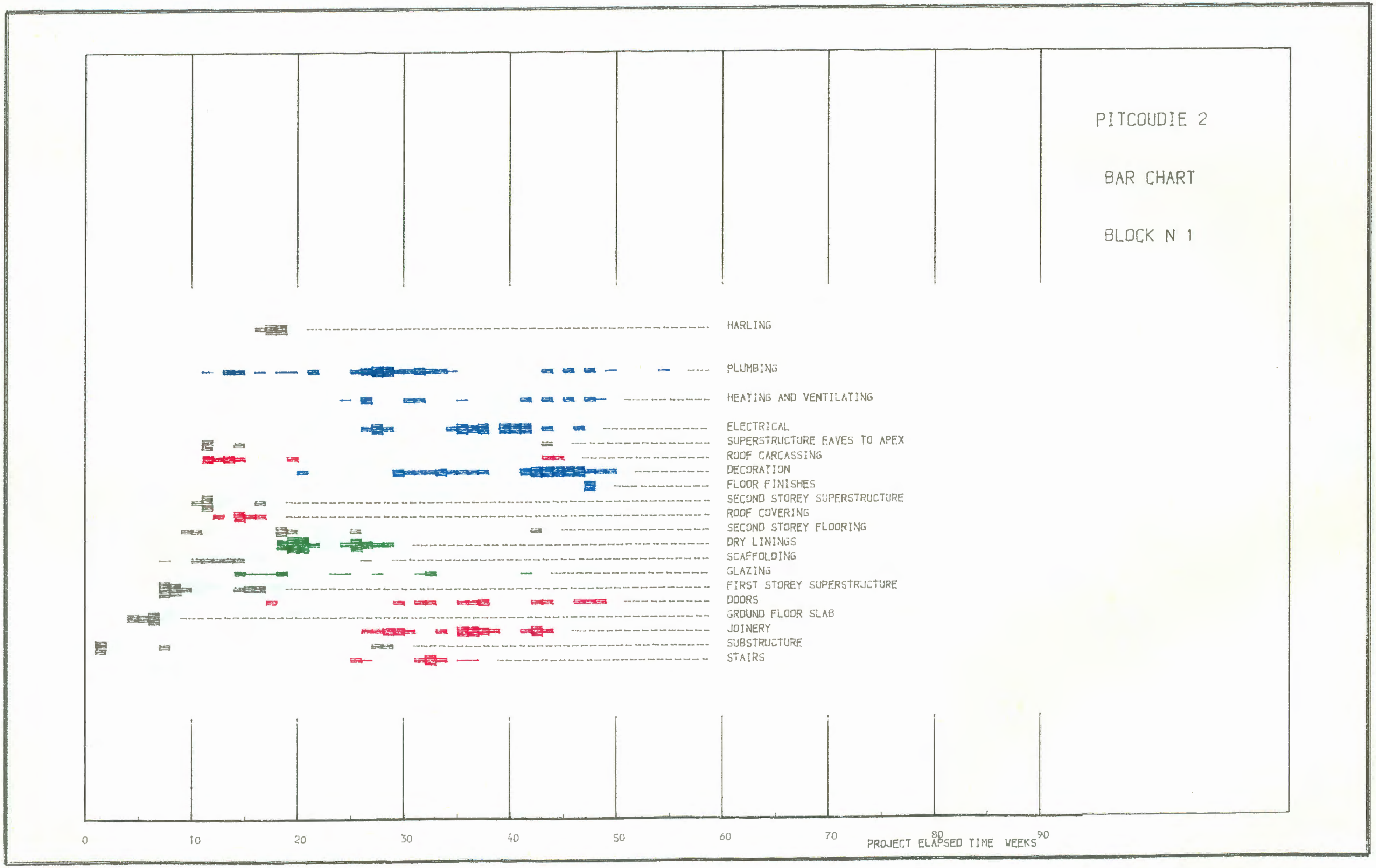

PITCOUDIE 2
BAR CHART
BLOCK N 1
HARLING
PLUMBING
HEATING AND VENTILATING
ELECTRICAL
SUPERSTRUCTURE EAVES TO APEX
ROOF CARCASSING
DECORATION
FLOOR FINISHES
SECOND STOREY SUPERSTRUCTURE
ROOF COVERING
SECOND STOREY FLOORING
DRY LININGS
SCAFFOLDING
GLAZING
FIRST STOREY SUPERSTRUCTURE
DOORS
GROUND FLOOR SLAB
JOINERY
SUBSTRUCTURE
STAIRS
0
10
20
30
40
50
60
70
80
90
PROJECT ELAPSED TIME WEEKS

FIG. 18

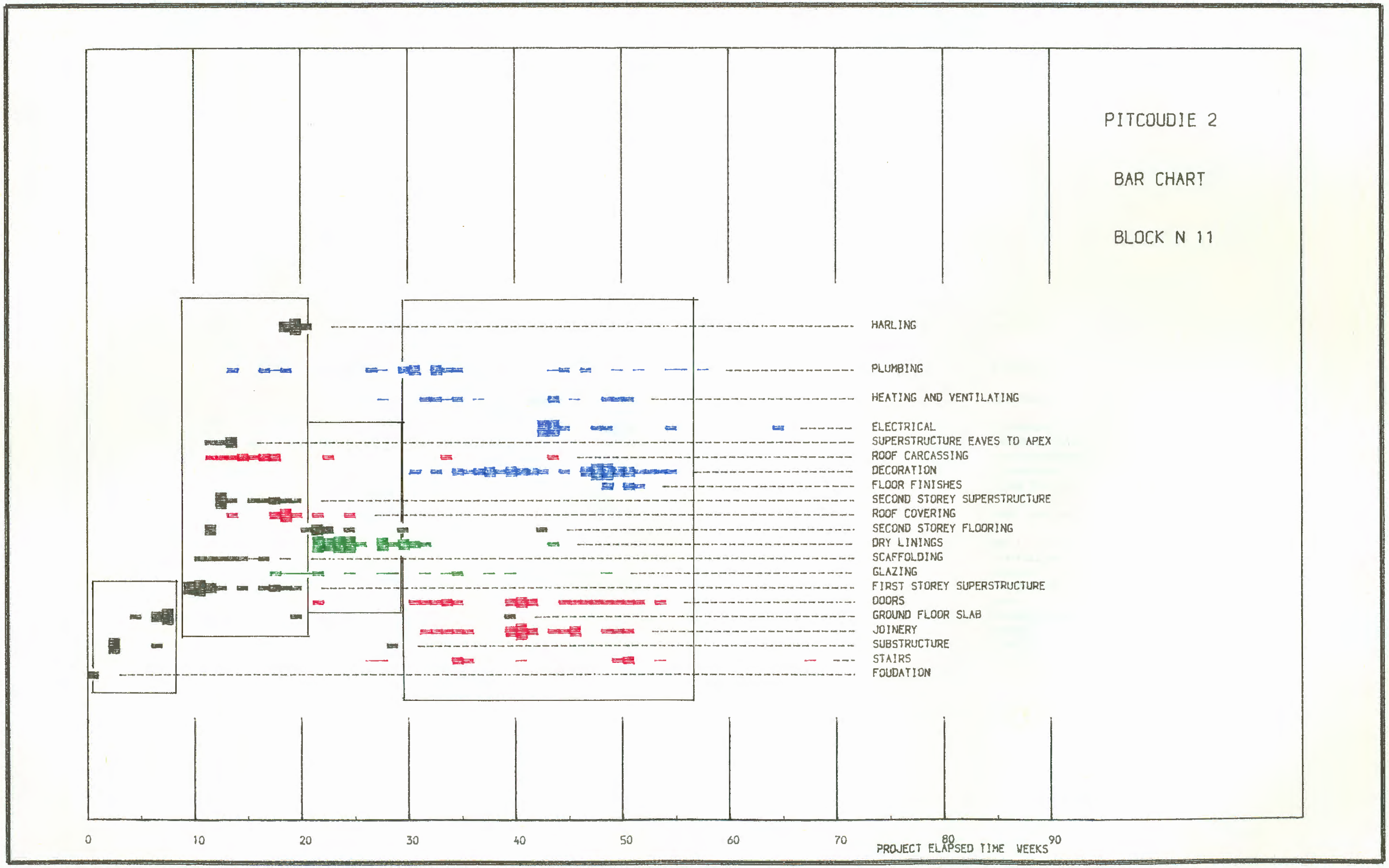

PITCOUDIE 2
BAR CHART
BLOCK N 11
HARLING
PLUMBING
HEATING AND VENTILATING
ELECTRICAL
SUPERSTRUCTURE EAVES TO APEX
ROOF CARCASSING
DECORATION
FLOOR FINISHES
SECOND STOREY SUPERSTRUCTURE
ROOF COVERING
SECOND STOREY FLOORING
DRY LININGS
SCAFFOLDING
GLAZING
FIRST STOREY SUPERSTRUCTURE
DOORS
GROUND FLOOR SLAB
JOINERY
SUBSTRUCTURE
STAIRS
FOUDATION
0
10
20
30
40
50
60
70
80
90
PROJECT ELAPSED TIME WEEKS

FIG. 19

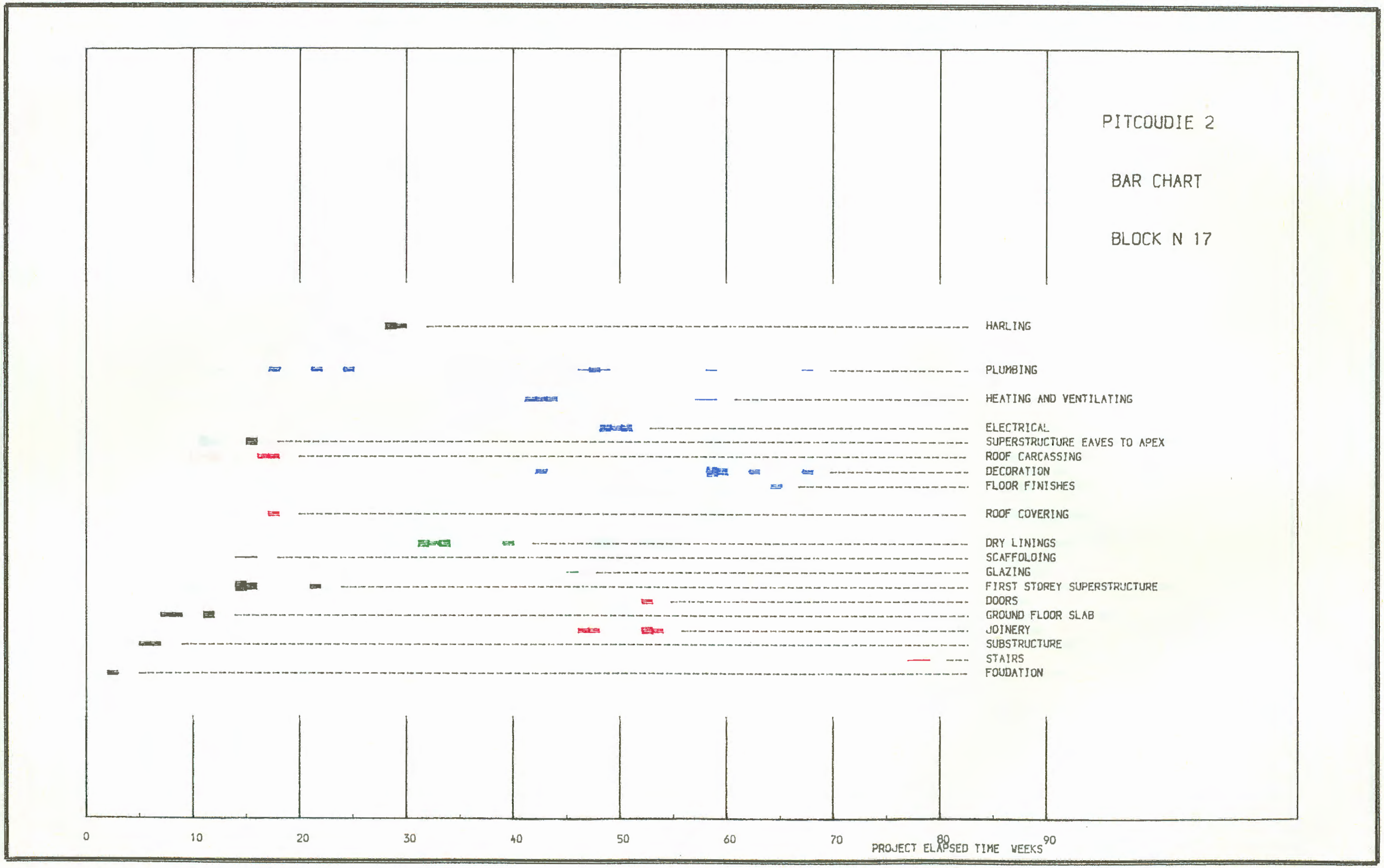

PITCOUDIE 2
BAR CHART
BLOCK N 17
HARLING
PLUMBING
HEATING AND VENTILATING
ELECTRICAL
SUPERSTRUCTURE EAVES TO APEX
ROOF CARCASSING
DECORATION
FLOOR FINISHES
ROOF COVERING
DRY LININGS
SCAFFOLDING
GLAZING
FIRST STOREY SUPERSTRUCTURE
DOORS
GROUND FLOOR SLAB
JOINERY
SUBSTRUCTURE
STAIRS
FOUDATION
0
10
20
30
40
50
60
70
80
90
PROJECT ELAPSED TIME WEEKS

FIG. 20

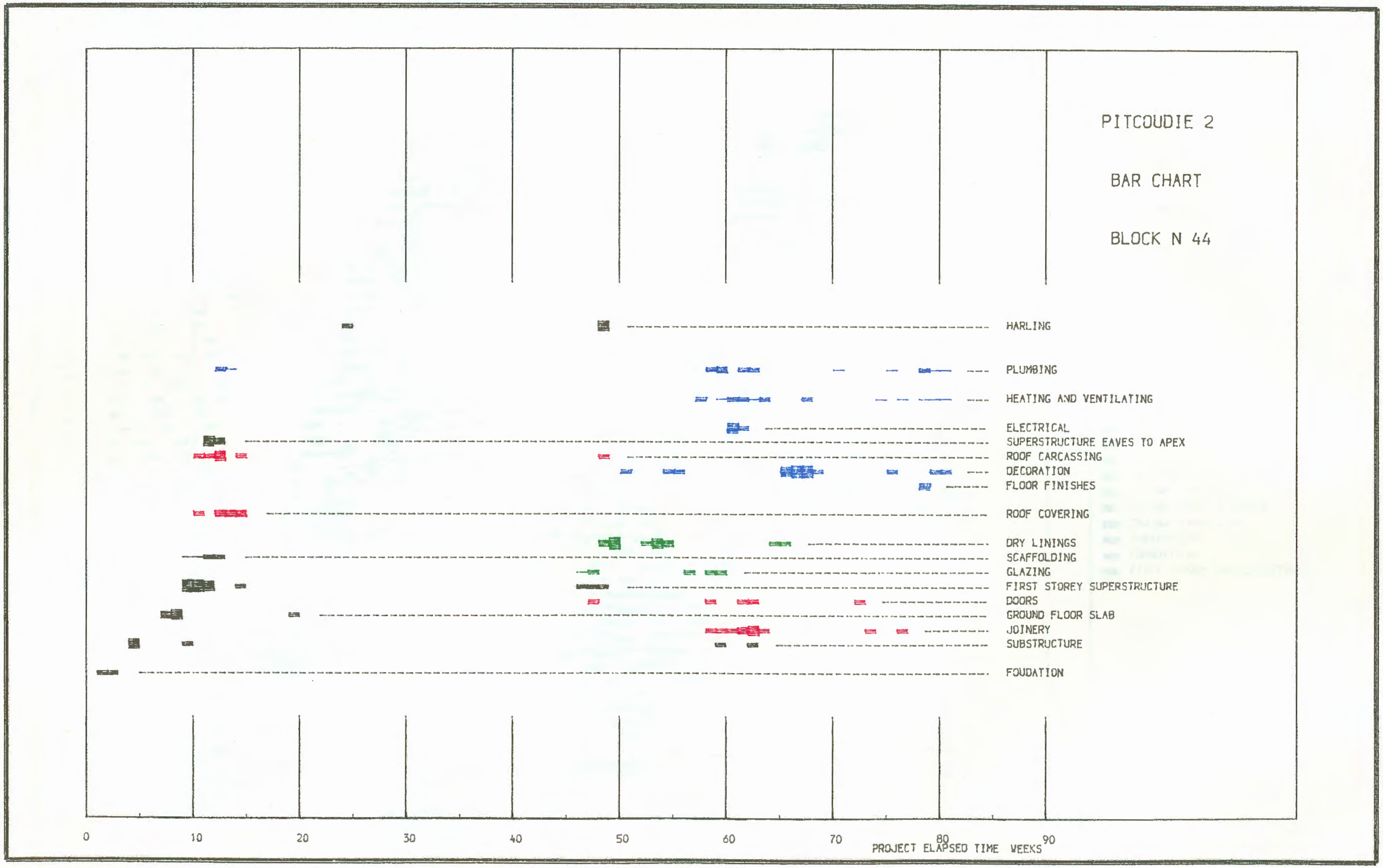

PITCOUDIE 2
BAR CHART
BLOCK N 44
HARLING
PLUMBING
HEATING AND VENTILATING
ELECTRICAL
SUPERSTRUCTURE EAVES TO APEX
ROOF CARCASSING
DECORATION
FLOOR FINISHES
ROOF COVERING
DRY LININGS
SCAFFOLDING
GLAZING
FIRST STOREY SUPERSTRUCTURE
DOORS
GROUND FLOOR SLAB
JOINERY
SUBSTRUCTURE
FOUDATION
0
10
20
30
40
50
60
70
80
90
PROJECT ELAPSED TIME WEEKS

FIG. 21

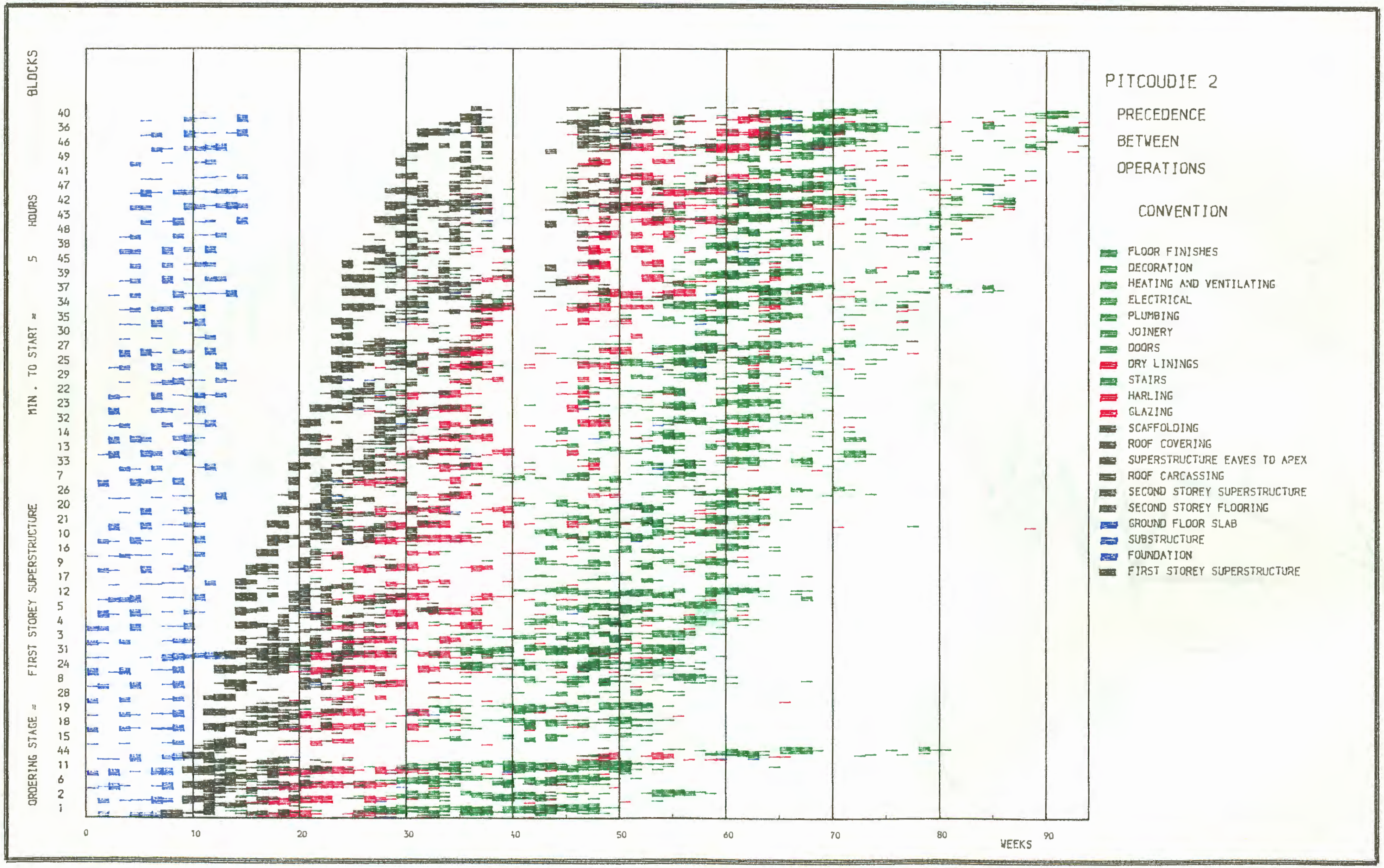

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
FLOOR FINISHES
DECORATION
HEATING AND VENTILATING
ELECTRICAL
PLUMBING
JOINERY
DOORS
DRY LININGS
STAIRS
HARLING
GLAZING
SCAFFOLDING
ROOF COVERING
SUPERSTRUCTURE EAVES TO APEX
ROOF CARCASSING
SECOND STOREY SUPERSTRUCTURE
SECOND STOREY FLOORING
GROUND FLOOR SLAB
SUBSTRUCTURE
FOUNDATION
FIRST STOREY SUPERSTRUCTURE
BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE
MIN. TO START = 5 HOURS
WEEKS

FIG. 22

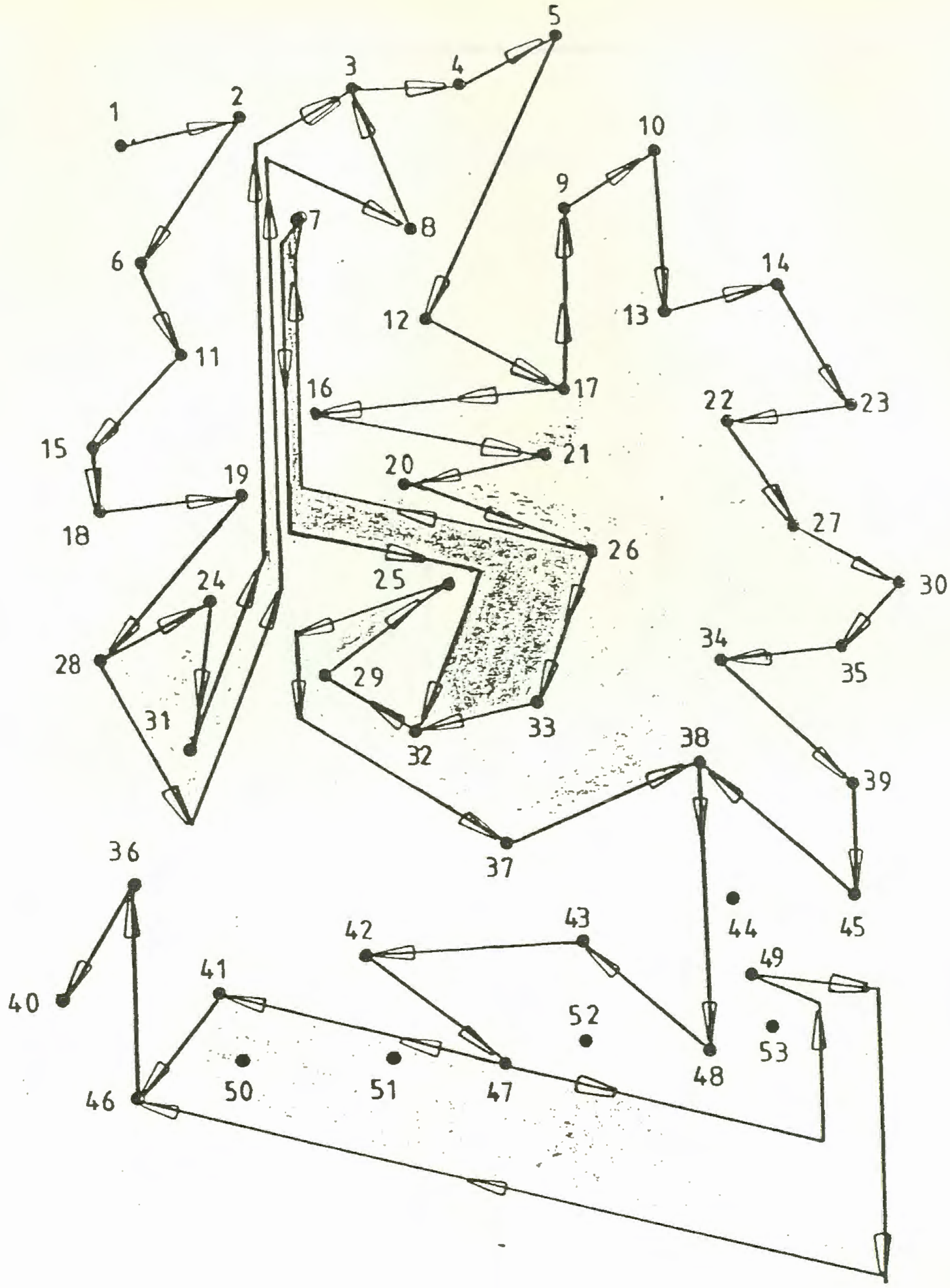


FIG. 23

No.
- block location and number
- the boundaries of the regions in grey are parallel lines of flow of work

Notes:

- block No. 44 was started after block No. 1, in the same week as blocks No. 6, No. 2 and No. 11
- blocks No. 50, No. 51, No. 52 and No. 53 are flats: they are not considered in this flow diagram
- the stage of work is considered started in each block when the weekly allocation of man-hours exceeds 4 hours

Figure 23

Flow of Starts of Work in the First-storey Superstructure Stage

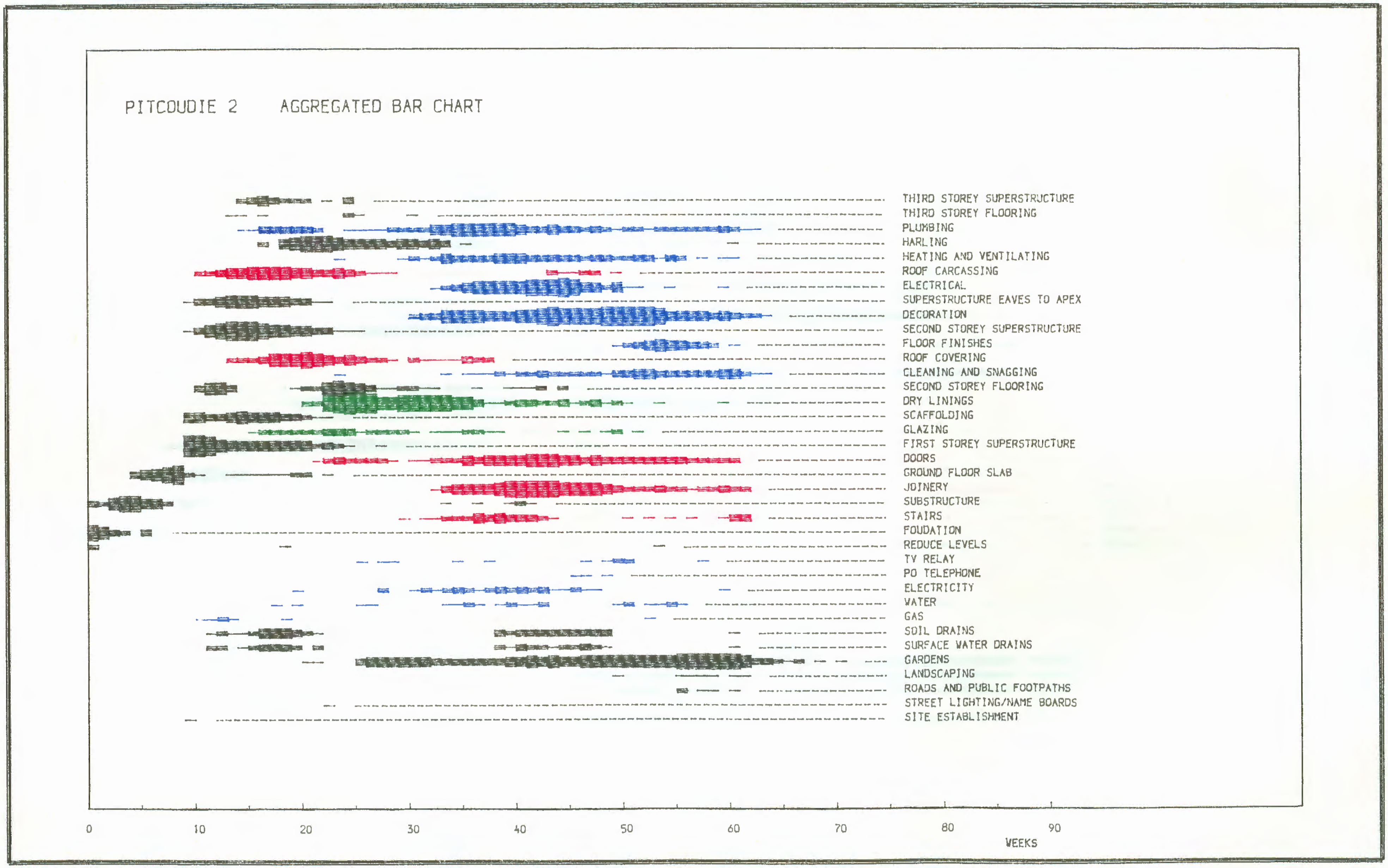

PITCOUDIE 2 AGGREGATED BAR CHART
THIRD STOREY SUPERSTRUCTURE
THIRD STOREY FLOORING
PLUMBING
HARLING
HEATING AND VENTILATING
ROOF CARCASSING
ELECTRICAL
SUPERSTRUCTURE EAVES TO APEX
DECORATION
SECOND STOREY SUPERSTRUCTURE
FLOOR FINISHES
ROOF COVERING
CLEANING AND SNAGGING
SECOND STOREY FLOORING
DRY LININGS
SCAFFOLDING
GLAZING
FIRST STOREY SUPERSTRUCTURE
DOORS
GROUND FLOOR SLAB
JOINERY
SUBSTRUCTURE
STAIRS
FOUDATION
REDUCE LEVELS
TV RELAY
PO TELEPHONE
ELECTRICITY
WATER
GAS
SOIL DRAINS
SURFACE WATER DRAINS
GARDENS
LANDSCAPING
ROADS AND PUBLIC FOOTPATHS
STREET LIGHTING/NAME BOARDS
SITE ESTABLISHMENT
0
10
20
30
40
50
60
70
80
90
WEEKS

FIG. 24

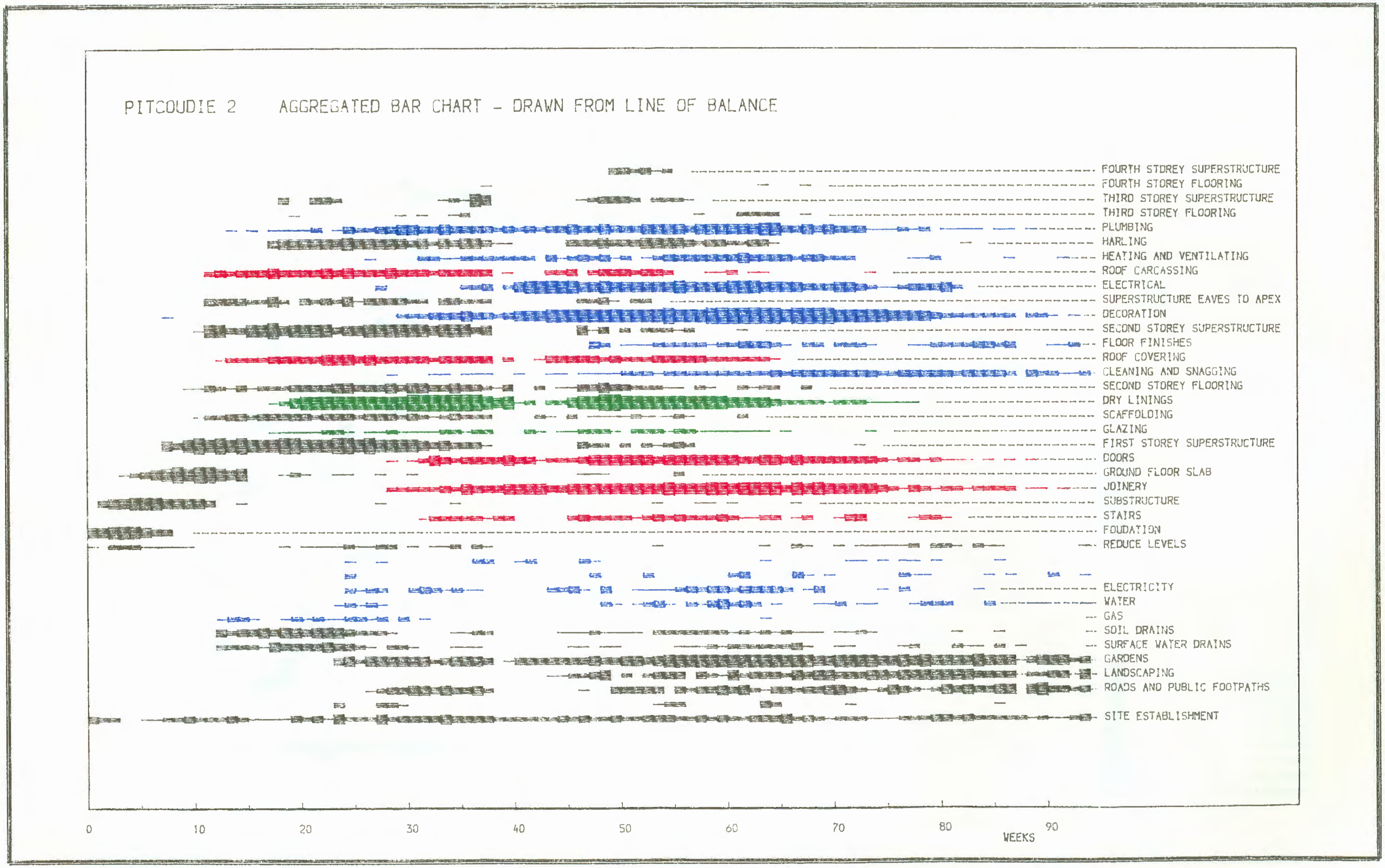
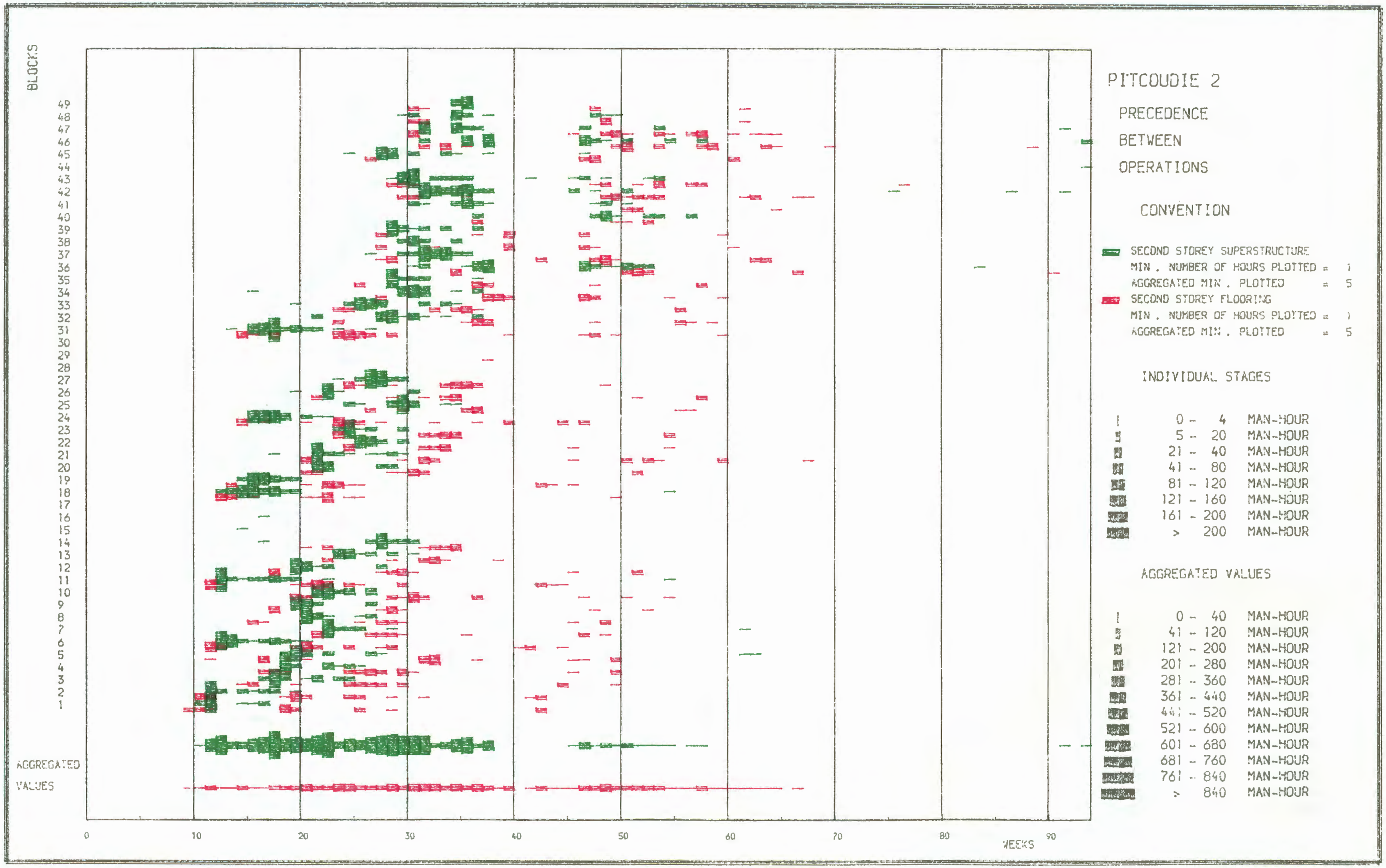

PITCOUDIE 2 AGGREGATED BAR CHART - DRAWN FROM LINE OF BALANCE
FOURTH STOREY SUPERSTRUCTURE
FOURTH STOREY FLOORING
THIRD STOREY SUPERSTRUCTURE
THIRD STOREY FLOORING
PLUMBING
HARLING
HEATING AND VENTILATING
ROOF CARCASSING
ELECTRICAL
SUPERSTRUCTURE EAVES TO APEX
DECORATION
SECOND STOREY SUPERSTRUCTURE
FLOOR FINISHES
ROOF COVERING
CLEANING AND SNAGGING
SECOND STOREY FLOORING
DRY LININGS
SCAFFOLDING
GLAZING
FIRST STOREY SUPERSTRUCTURE
DOORS
GROUND FLOOR SLAB
JOINERY
SUBSTRUCTURE
STAIRS
FOUDATION
REDUCE LEVELS
ELECTRICITY
WATER
GAS
SOIL DRAINS
SURFACE WATER DRAINS
GARDENS
LANDSCAPING
ROADS AND PUBLIC FOOTPATHS
SITE ESTABLISHMENT
0
10
20
30
40
50
60
70
80
90
WEEKS

FIG. 25



BLOCKS
49
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
SECOND STOREY FLOORING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 26

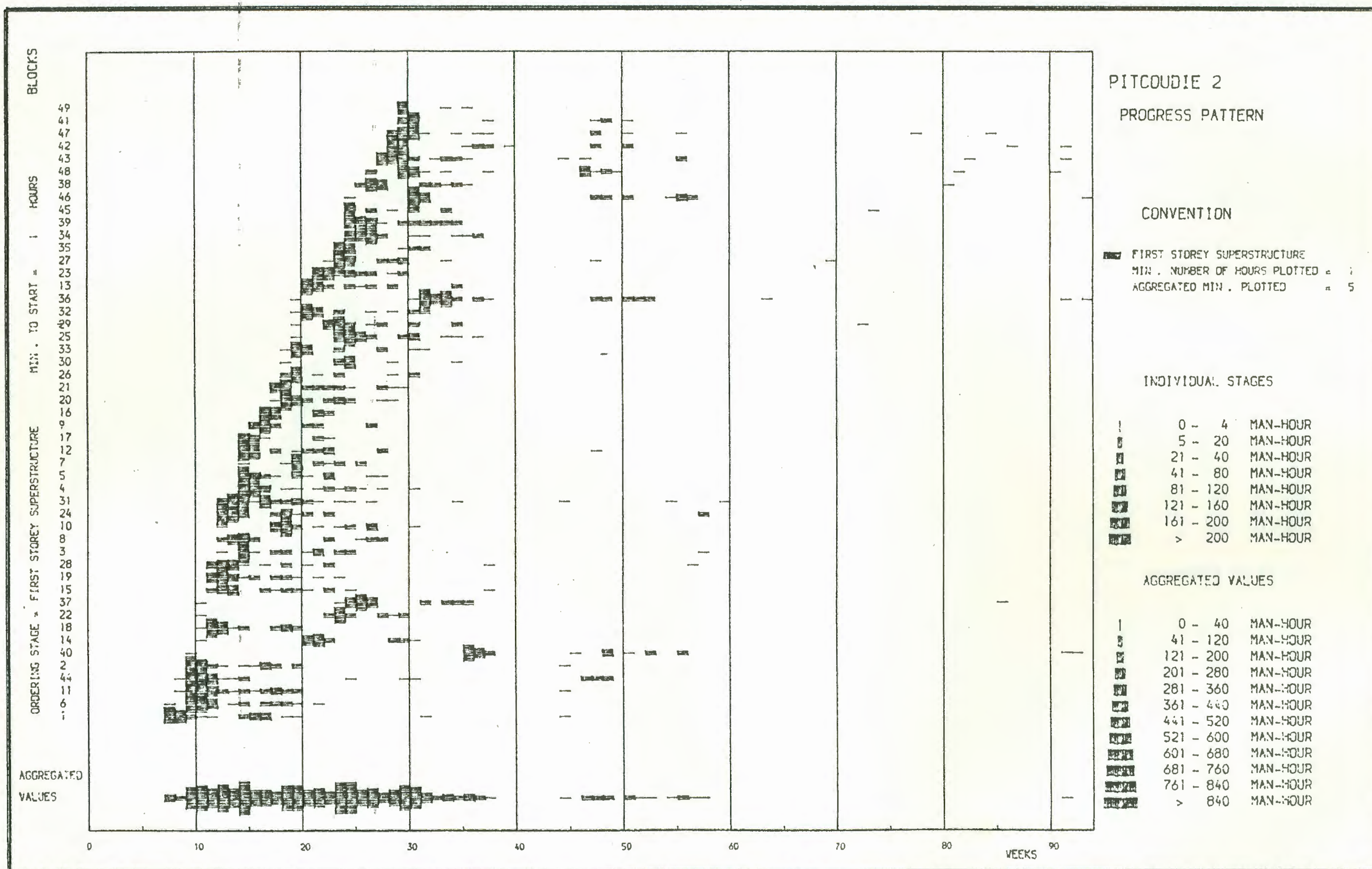

BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE MIN. TO START = 1 HOURS
49 41 47 42 43 48 38 46 45 39 34 35 27 23 13 36 32 29 25 33 30 26 21 20 16 9 17 12 7 5 4 31 24 10 8 3 28 19 15 37 22 18 14 40 2 44 11 6 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
FIRST STOREY SUPERSTRUCTURE
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 27

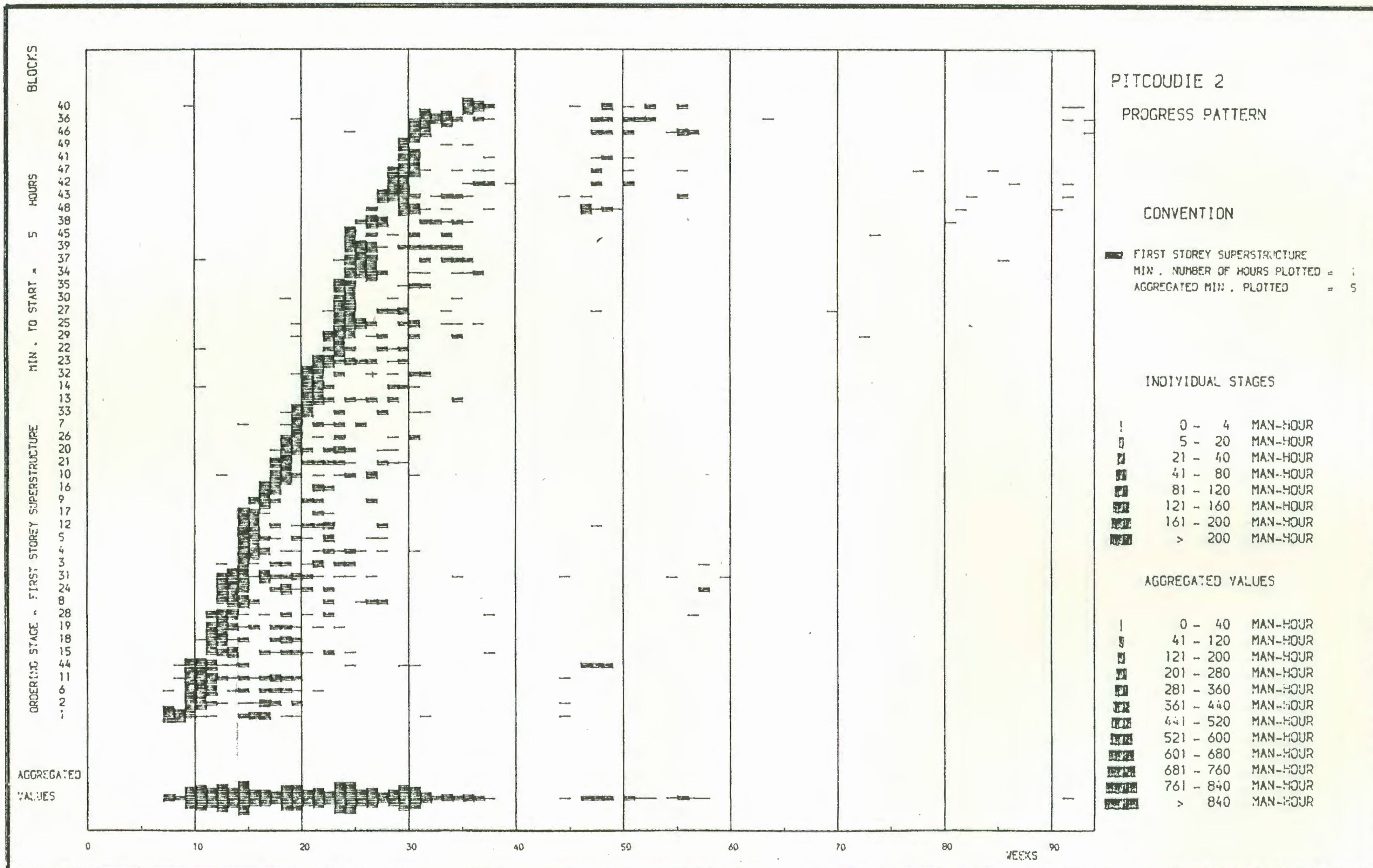

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
FIRST STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE MIN . TO START = 5 HOURS
40 36 46 49 41 47 42 43 48 38 45 39 37 34 35 30 27 25 29 22 23 32 14 13 33 7 26 20 21 10 16 9 17 12 5 4 3 31 24 8 28 19 18 15 44 11 6 2 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 28

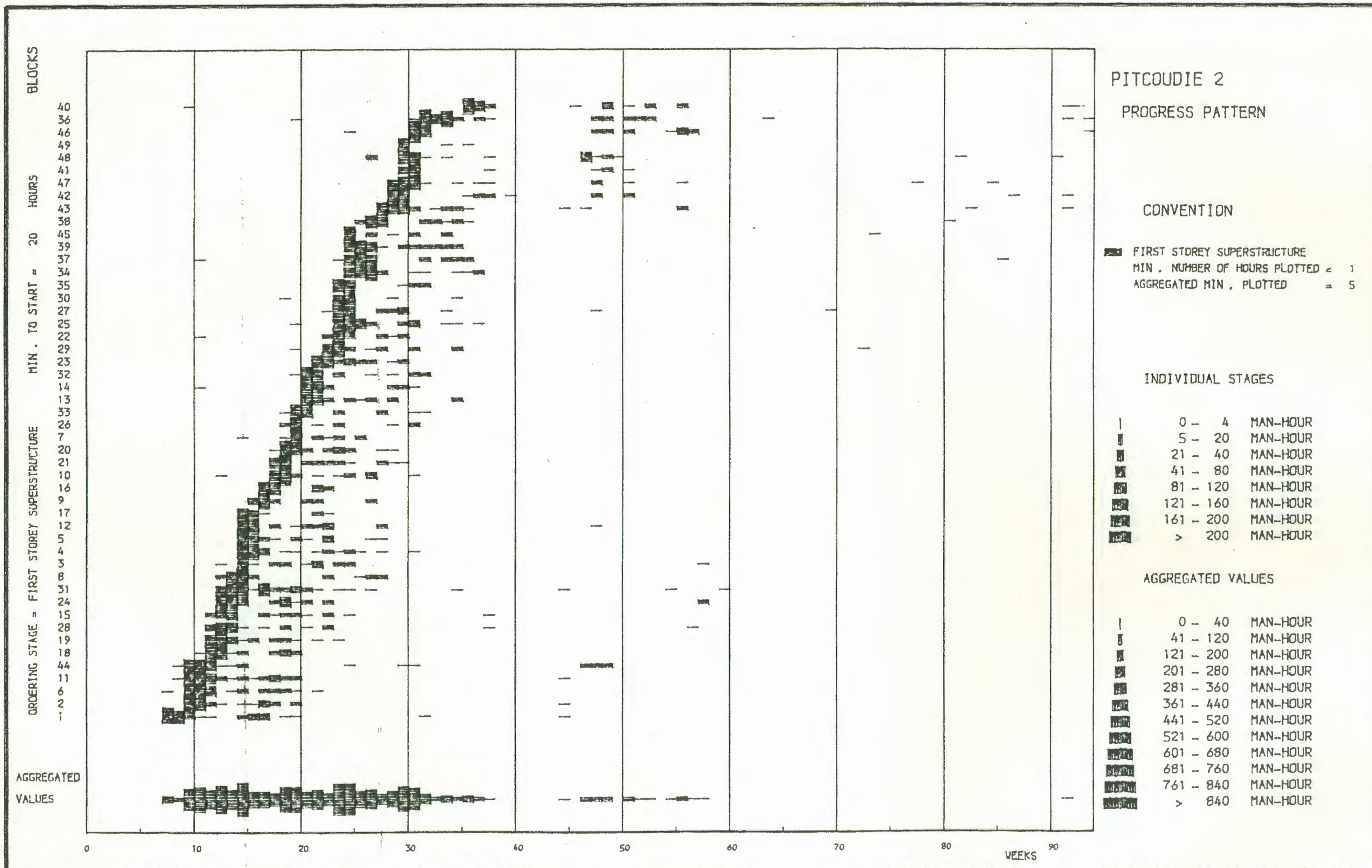

PITCOUDIE 2
PROGRESS PATTERN
BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE   MIN. TO START = 20 HOURS
40 36 46 49 48 41 47 42 43 38 45 39 37 34 35 30 27 25 22 29 23 32 14 13 33 26 7 20 21 10 16 9 17 12 5 4 3 8 31 24 15 28 19 18 44 11 6 2 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
CONVENTION
FIRST STOREY SUPERSTRUCTURE
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 120 MAN-HOUR
121 – 160 MAN-HOUR
161 – 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 120 MAN-HOUR
121 – 200 MAN-HOUR
201 – 280 MAN-HOUR
281 – 360 MAN-HOUR
361 – 440 MAN-HOUR
441 – 520 MAN-HOUR
521 – 600 MAN-HOUR
601 – 680 MAN-HOUR
681 – 760 MAN-HOUR
761 – 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 29

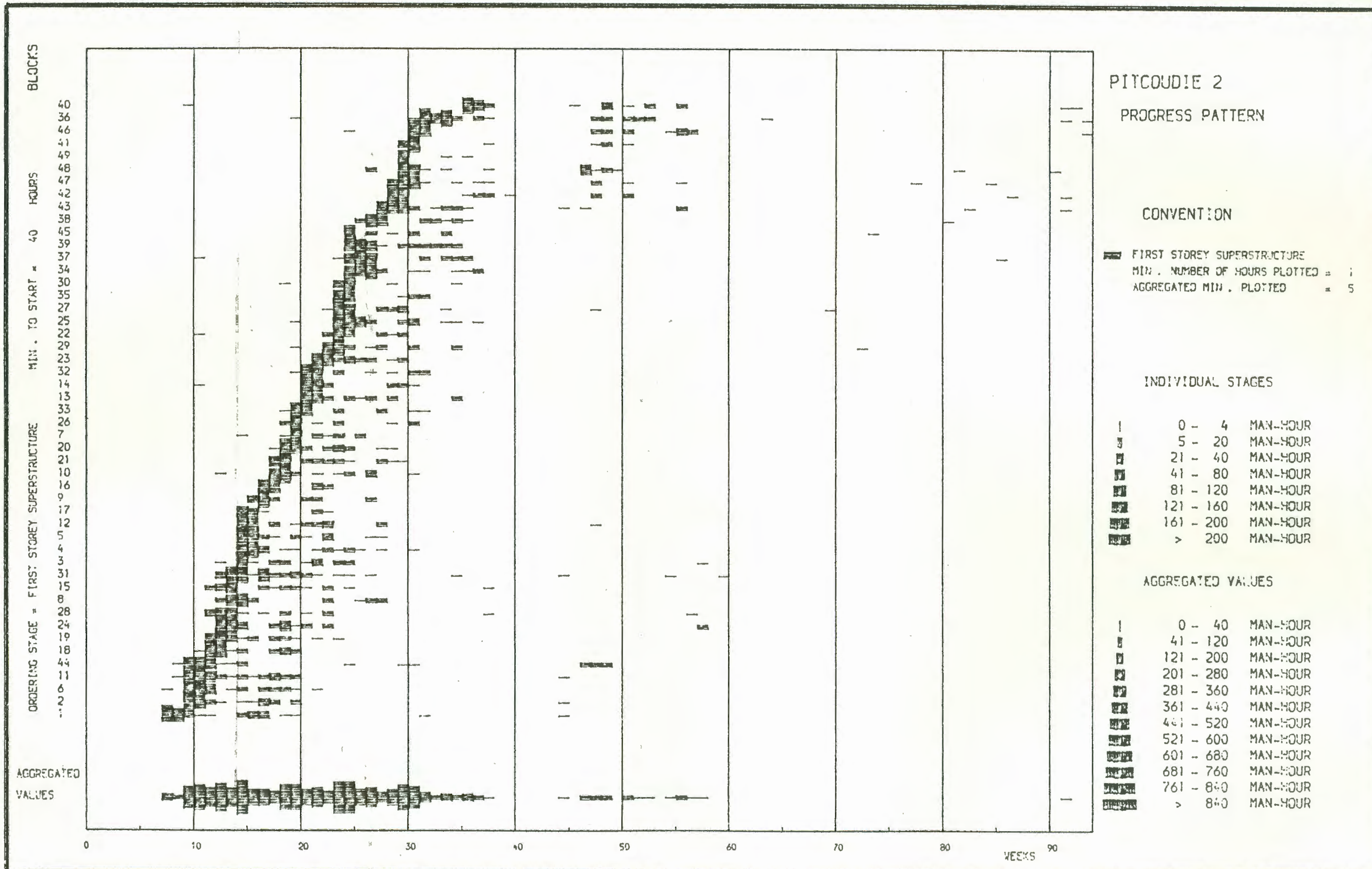
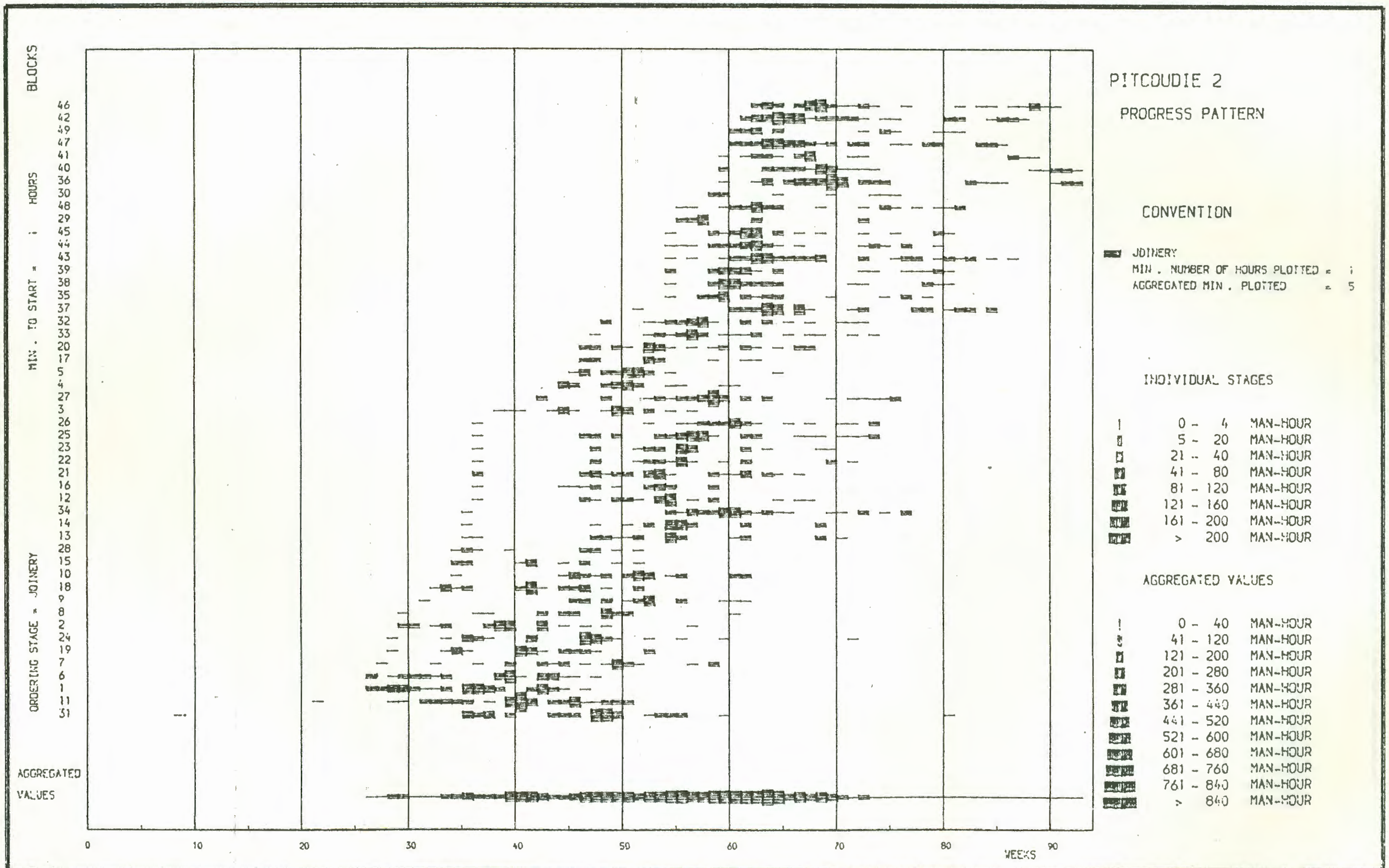

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
FIRST STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE MIN. TO START = 40 HOURS
AGGREGATED VALUES
WEEKS

FIG. 30



PITCOUDIE 2
PROGRESS PATTERN
BLOCKS
MIN. TO START = 1 HOURS
ORDERING STAGE = JOINERY
46 42 49 47 41 40 36 30 48 29 45 44 43 39 38 35 37 32 33 20 17 5 4 27 3 26 25 23 22 21 16 12 34 14 13 28 15 10 18 9 8 2 24 19 7 6 1 11 31
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
CONVENTION
JOINERY
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 31

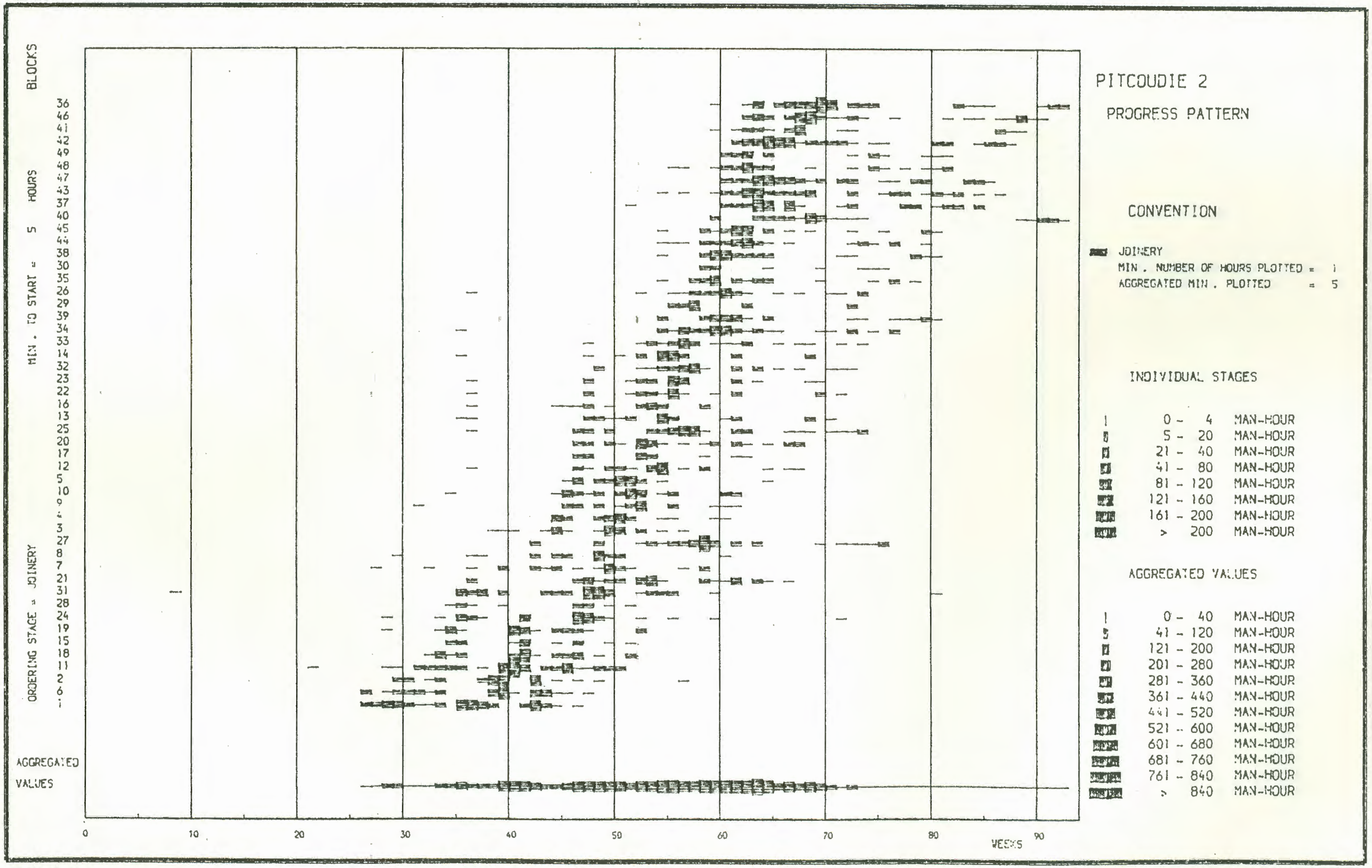
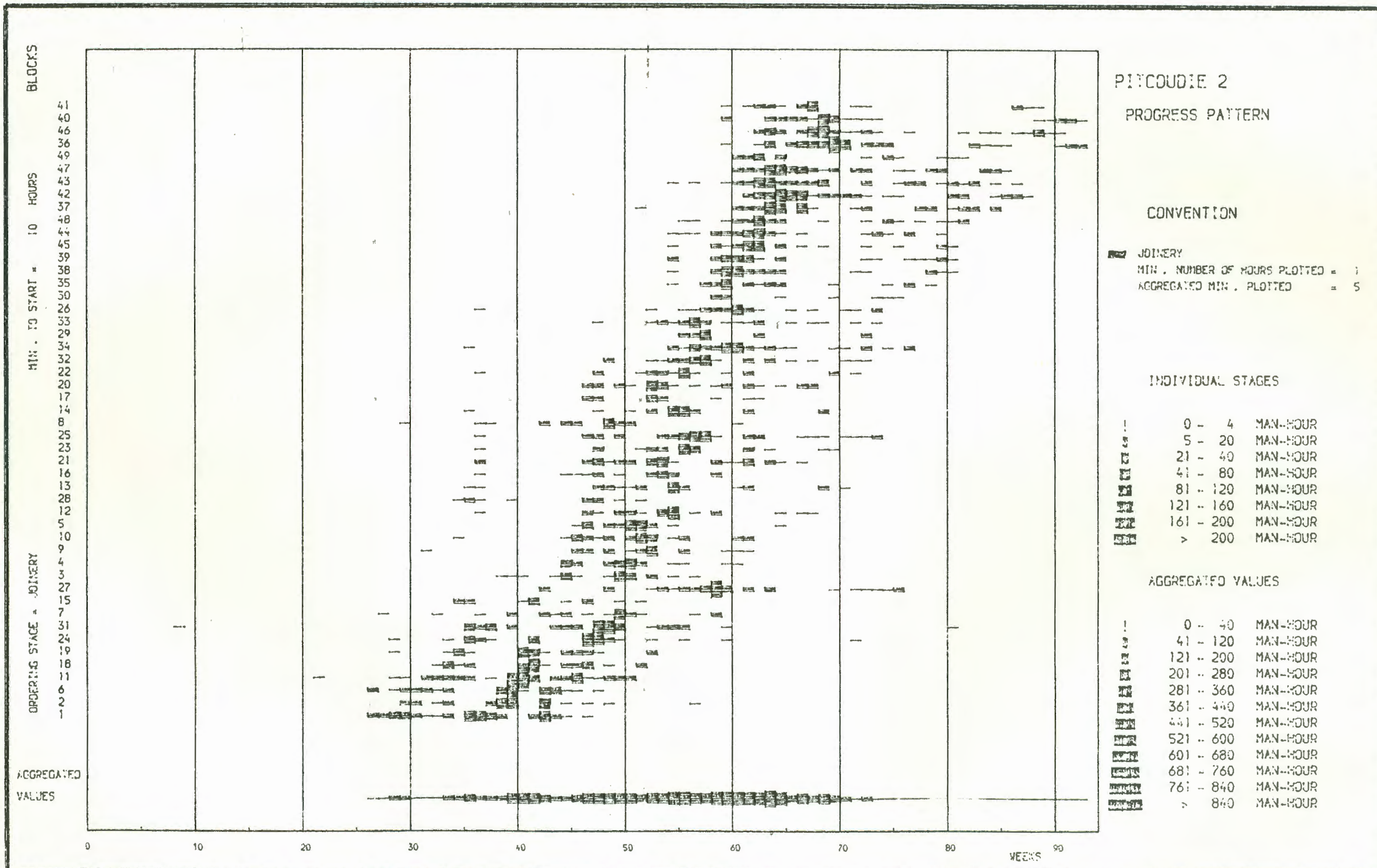
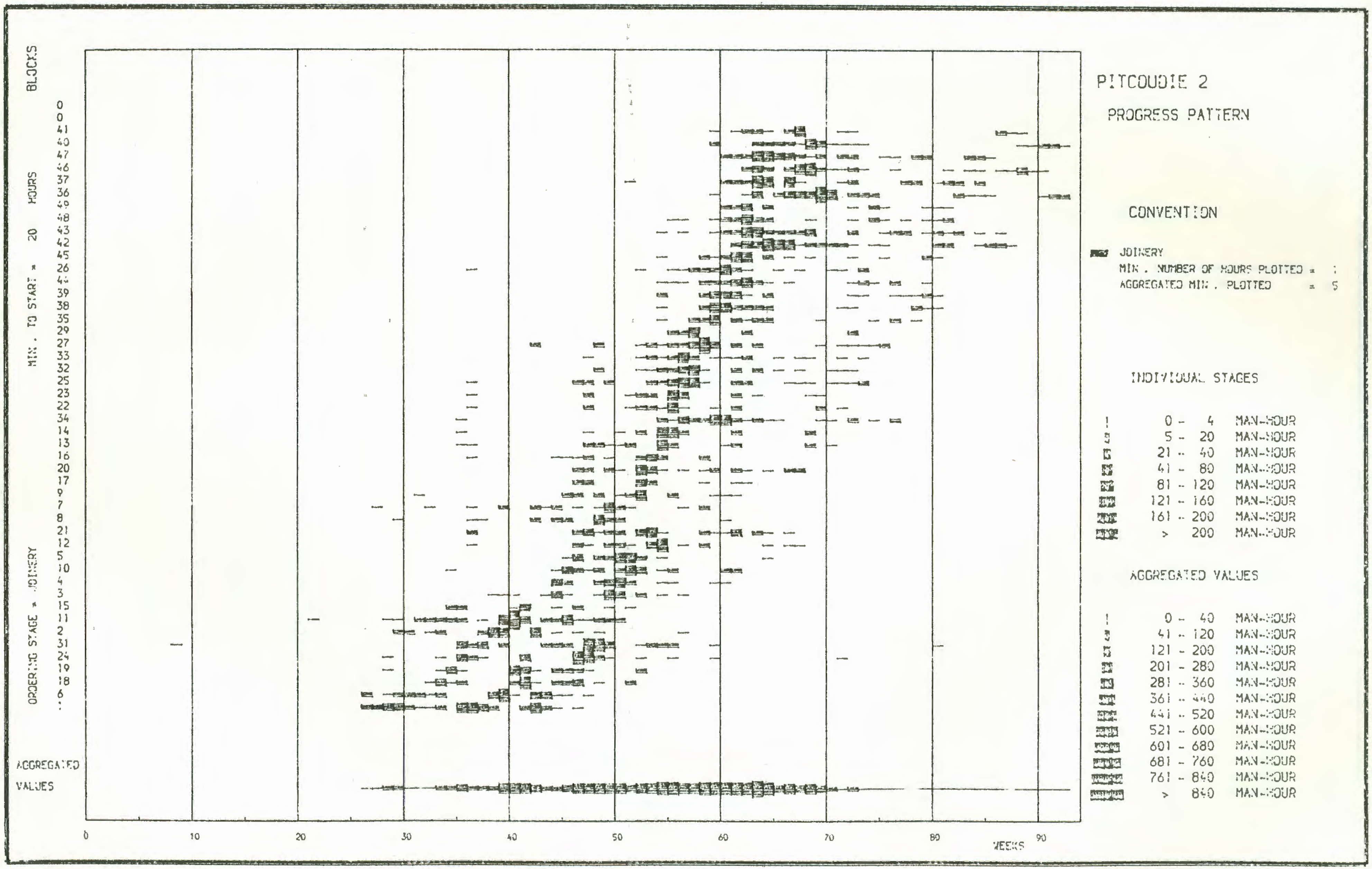

PITCOUDIE 2
PROGRESS PATTERN
BLOCKS
MIN. TO START = 5 HOURS
ORDERING STAGE = JOINERY
36
46
41
42
49
48
47
43
37
40
45
44
38
30
35
26
29
39
34
33
14
32
23
22
16
13
25
20
17
12
5
10
9
4
3
27
8
7
21
31
28
24
19
15
18
11
2
6
1
AGGREGATED VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
CONVENTION
JOINERY
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 32



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
JOINERY
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 10 HOURS
ORDERING STAGE - JOINERY
AGGREGATED VALUES
WEEKS

FIG. 33



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
JOINERY
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN. TO START = 20 HOURS
ORDERING STAGE = JOINERY
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 34

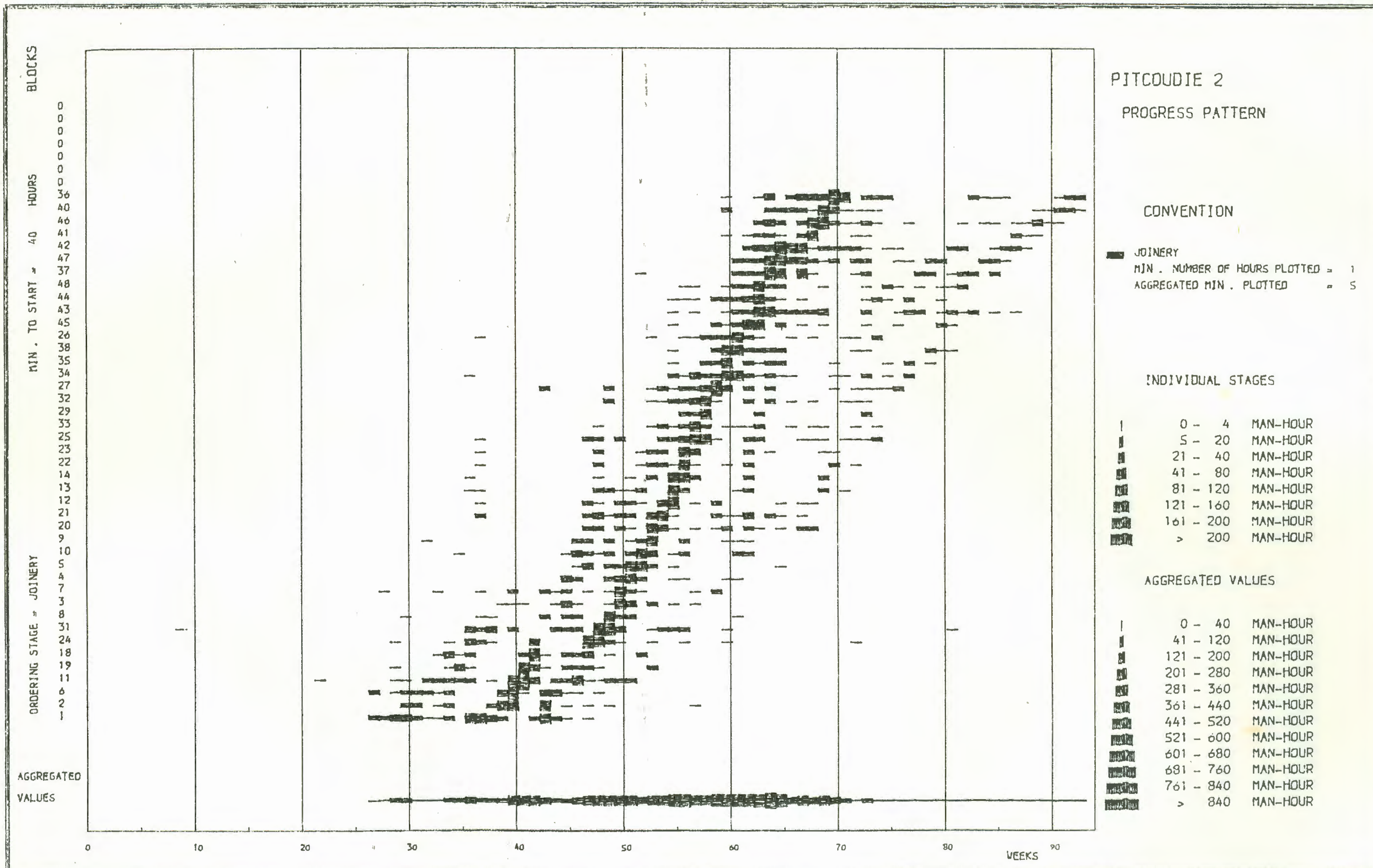
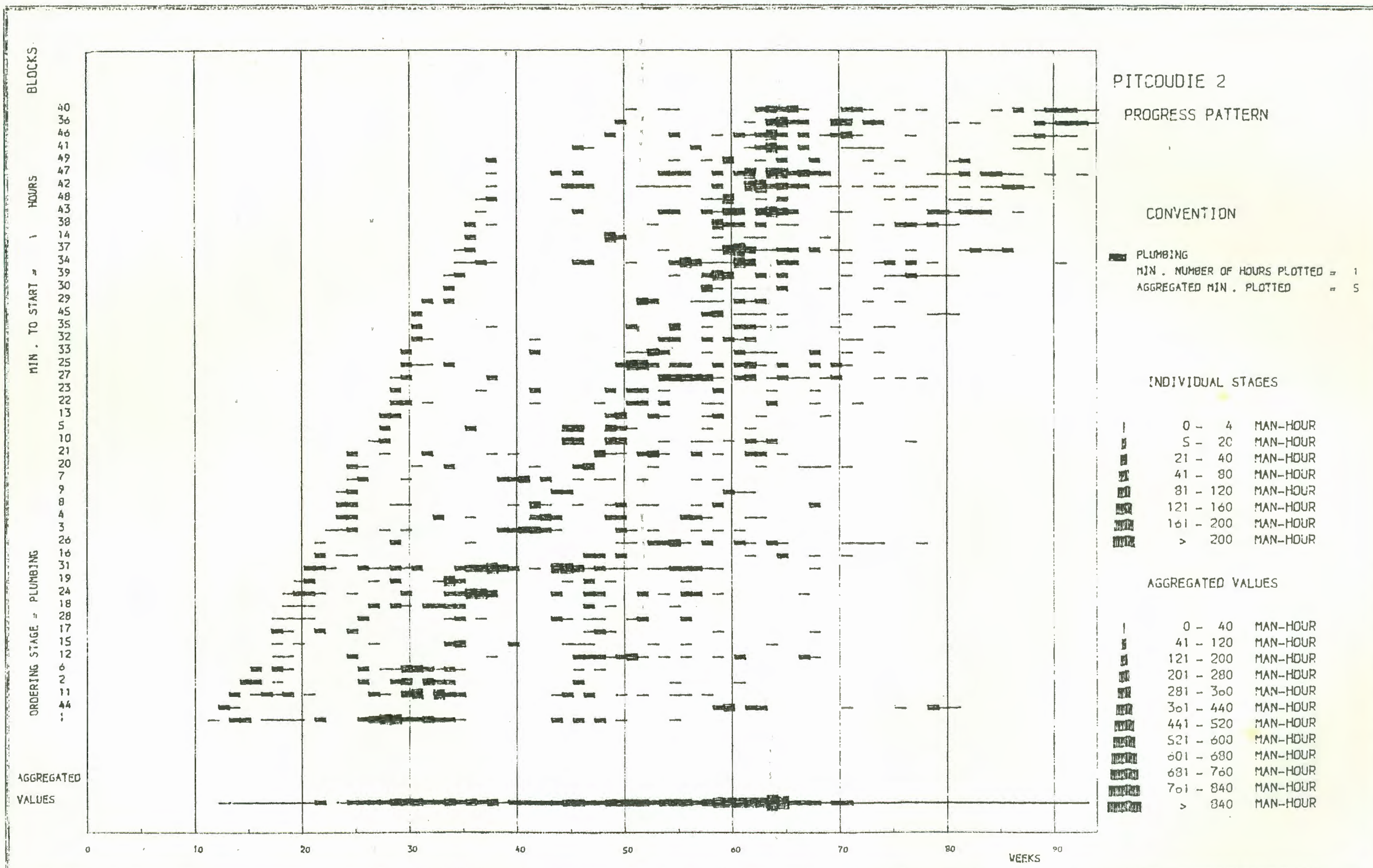

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
JOINERY
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
ORDERING STAGE = JOINERY
MIN . TO START = 40 HOURS
BLOCKS
0
0
0
0
0
0
0
36
40
46
41
42
47
37
48
44
43
45
26
38
35
34
27
32
29
33
25
23
22
14
13
12
21
20
9
10
5
4
7
3
8
31
24
18
19
11
6
2
1
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS

FIG. 35



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
PLUMBING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 1 HOURS
ORDERING STAGE = PLUMBING
AGGREGATED
VALUES
WEEKS
0
10
20
30
40
50
60
70
80
90

FIG. 36

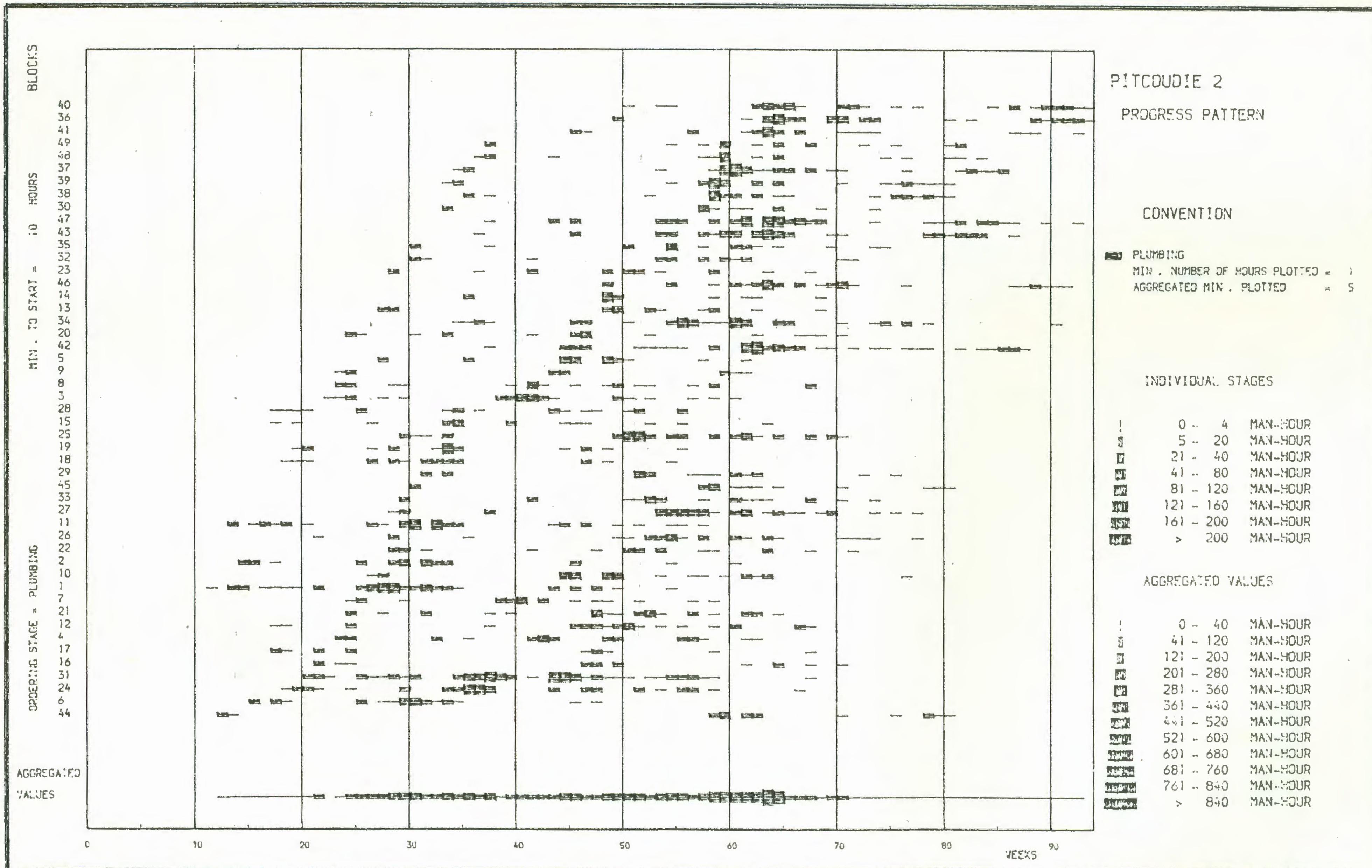

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
PLUMBING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 10 HOURS
ORDERING STAGE = PLUMBING
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 37

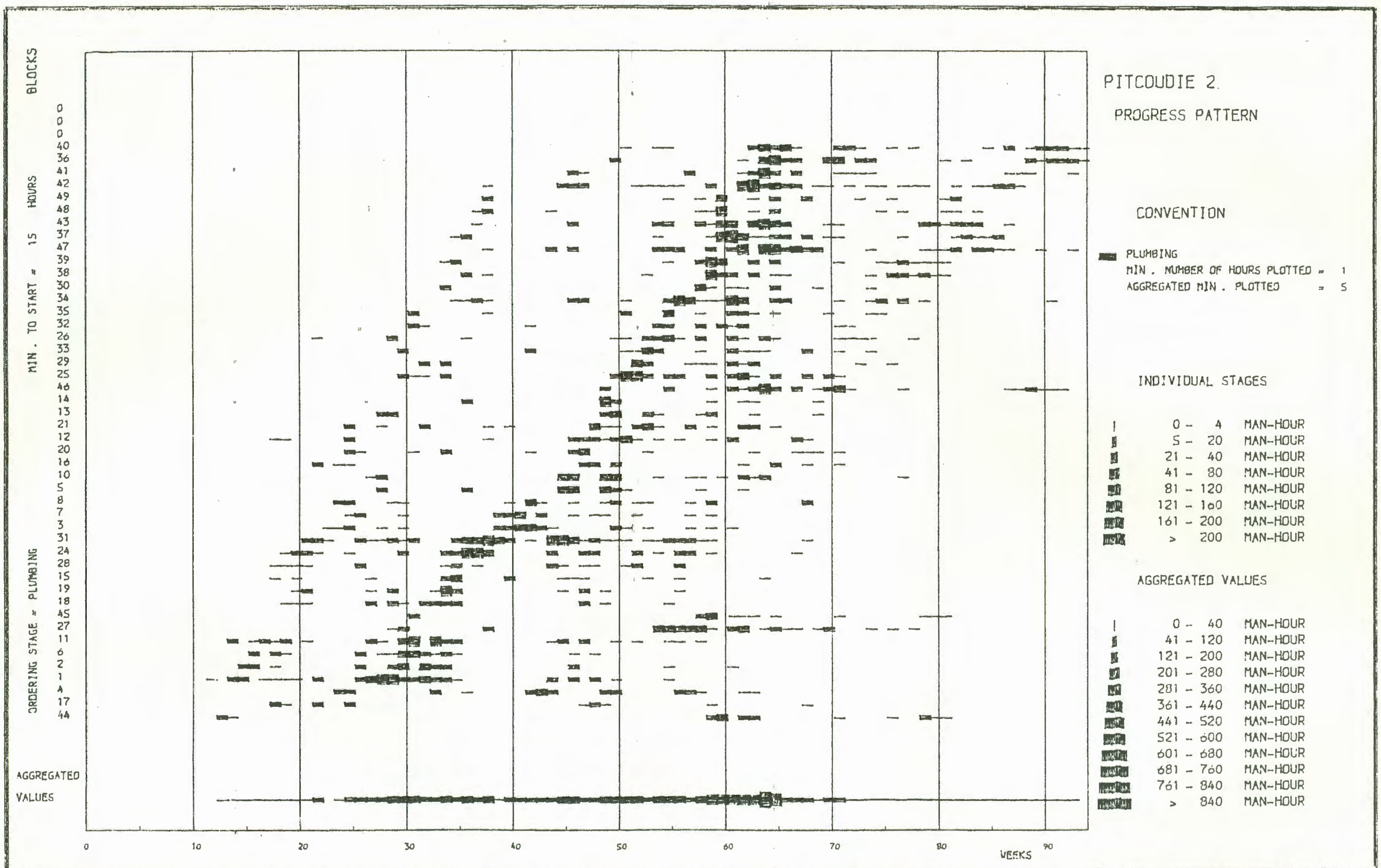

PITCOUDIE 2.
PROGRESS PATTERN
BLOCKS
MIN . TO START = 15 HOURS
ORDERING STAGE = PLUMBING
0 0 0 40 36 41 42 49 48 43 37 47 39 38 30 34 35 32 26 33 29 25 46 14 13 21 12 20 16 10 5 8 7 3 31 24 28 15 19 18 45 27 11 6 2 1 4 17 44
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
CONVENTION
PLUMBING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 38

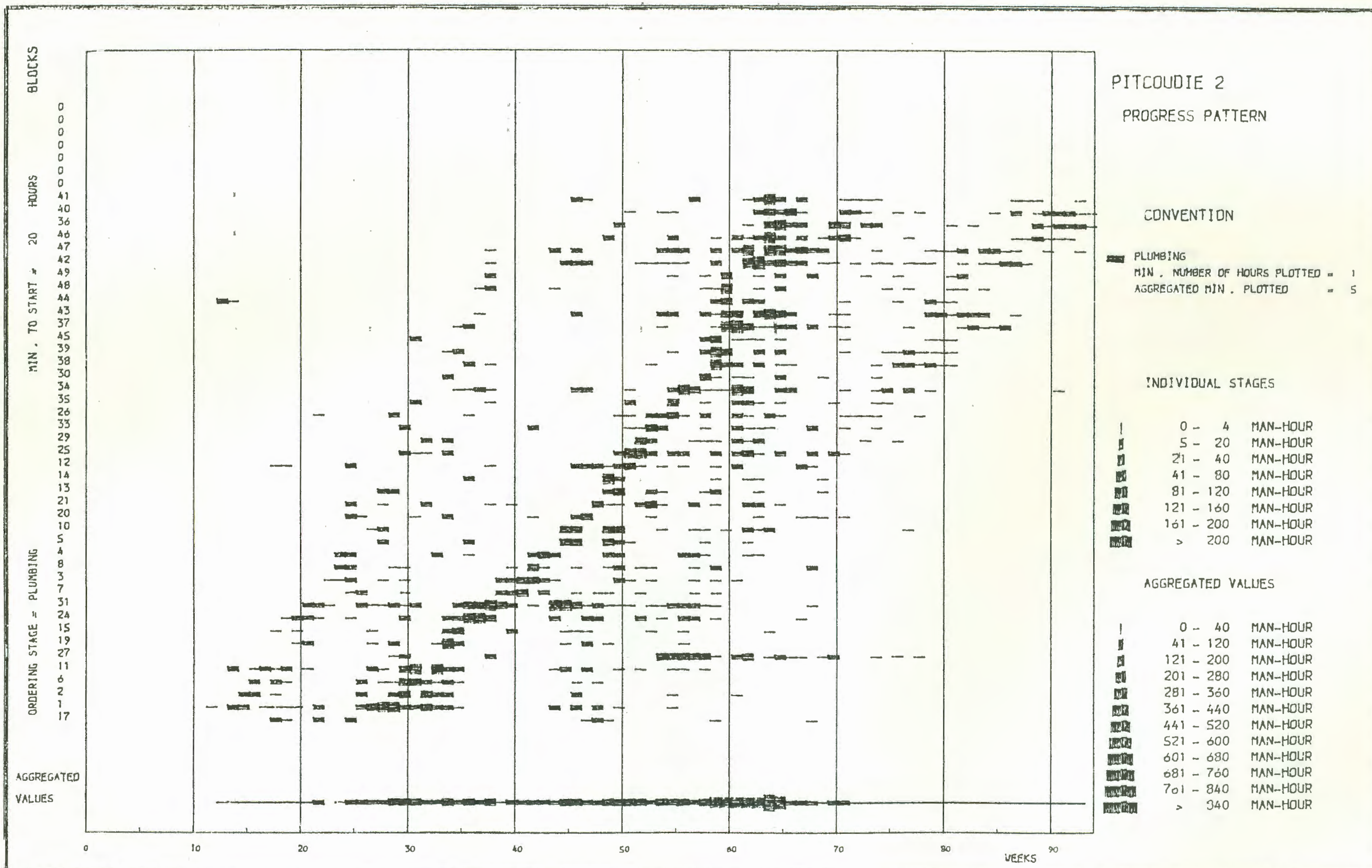

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
PLUMBING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 20 HOURS
ORDERING STAGE = PLUMBING
0 0 0 0 0 0 0 41 40 36 46 47 42 49 48 44 43 37 45 39 38 30 34 35 26 33 29 25 12 14 13 21 20 10 5 4 8 3 7 31 24 15 19 27 11 6 2 1 17
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 39

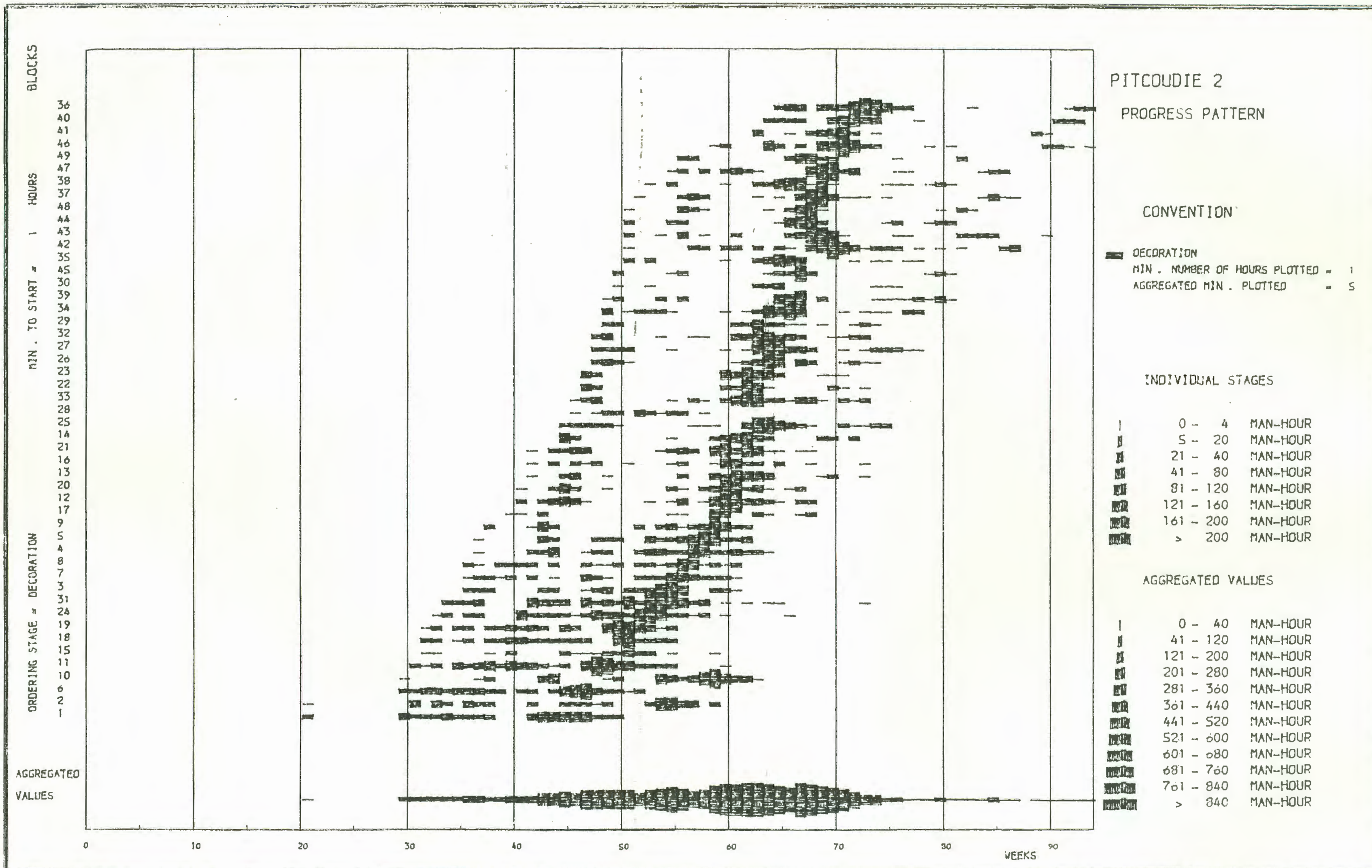
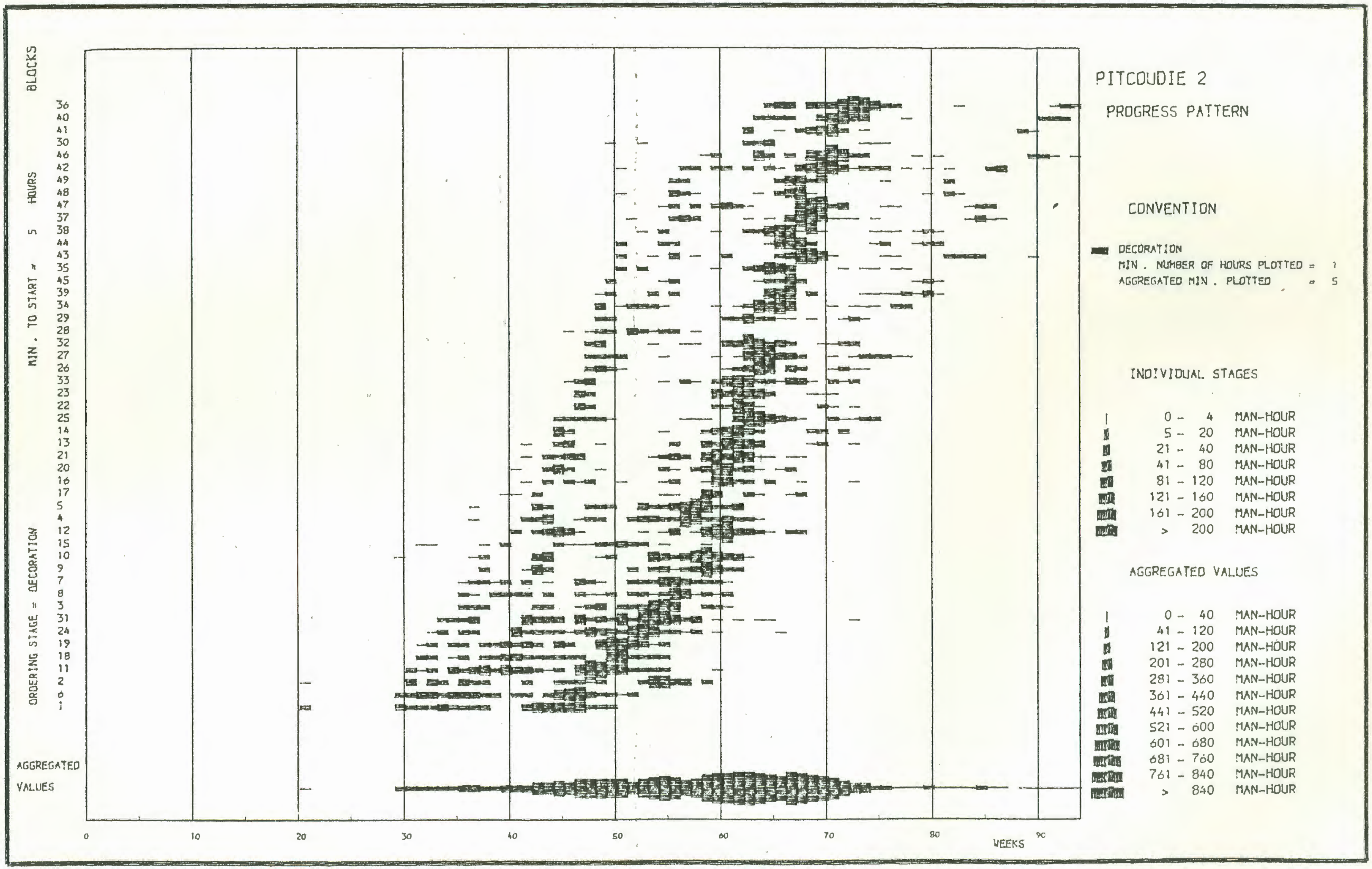

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 1 HOURS
ORDERING STAGE = DECORATION
AGGREGATED VALUES
WEEKS

FIG. 40



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 120 MAN-HOUR
121 – 160 MAN-HOUR
161 – 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 120 MAN-HOUR
121 – 200 MAN-HOUR
201 – 280 MAN-HOUR
281 – 360 MAN-HOUR
361 – 440 MAN-HOUR
441 – 520 MAN-HOUR
521 – 600 MAN-HOUR
601 – 680 MAN-HOUR
681 – 760 MAN-HOUR
761 – 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = DECORATION
36 40 41 30 46 42 49 48 47 37 38 44 43 35 45 39 34 29 28 32 27 26 33 23 22 25 14 13 21 20 16 17 5 4 12 15 10 9 7 8 3 31 24 19 18 11 2 6 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 41

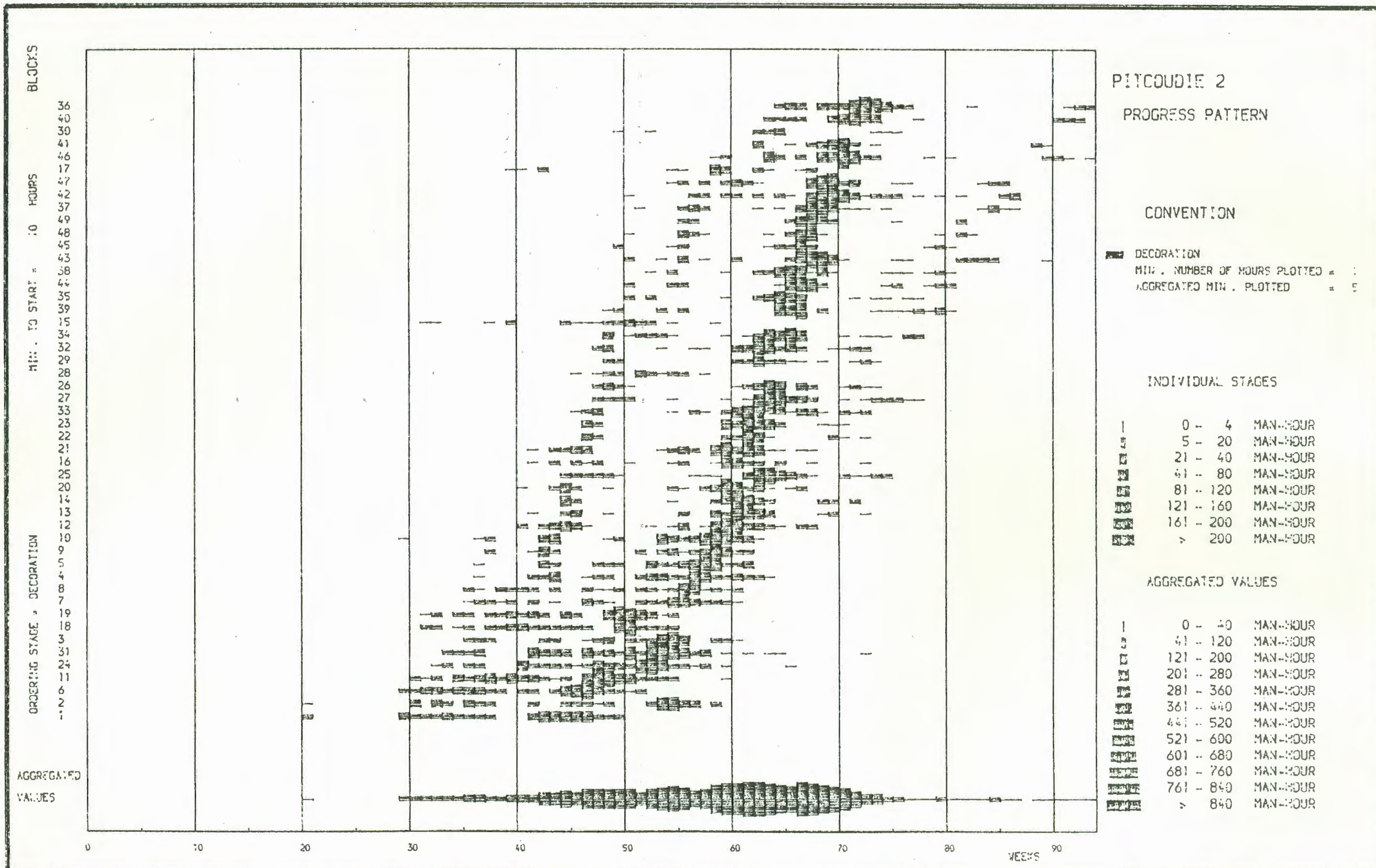

PITCOUDIE 2
PROGRESS PATTERN
BLOCKS
MIN. TO START = 10 HOURS
ORDERING STAGE = DECORATION
36 40 30 41 46 17 47 42 37 49 48 45 43 38 44 35 39 15 34 32 29 28 26 27 33 23 22 21 16 25 20 14 13 12 10 9 5 4 8 7 19 18 3 31 24 11 6 2 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
CONVENTION
DECORATION
MIN. NUMBER OF HOURS PLOTTED =
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 42

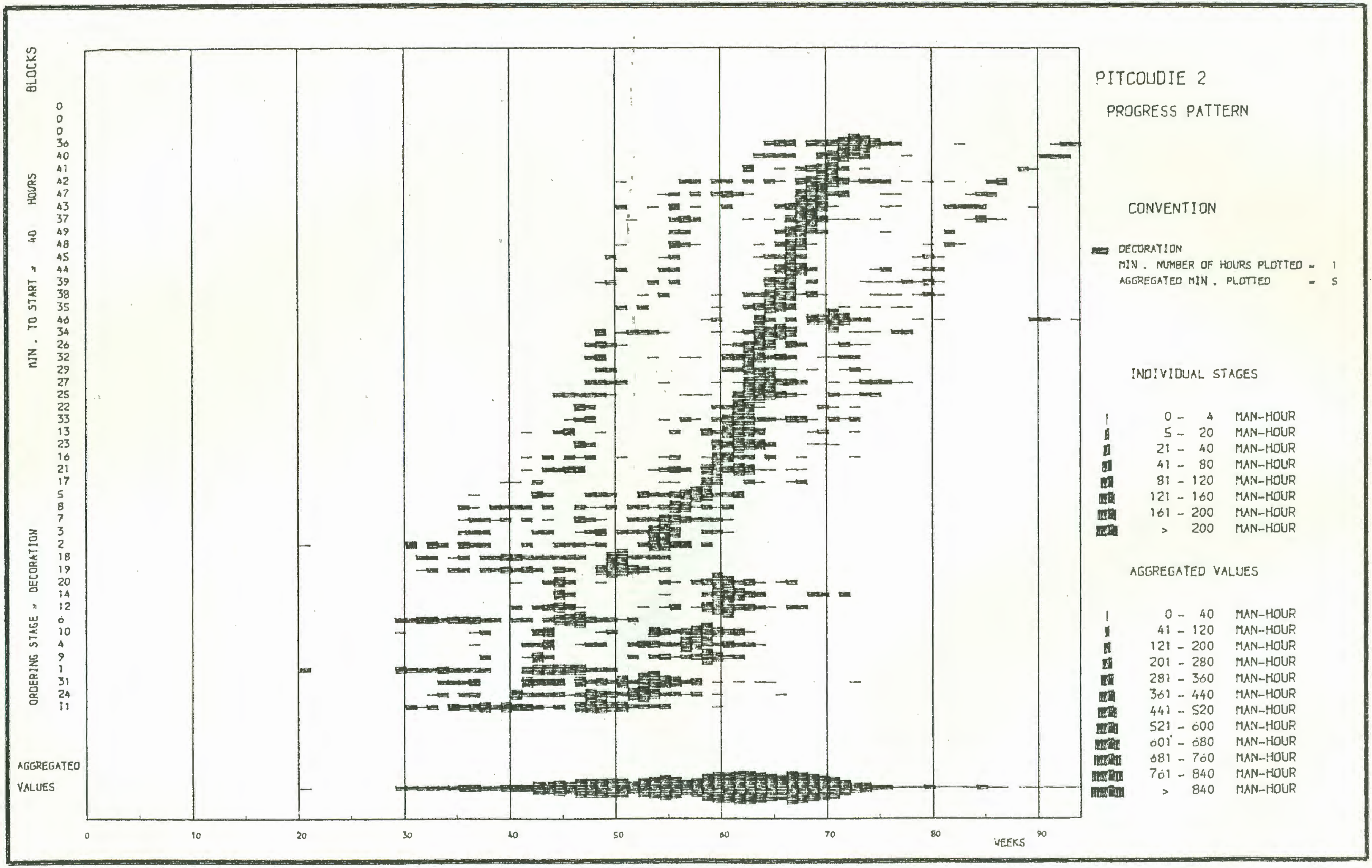
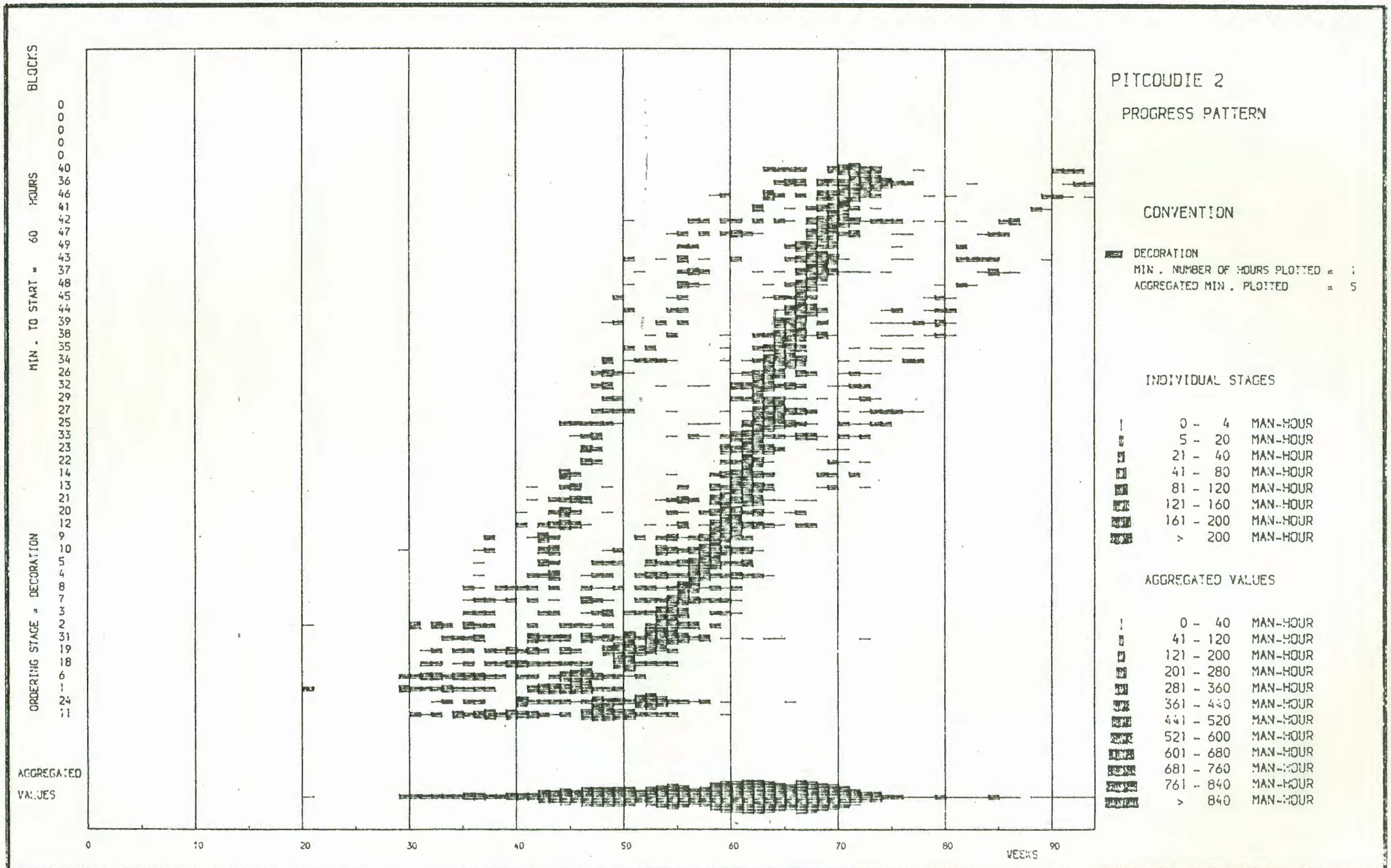
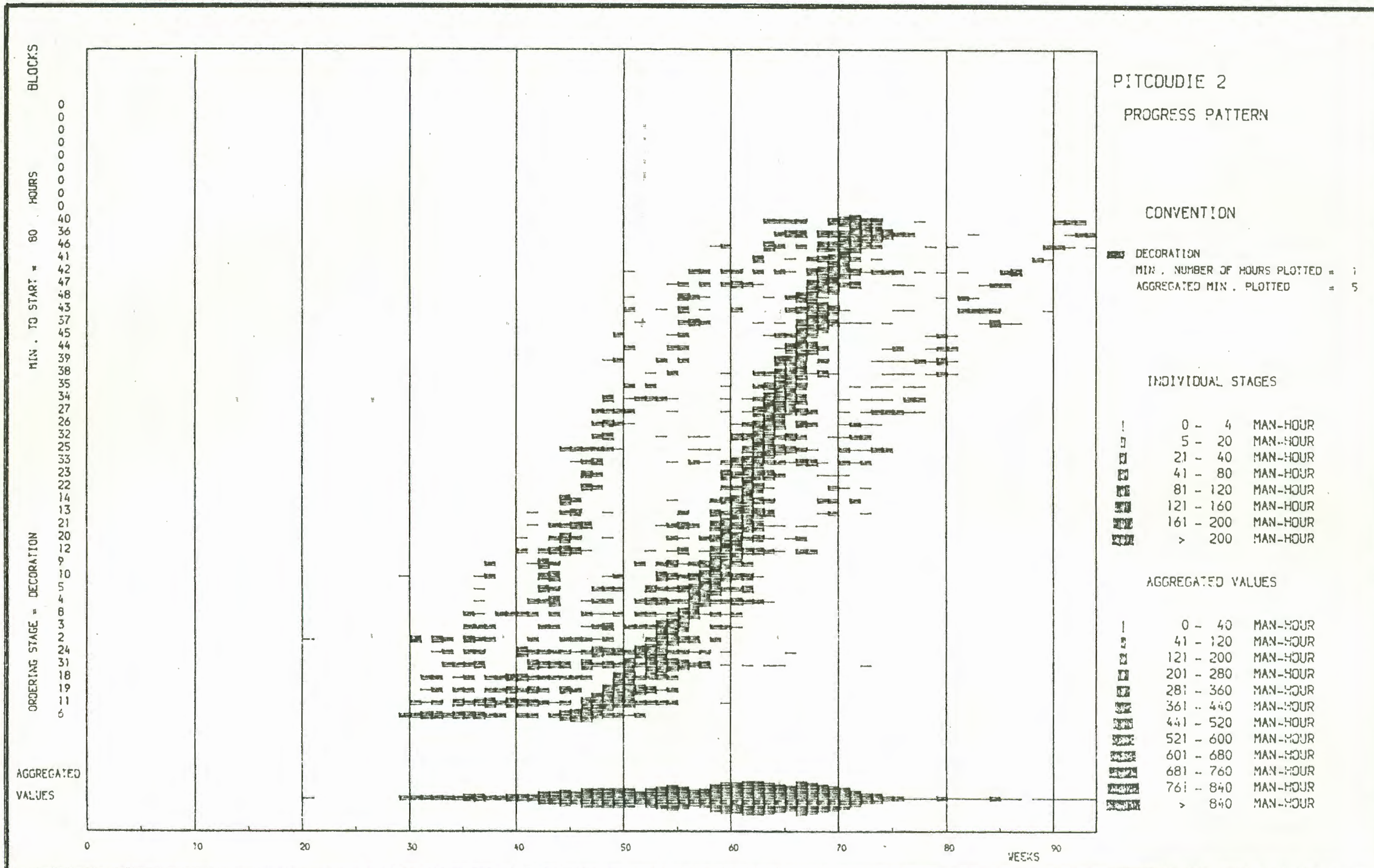

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 40 HOURS
ORDERING STAGE = DECORATION
0 0 0 36 40 41 42 47 43 37 49 48 45 44 39 38 35 46 34 26 32 29 27 25 22 33 13 23 16 21 17 5 8 7 3 2 18 19 20 14 12 6 10 4 9 1 31 24 11
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 43



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 60 HOURS
ORDERING STAGE = DECORATION
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 44



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 80 . HOURS
ORDERING STAGE = DECORATION
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 45

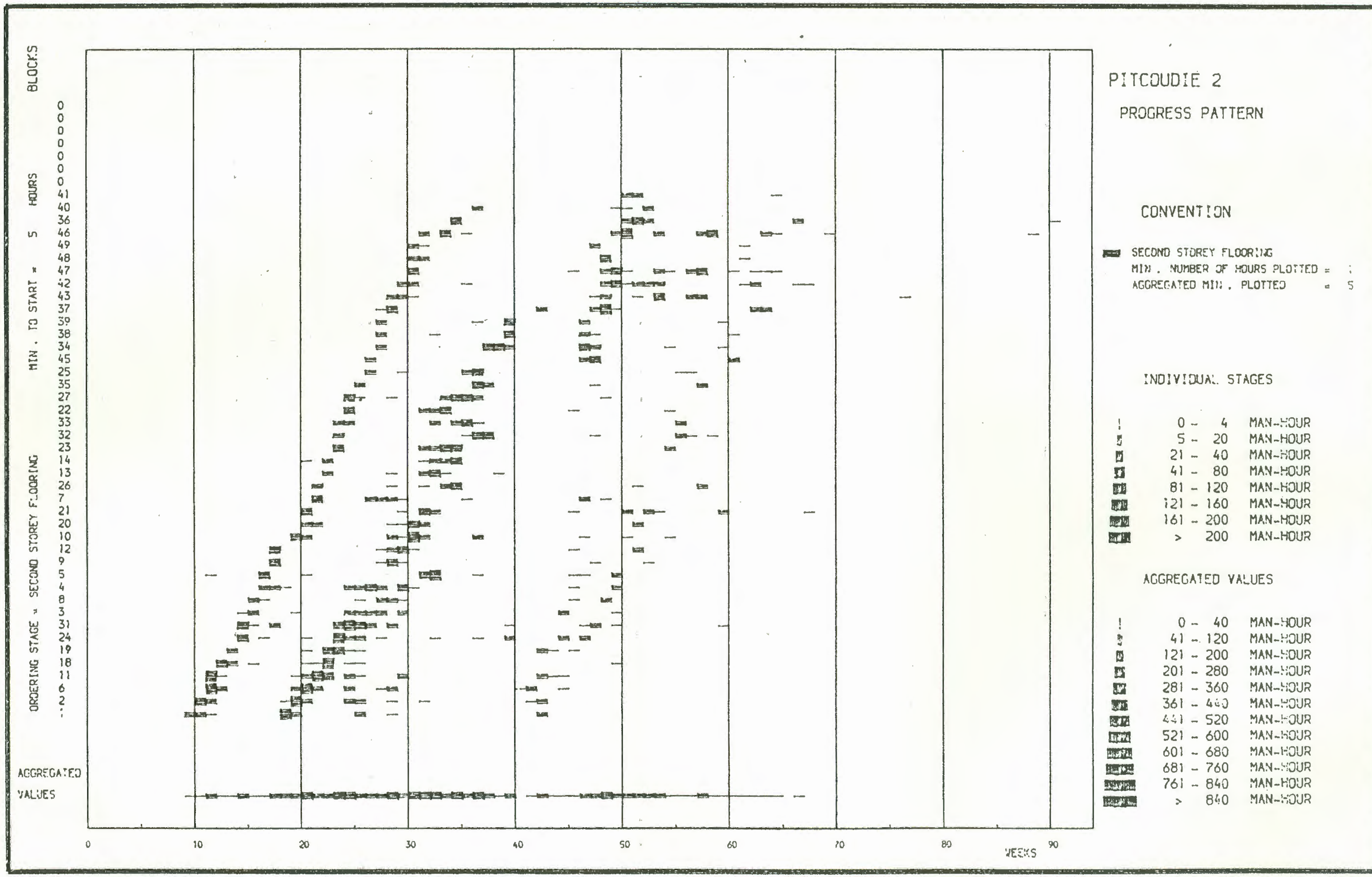

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
SECOND STOREY FLOORING
MIN. NUMBER OF HOURS PLOTTED =
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
ORDERING STAGE = SECOND STOREY FLOORING
MIN. TO START = 5 HOURS
BLOCKS
0 0 0 0 0 0 0 41 40 36 46 49 48 47 42 43 37 39 38 34 45 25 35 27 22 33 32 23 14 13 26 7 21 20 10 12 9 5 4 8 3 31 24 19 18 11 6 2
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 46

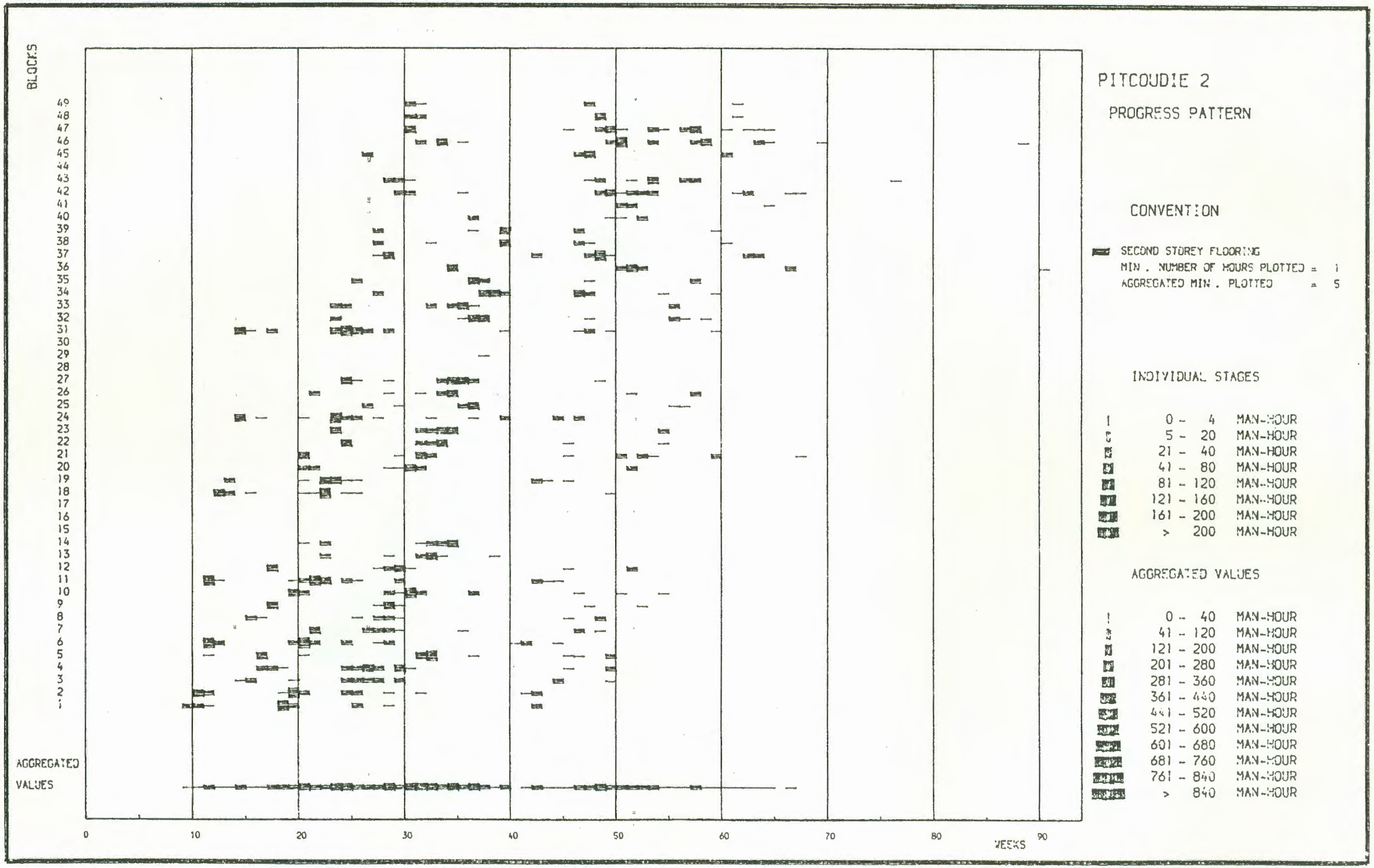

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
SECOND STOREY FLOORING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
AGGREGATED VALUES
WEEKS
0
10
20
30
40
50
60
70
80
90

FIG. 47

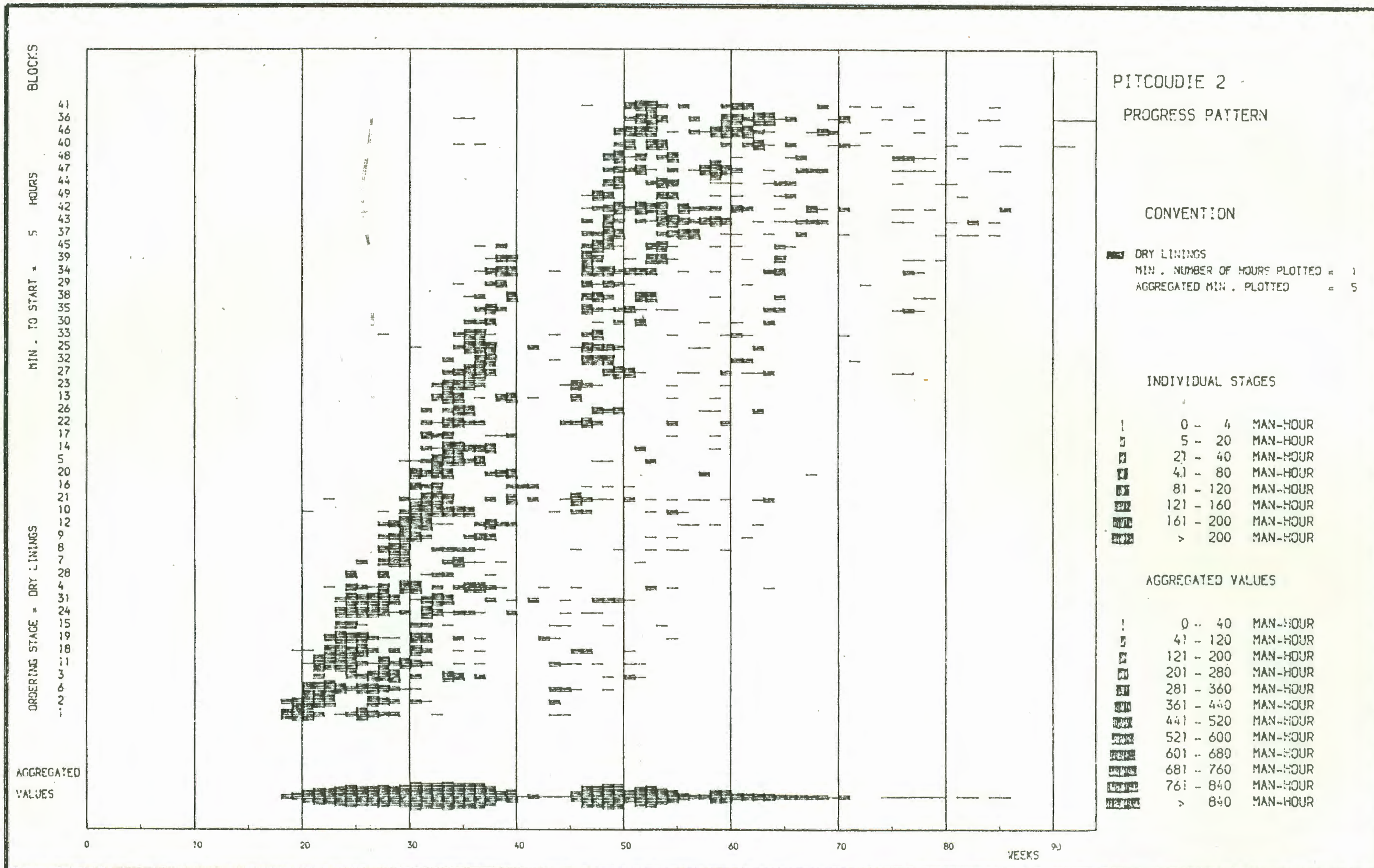

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = DRY LININGS
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 48

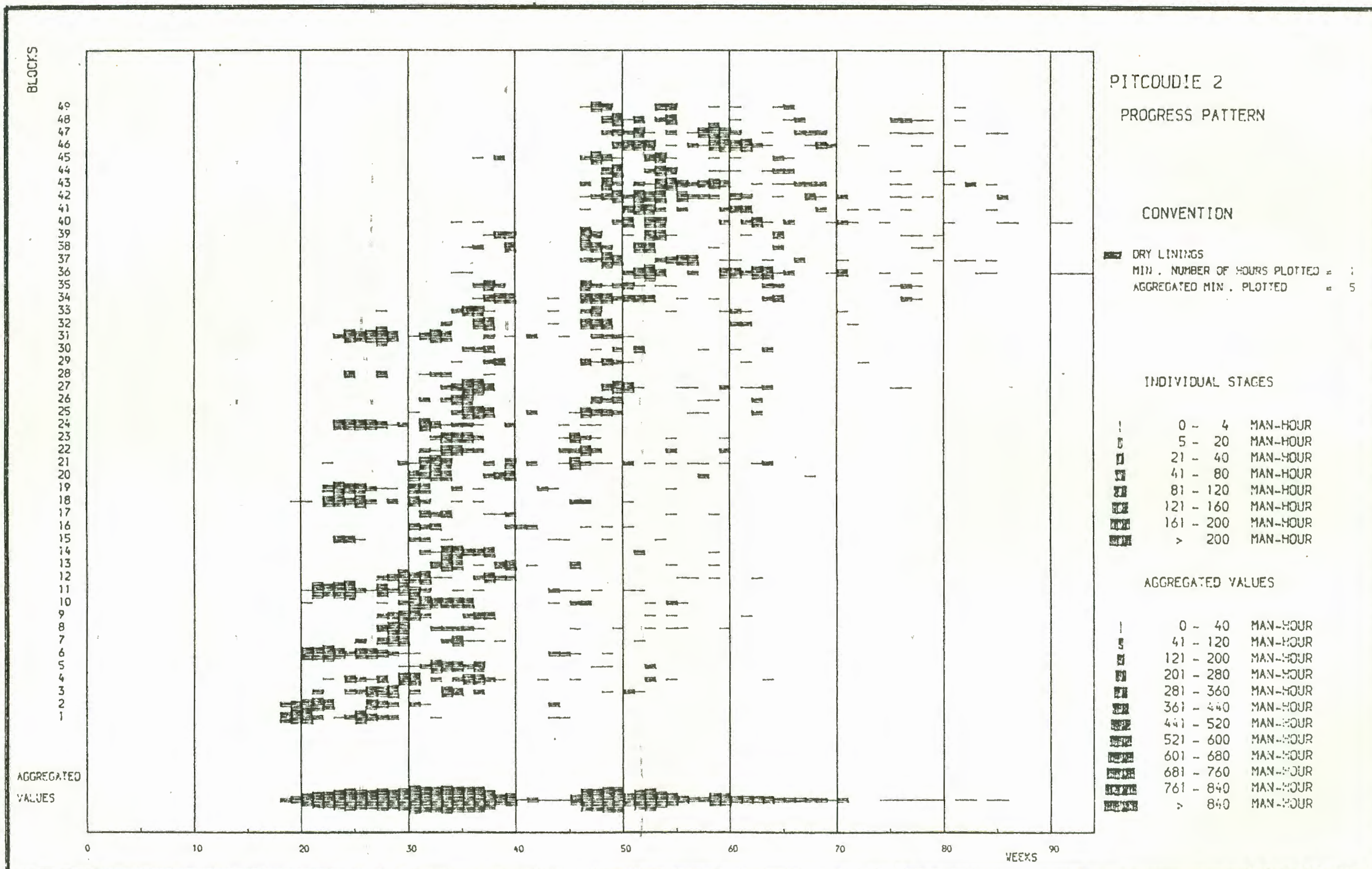
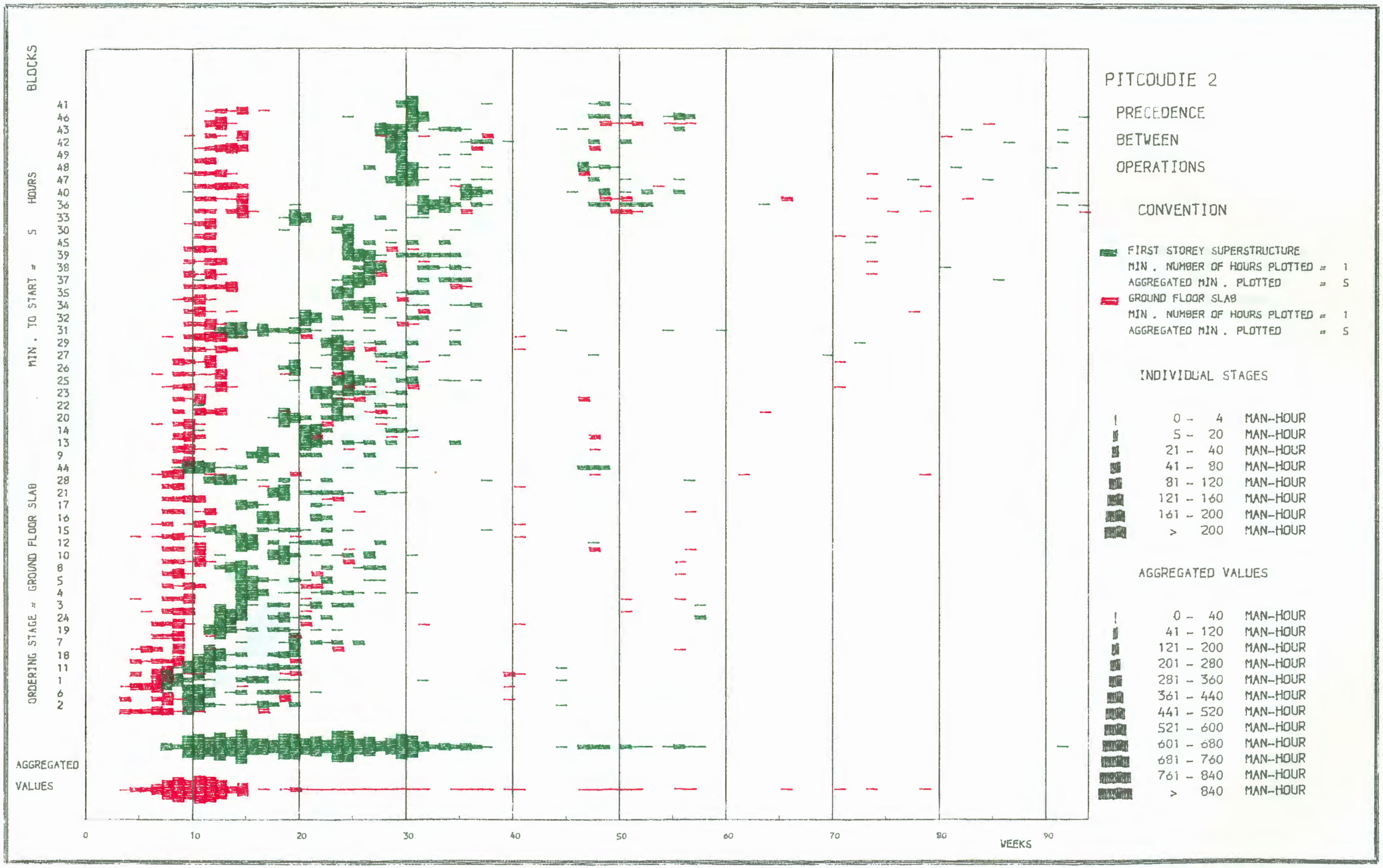

BLOCKS
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DRY LININGS
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 49


PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
FIRST STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
GROUND FLOOR SLAB
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = GROUND FLOOR SLAB
41 46 43 42 49 48 47 40 36 33 30 45 39 38 37 35 34 32 31 29 27 26 25 23 22 20 14 13 9 44 28 21 17 16 15 12 10 8 5 4 3 24 19 7 18 11 1 6 2
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG, 50

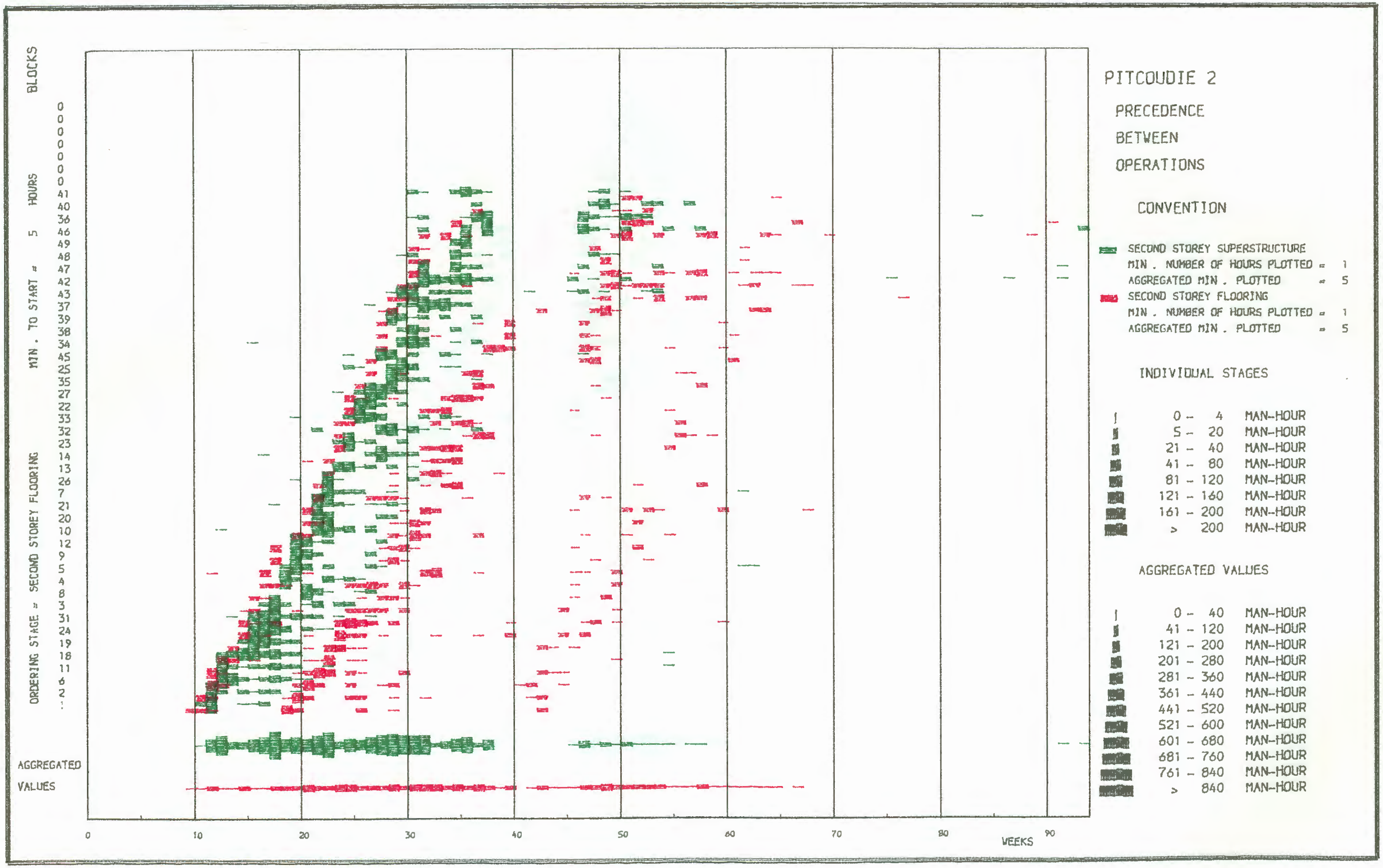

BLOCKS
0
0
0
0
0
0
0
41
40
36
46
49
48
47
42
43
37
39
38
34
45
25
35
27
22
33
32
23
14
13
26
7
21
20
10
12
9
5
4
8
3
31
24
19
18
11
6
2
ORDERING STAGE = SECOND STOREY FLOORING MIN . TO START = 5 HOURS
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
SECOND STOREY FLOORING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR

FIG. 51

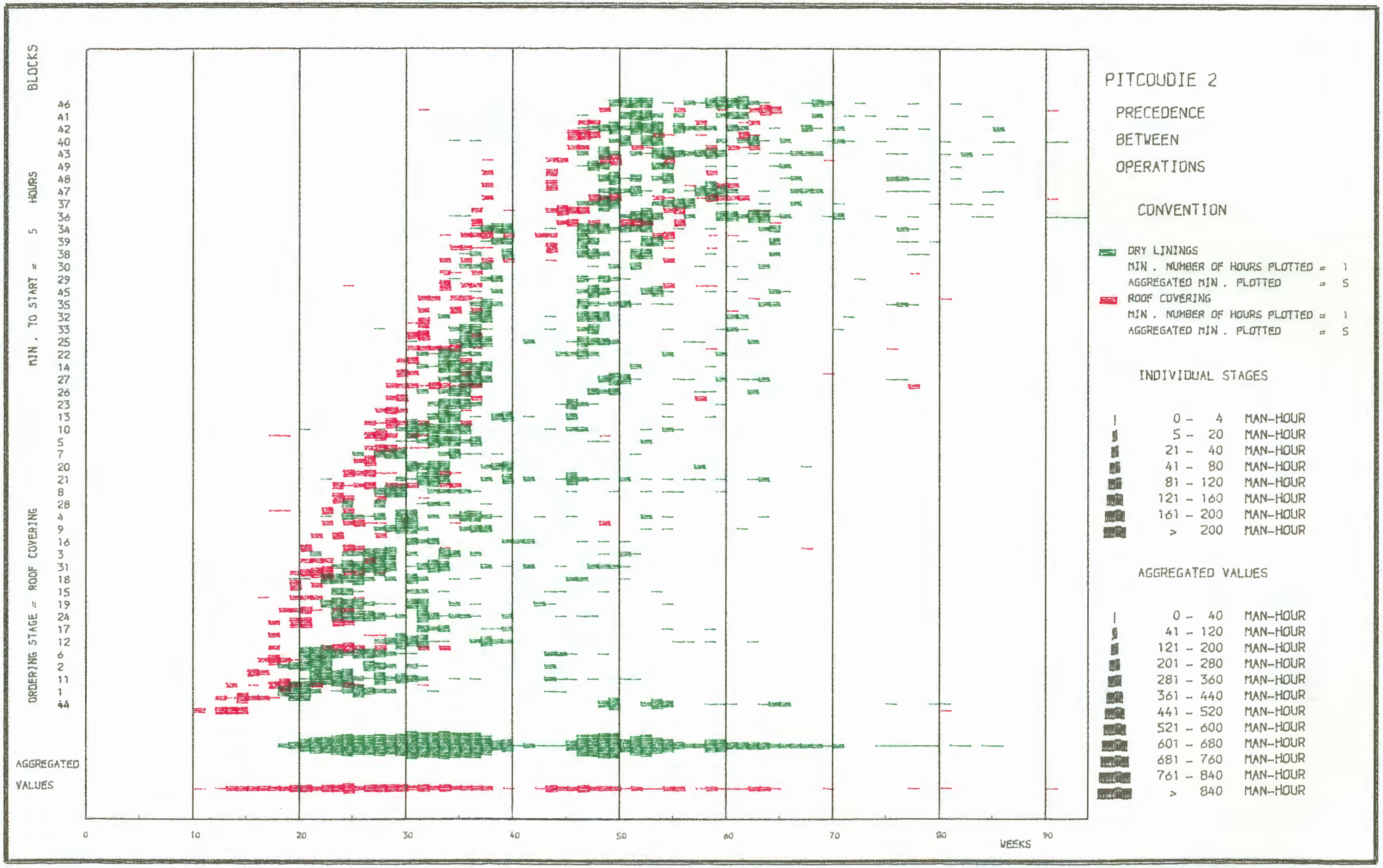

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
ROOF COVERING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = ROOF COVERING
46 41 42 40 43 49 48 47 37 36 34 39 38 30 29 45 35 32 33 25 22 14 27 26 23 13 10 5 7 20 21 8 28 4 9 16 3 31 18 15 19 24 17 12 6 2 11 1 44
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 52

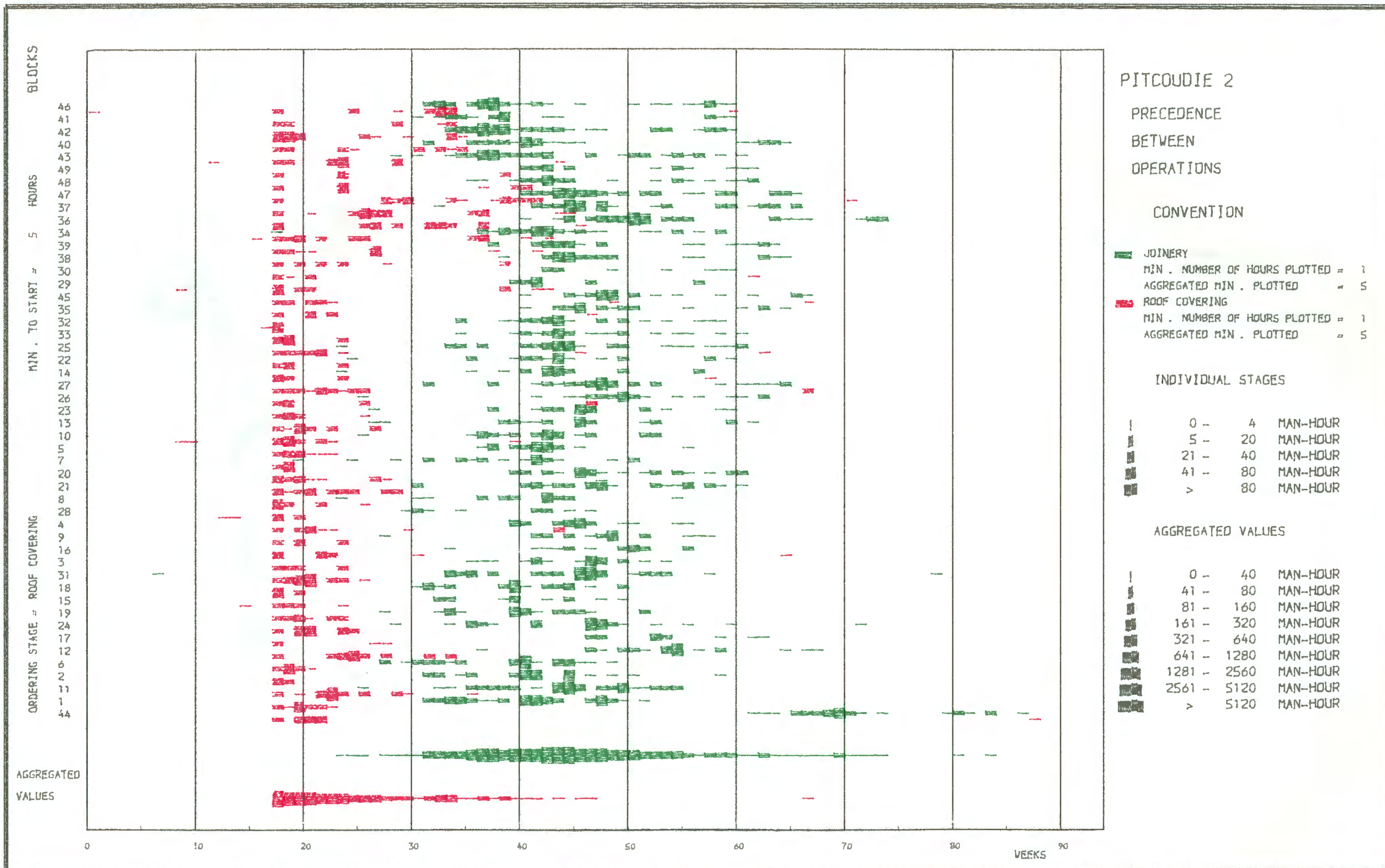
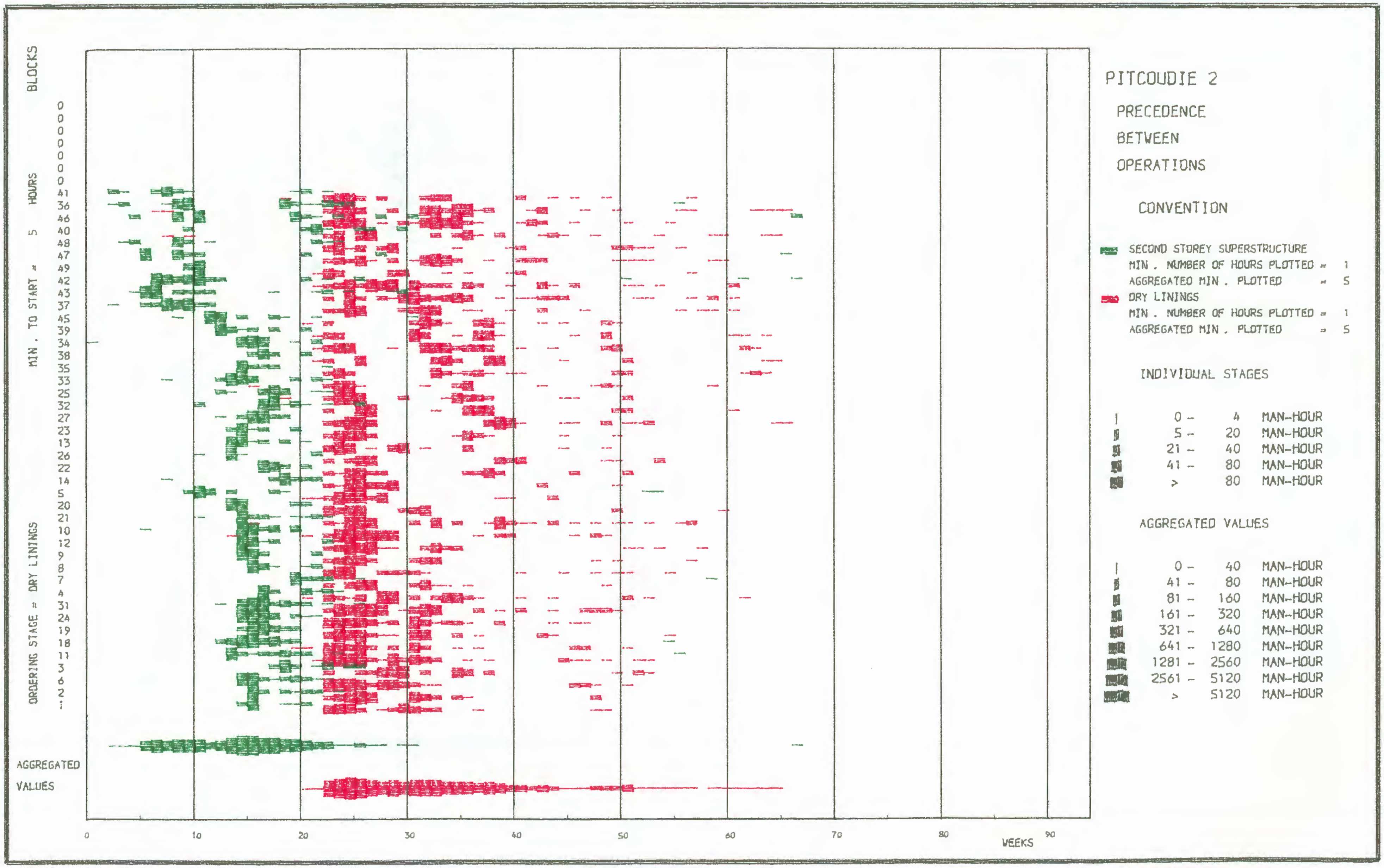
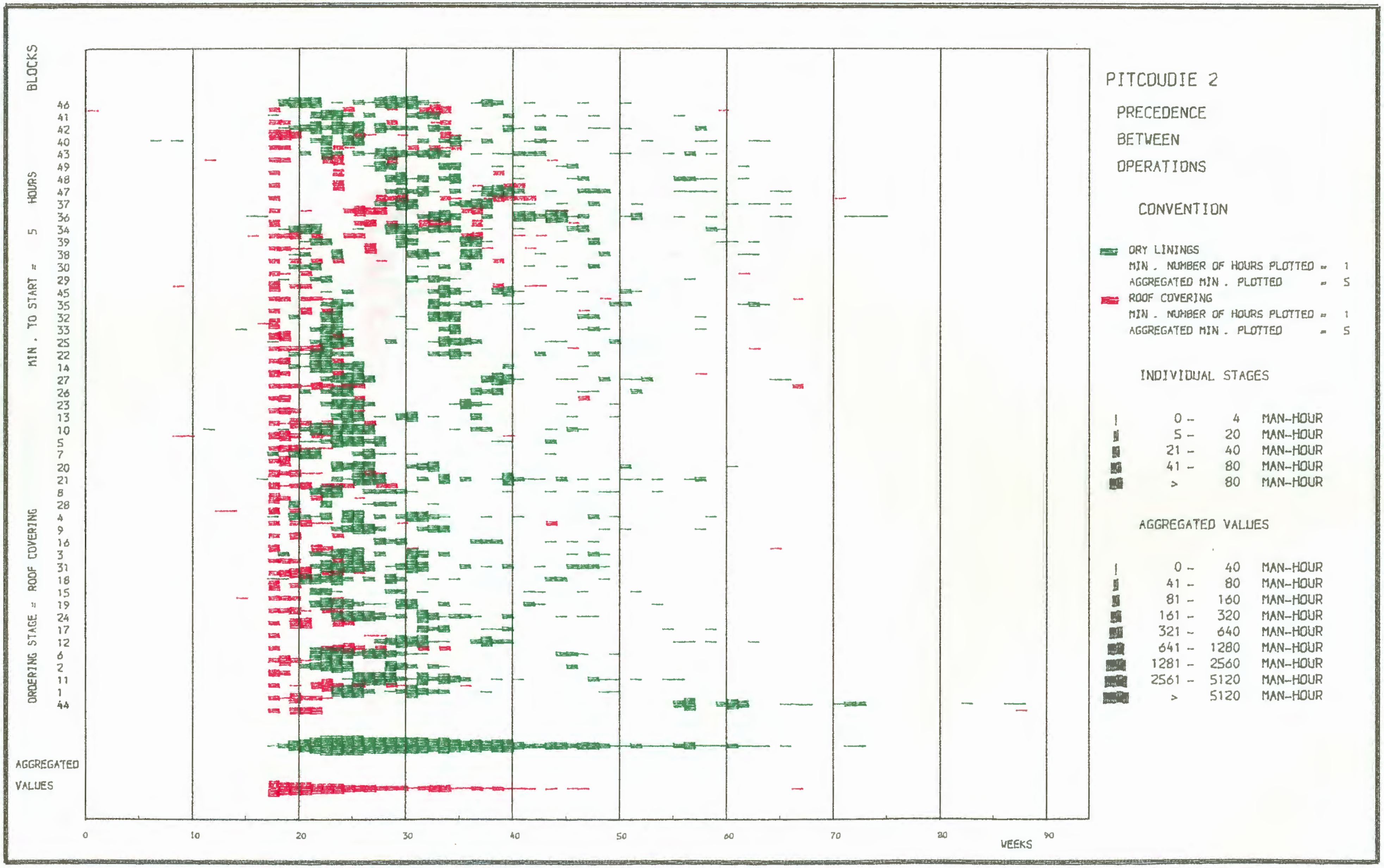

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
JOINERY
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
ROOF COVERING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = ROOF COVERING
MIN . TO START = 5 HOURS
AGGREGATED
VALUES
WEEKS
0
10
20
30
40
50
60
70
80
90

FIG. 53



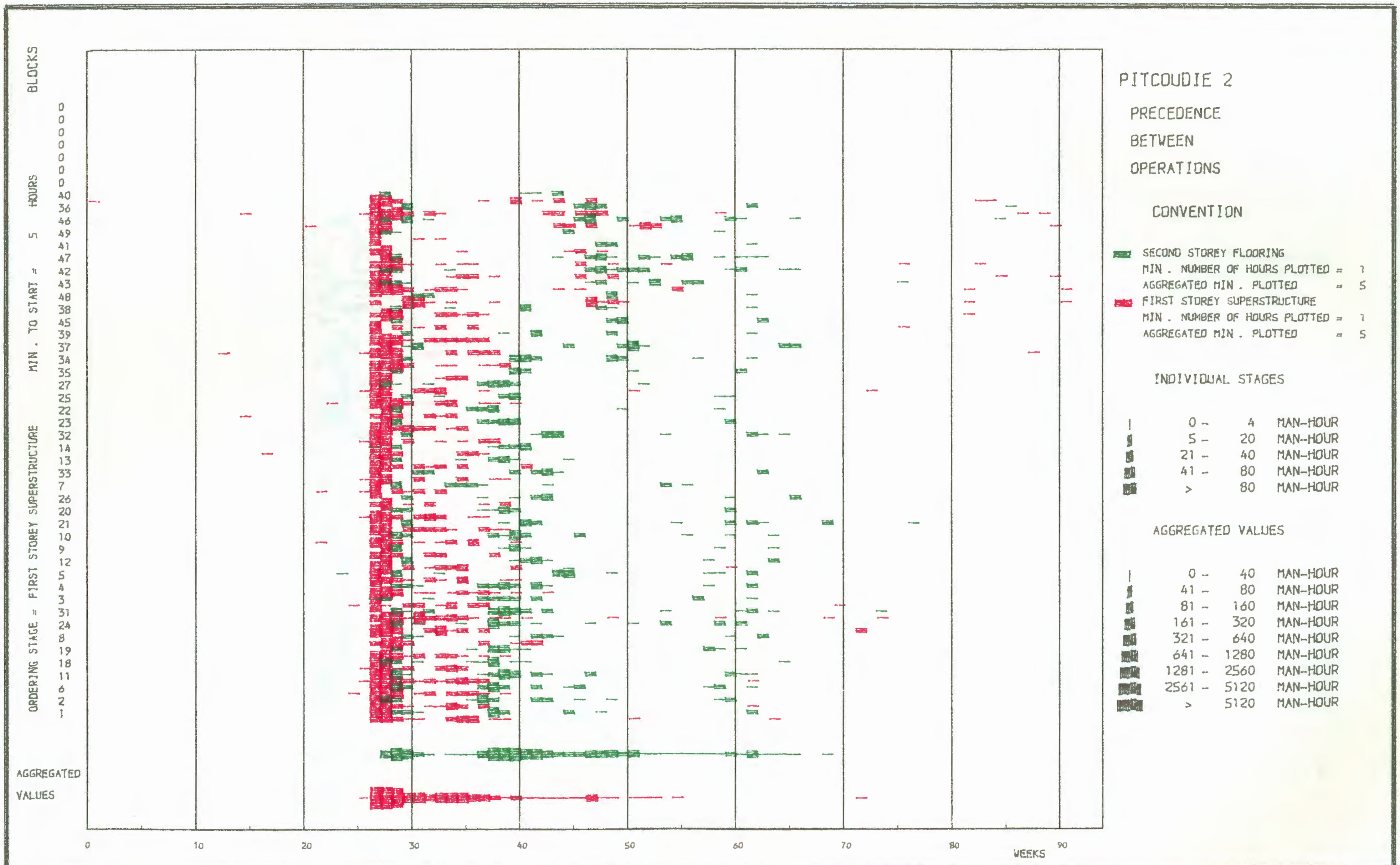
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = DRY LININGS
AGGREGATED
VALUES
WEEKS
0
10
20
30
40
50
60
70
80
90

FIG. 54



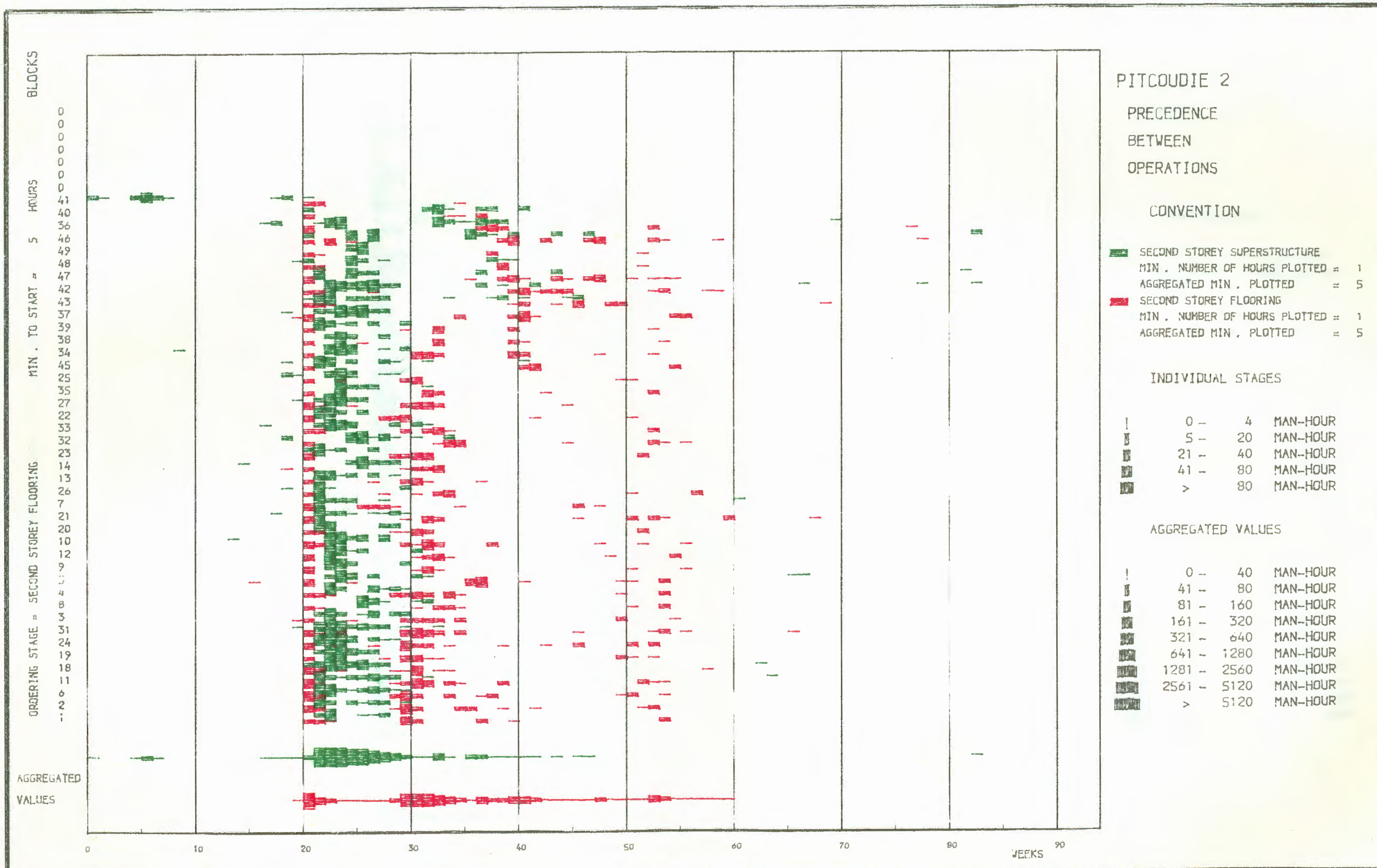
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
ROOF COVERING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = ROOF COVERING MIN . TO START = 5 HOURS
46 41 42 40 43 49 48 47 37 36 34 39 38 30 29 45 35 32 33 25 22 14 27 26 23 13 10 5 7 20 21 8 28 4 9 16 3 31 18 15 19 24 17 12 6 2 11 1 44
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 55



PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY FLOORING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
FIRST STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE MIN . TO START = 5 HOURS
0 0 0 0 0 0 0 40 36 46 49 41 47 42 43 48 38 45 39 37 34 35 27 25 22 23 32 14 13 33 7 26 20 21 10 9 12 5 4 3 31 24 8 19 18 11 6 2 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 56



PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
SECOND STOREY FLOORING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = SECOND STOREY FLOORING MIN . TO START = 5 HOURS
AGGREGATED VALUES
WEEKS
0
10
20
30
40
50
60
70
80
90

FIG. 57

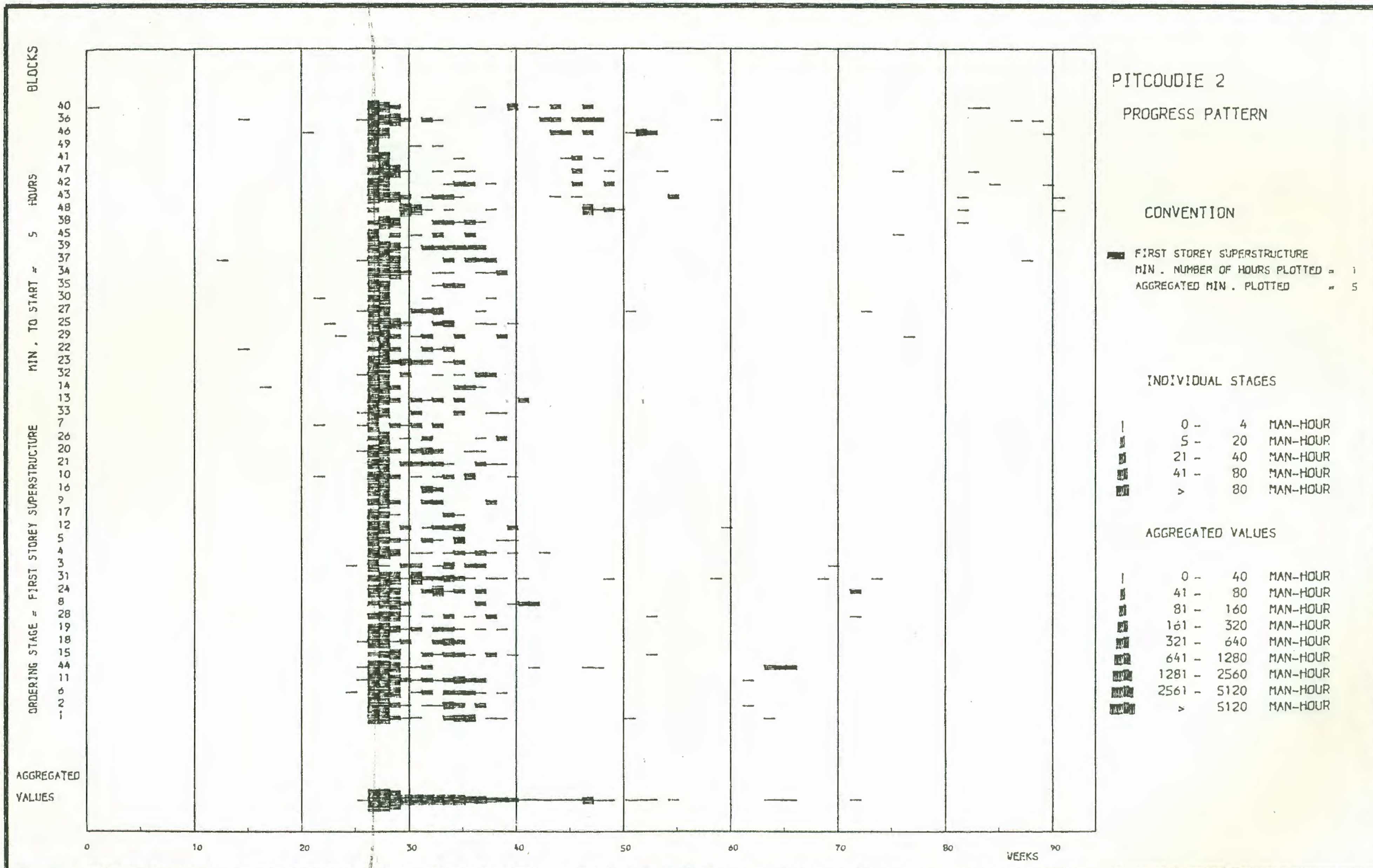

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
FIRST STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = FIRST STOREY SUPERSTRUCTURE MIN . TO START = 5 HOURS
40 36 46 49 41 47 42 43 48 38 45 39 37 34 35 30 27 25 29 22 23 32 14 13 33 7 26 20 21 10 16 9 17 12 5 4 3 31 24 8 28 19 18 15 44 11 6 2 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 58

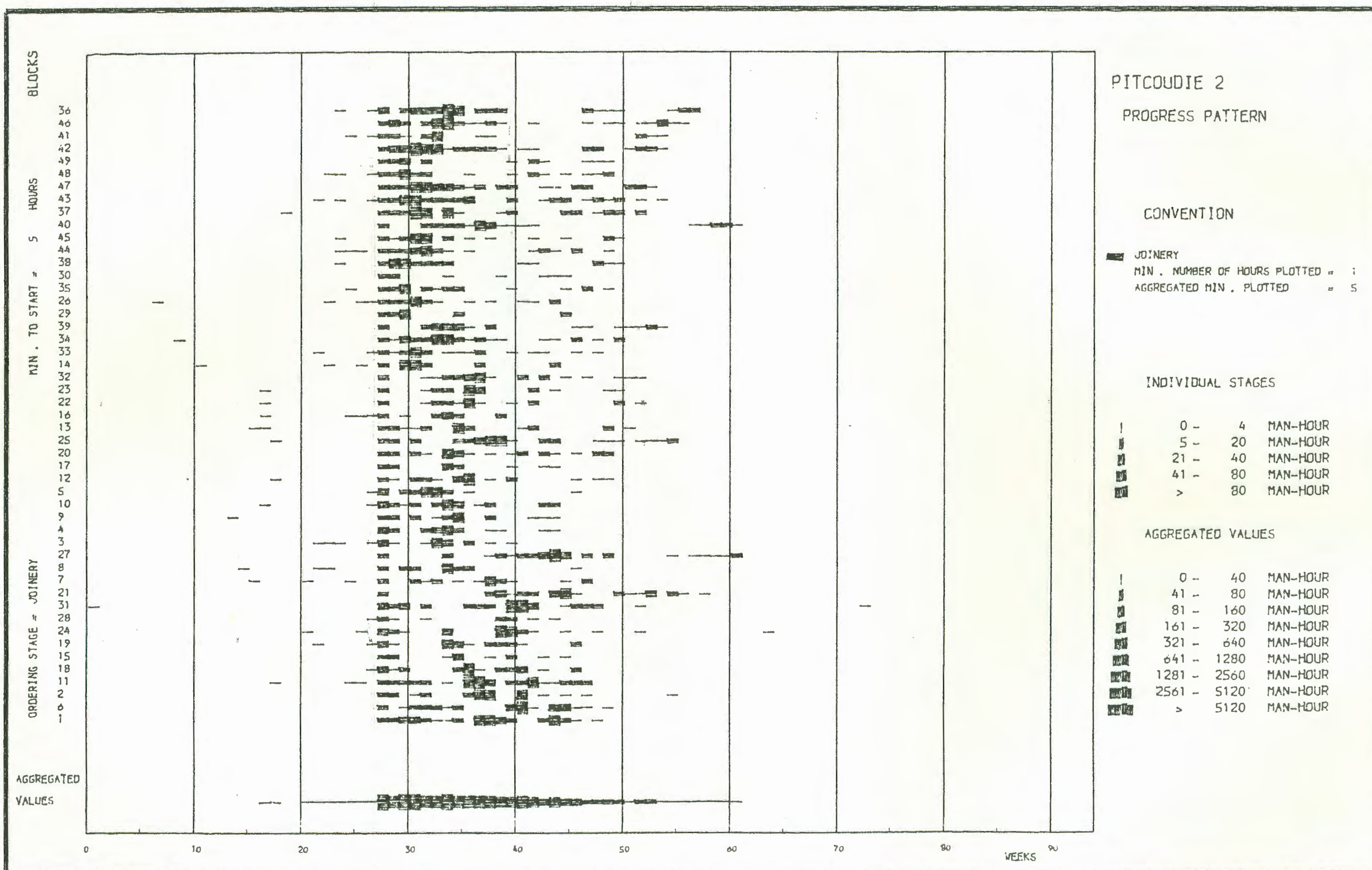

BLOCKS
ORDERING STAGE = JOINERY
MIN. TO START = 5 HOURS
36 46 41 42 49 48 47 43 37 40 45 44 38 30 35 26 29 39 34 33 14 32 23 22 16 13 25 20 17 12 5 10 9 4 3 27 8 7 21 31 28 24 19 15 18 11 2 6 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
JOINERY
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 59

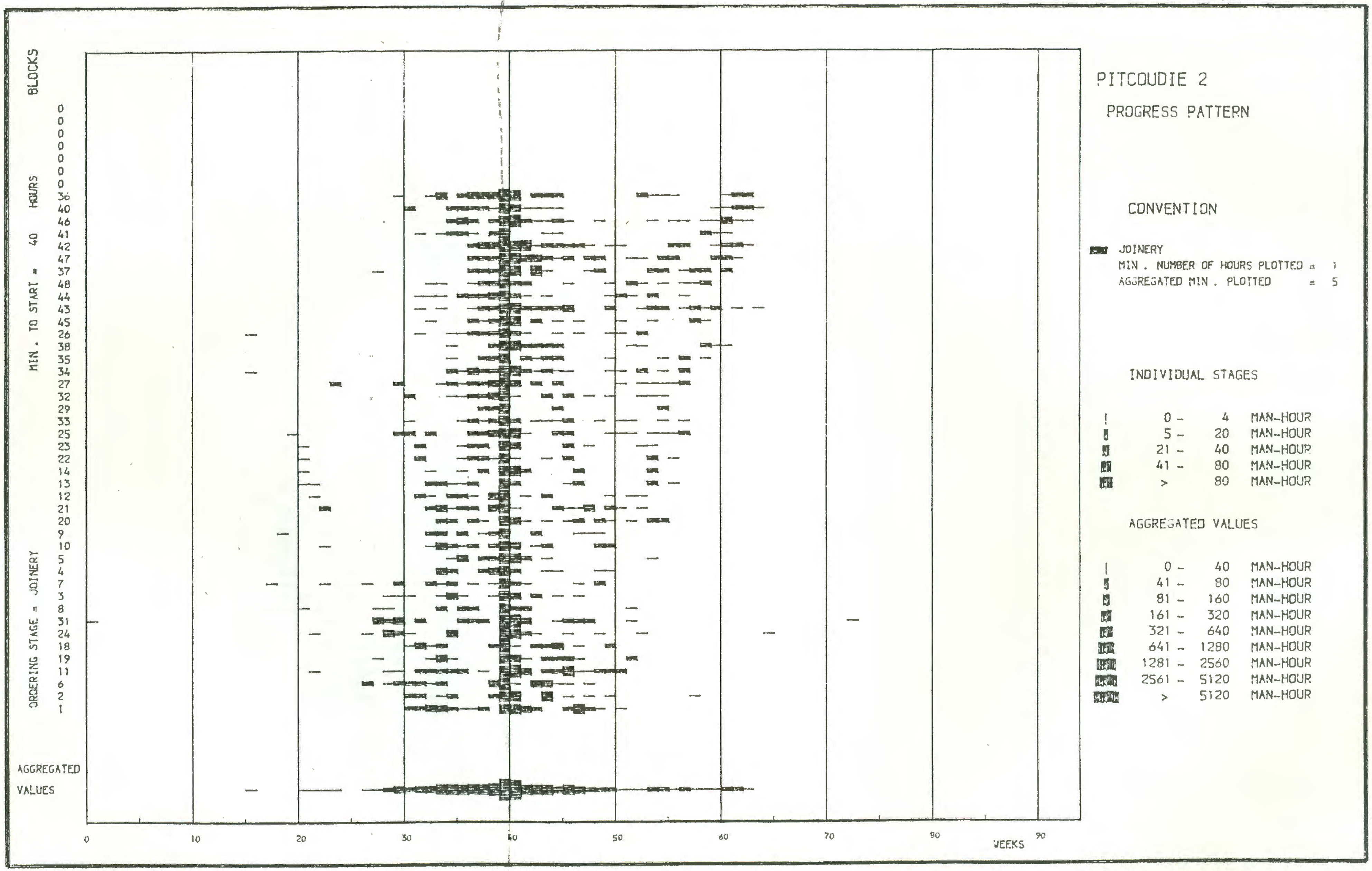
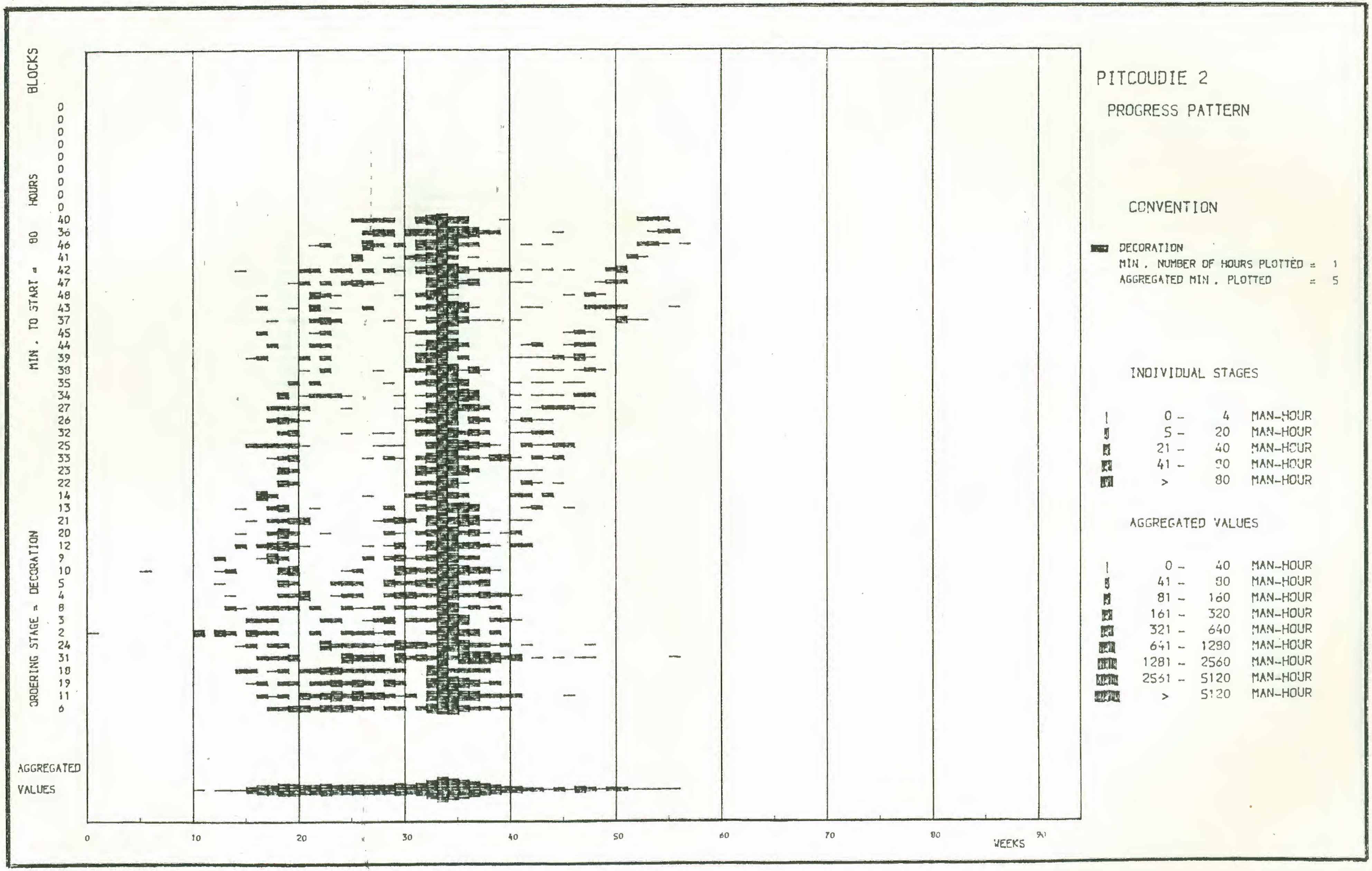

PITCOUDIE 2
PROGRESS PATTERN
BLOCKS
ORDERING STAGE = JOINERY
MIN. TO START = 40 HOURS
0
0
0
0
0
0
0
36
40
46
41
42
47
37
48
44
43
45
26
38
35
34
27
32
29
33
25
23
22
14
13
12
21
20
9
10
5
4
7
3
8
31
24
18
19
11
6
2
1
AGGREGATED VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
CONVENTION
JOINERY
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 60



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 80 HOURS
ORDERING STAGE = DECORATION
AGGREGATED VALUES
WEEKS

FIG. 61

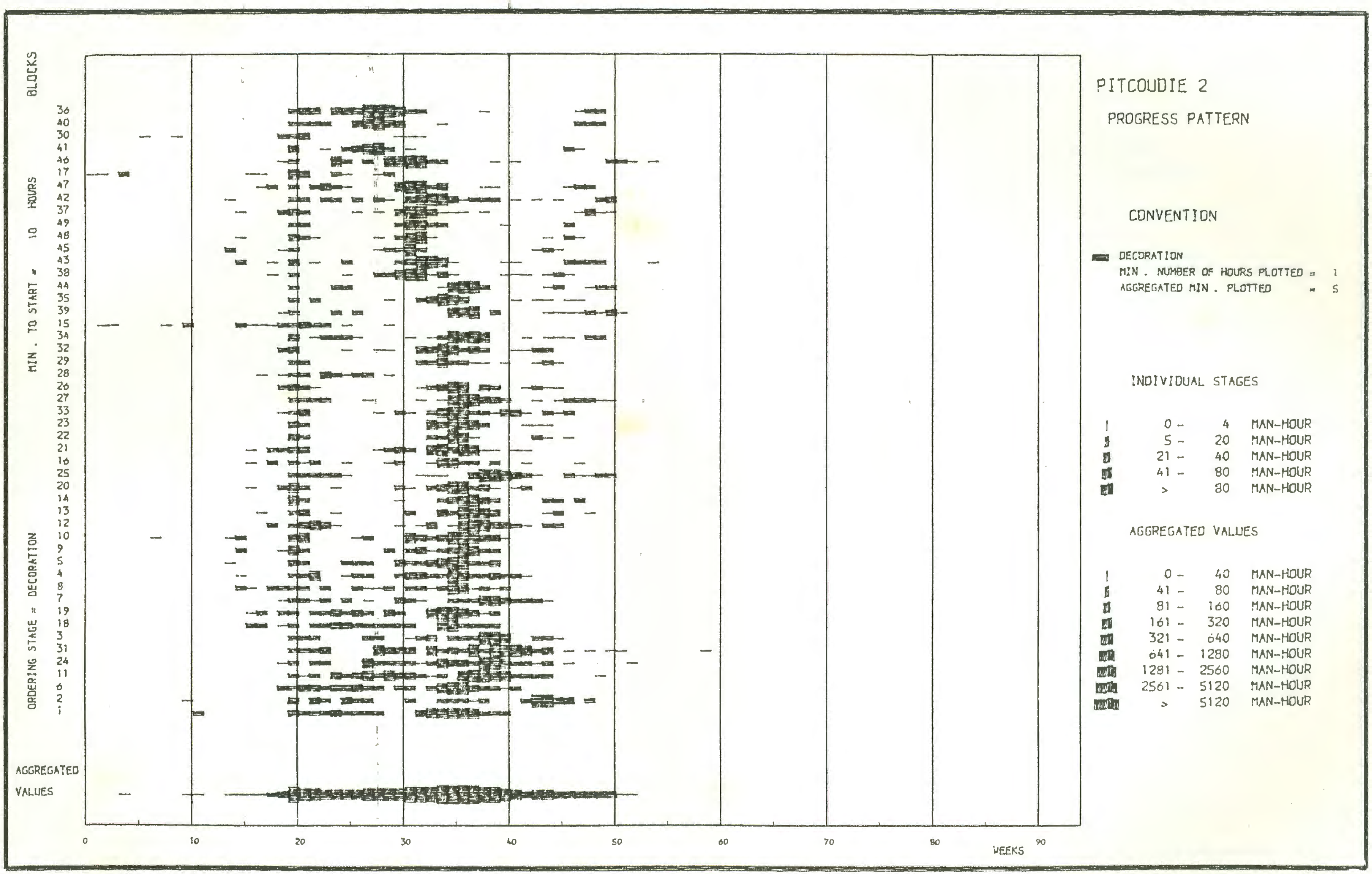

PITCOUDIE 2
PROGRESS PATTERN
BLOCKS
MIN. TO START = 10 HOURS
ORDERING STAGE = DECORATION
36 40 30 41 46 17 47 42 37 49 48 45 43 38 44 35 39 15 34 32 29 28 26 27 33 23 22 21 16 25 20 14 13 12 10 9 5 4 8 7 19 18 3 31 24 11 6 2 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
CONVENTION
DECORATION
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 62

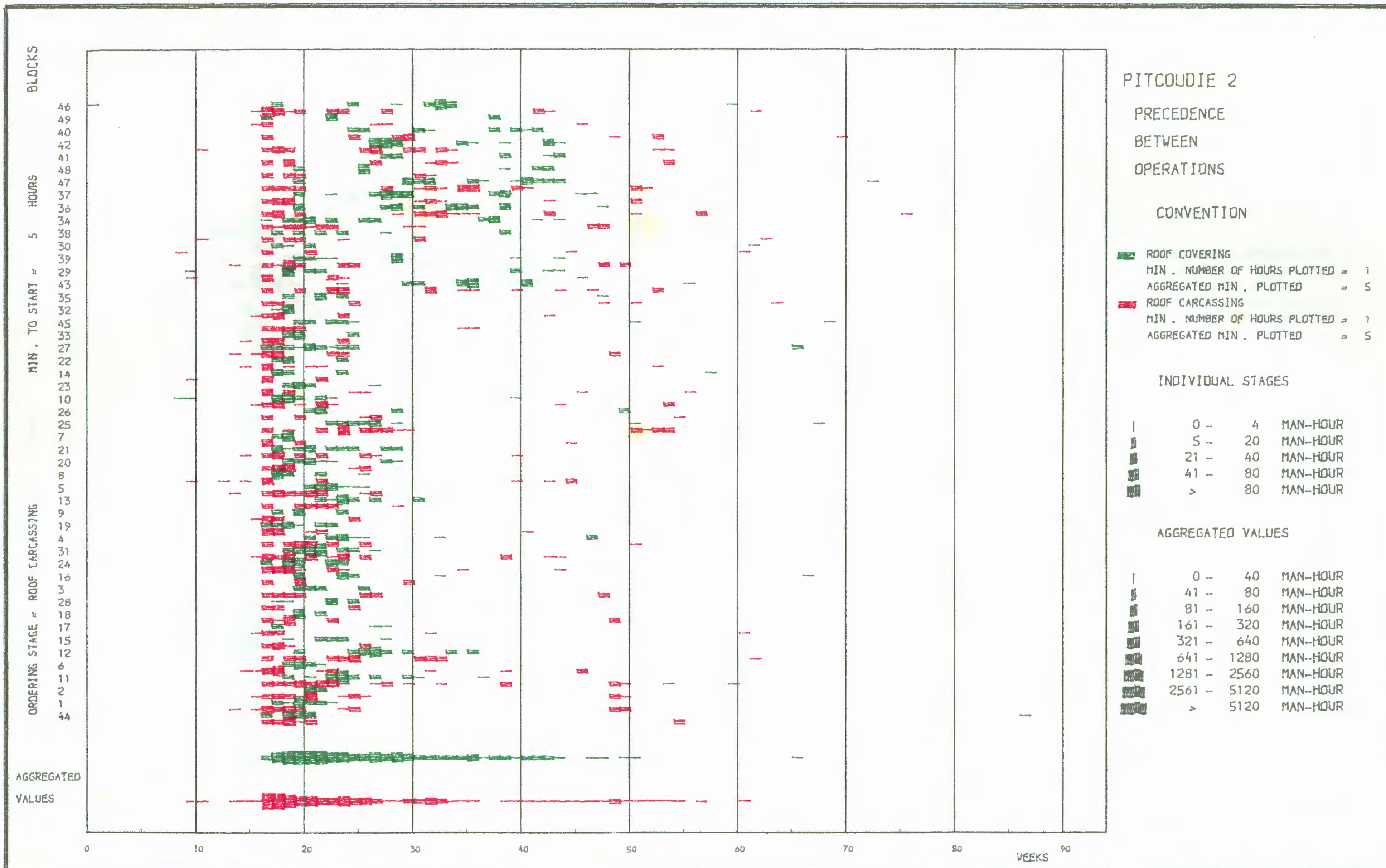
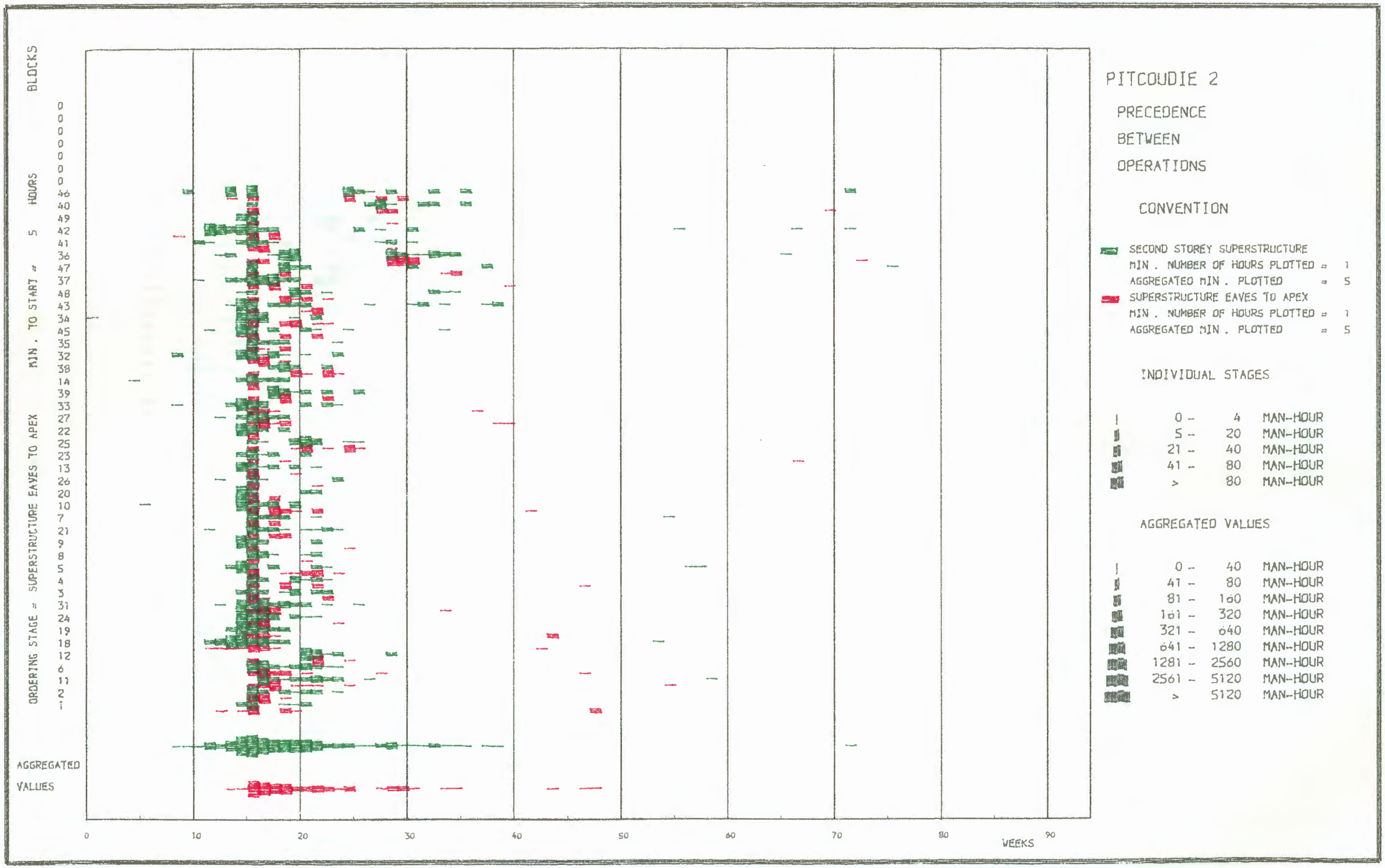

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
ROOF COVERING
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
ROOF CARCASSING
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = ROOF CARCASSING MIN. TO START = 5 HOURS
46 49 40 42 41 48 47 37 36 34 38 30 39 29 43 35 32 45 33 27 22 14 23 10 26 25 7 21 20 8 5 13 9 19 4 31 24 16 3 28 18 17 15 12 6 11 2 1 44
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 63



ORDERING STAGE = SUPERSTRUCTURE EAVES TO APEX
MIN . TO START = 5 HOURS
BLOCKS
0
0
0
0
0
0
0
46
40
49
42
41
36
47
37
48
43
34
45
35
32
38
14
39
33
27
22
25
23
13
26
20
10
7
21
9
8
5
4
3
31
24
19
18
12
6
11
2
1
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY SUPERSTRUCTURE
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
SUPERSTRUCTURE EAVES TO APEX
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 64

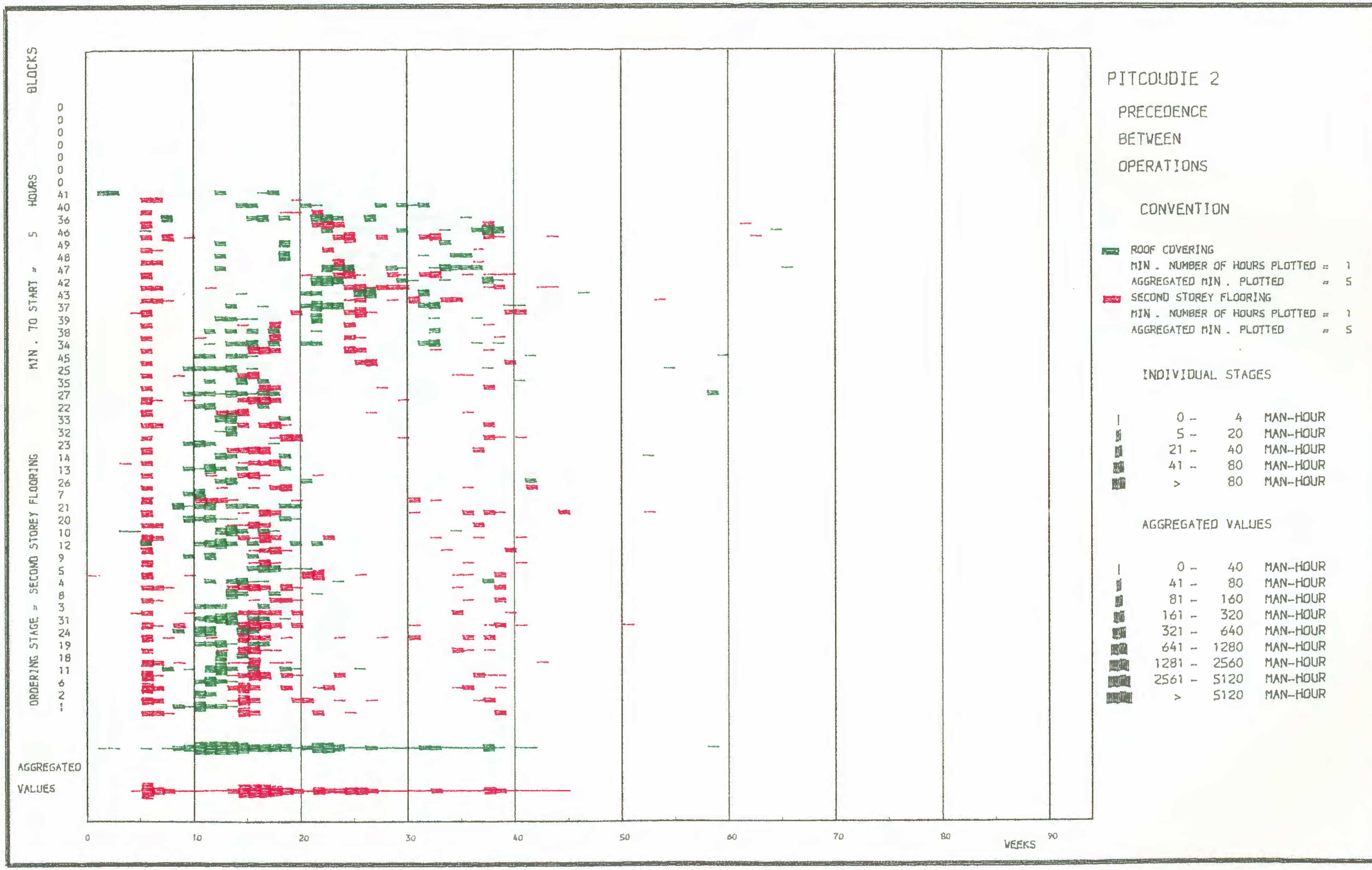

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
ROOF COVERING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
SECOND STOREY FLOORING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = SECOND STOREY FLOORING
AGGREGATED
VALUES
WEEKS
0
10
20
30
40
50
60
70
80
90

FIG. 65

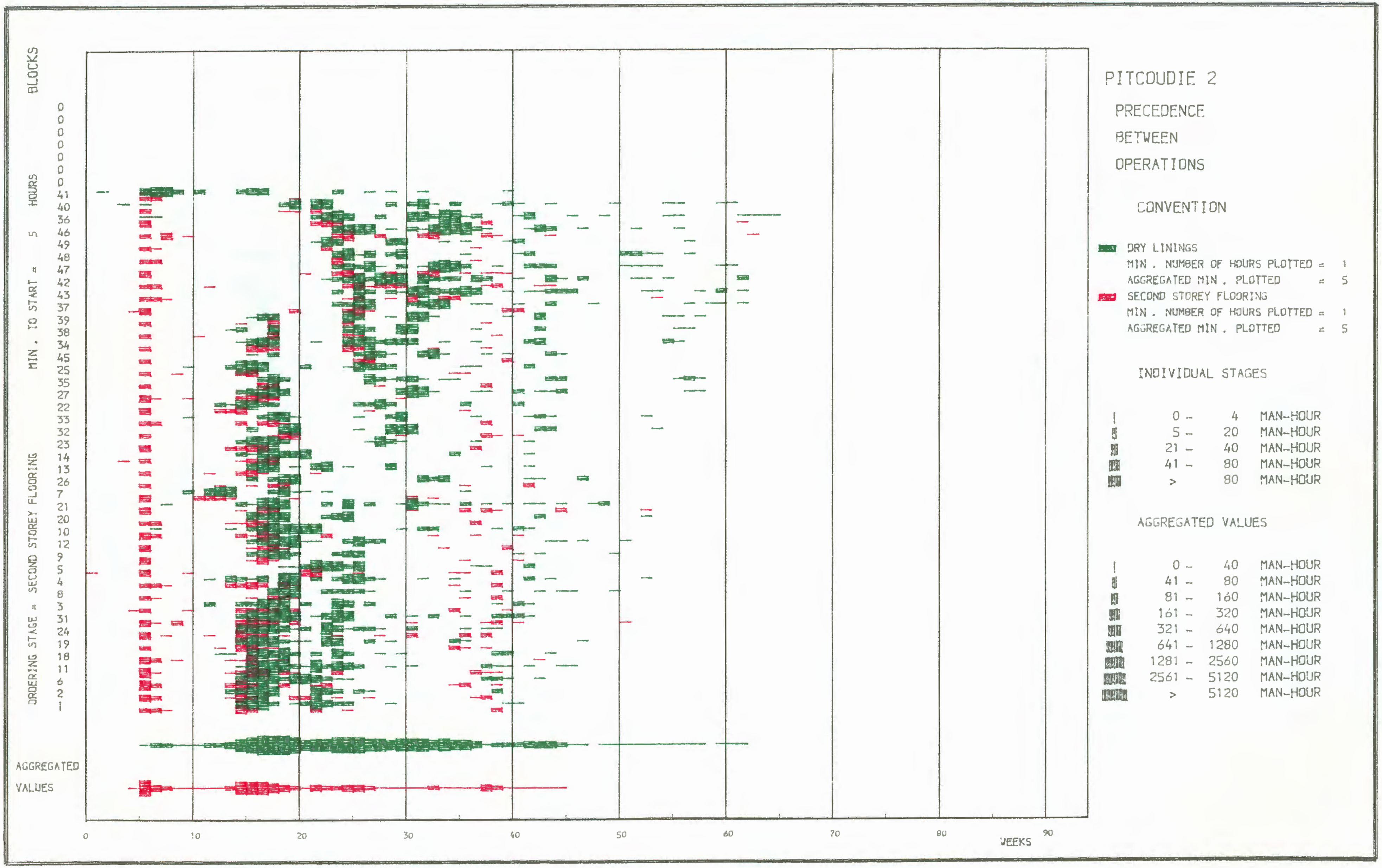

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DRY LININGS
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
SECOND STOREY FLOORING
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = SECOND STOREY FLOORING
MIN. TO START = 5 HOURS
0 0 0 0 0 0 0 41 40 36 46 49 48 47 42 43 37 39 38 34 45 25 35 27 22 33 32 23 14 13 26 7 21 20 10 12 9 5 4 8 3 31 24 19 18 11 6 2 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 66

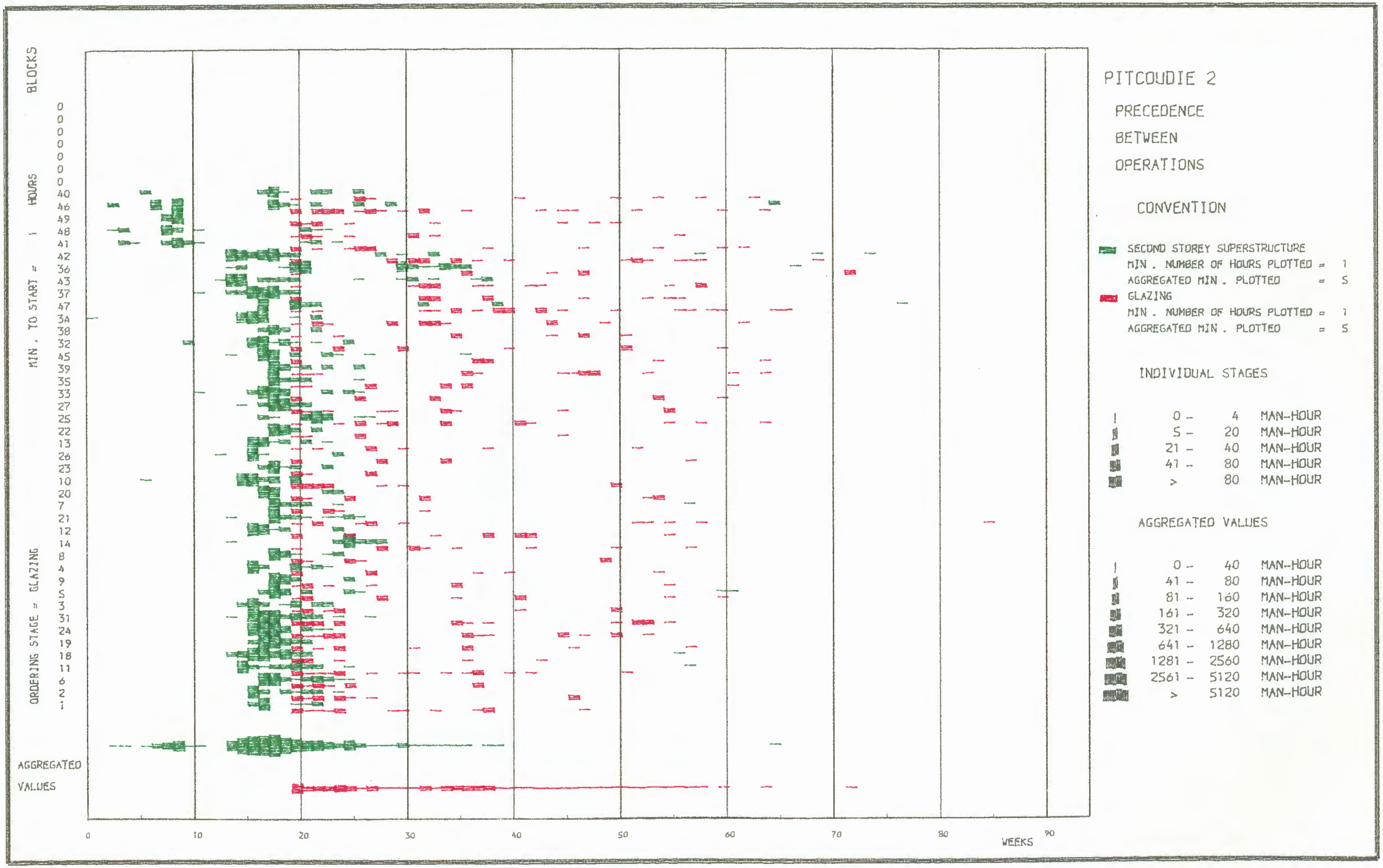
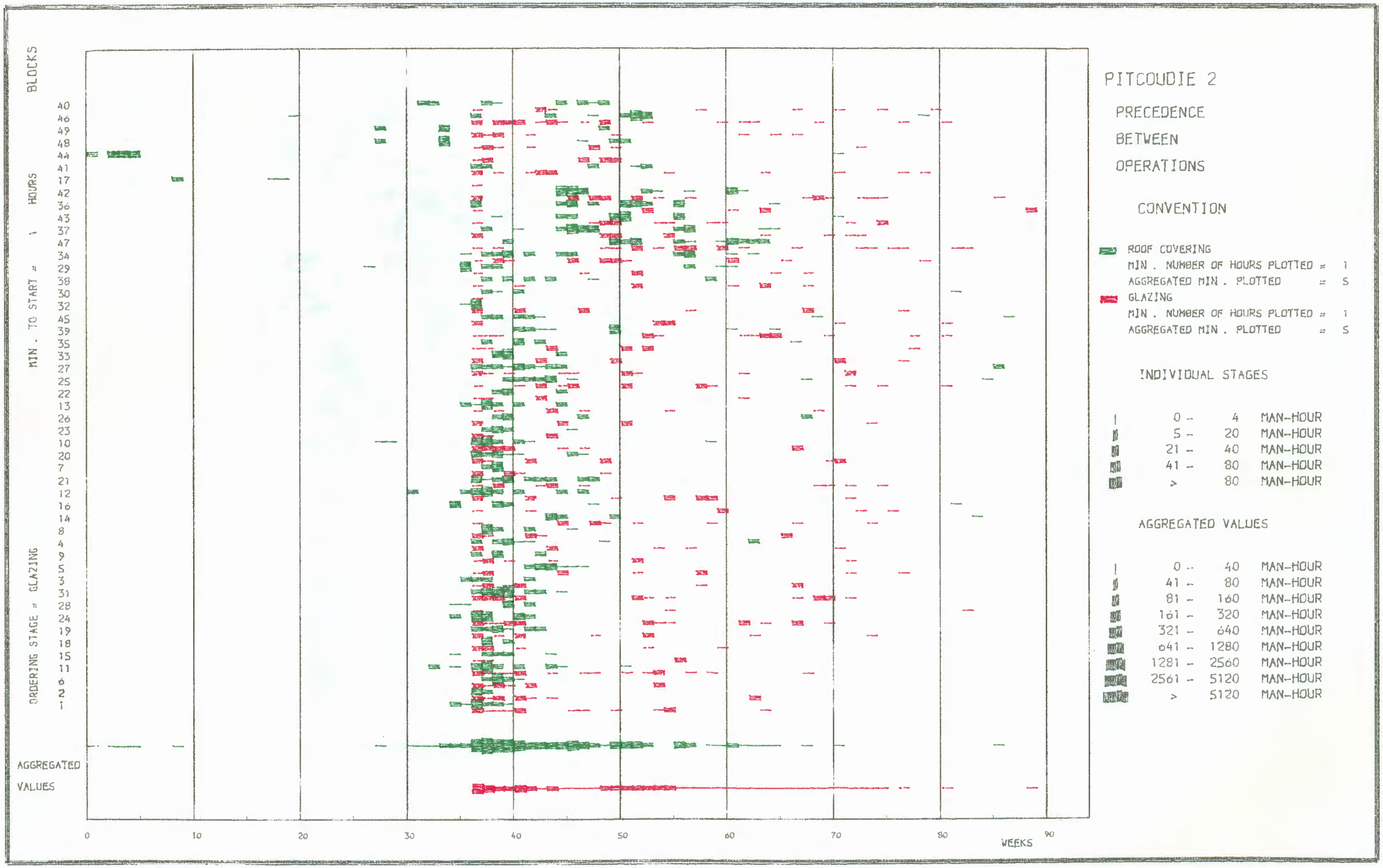

BLOCKS
MIN. TO START = 1 HOURS
ORDERING STAGE = GLAZING
0
0
0
0
0
0
0
40
46
49
48
41
42
36
43
37
47
34
38
32
45
39
35
33
27
25
22
13
26
23
10
20
7
21
12
14
8
4
9
5
3
31
24
19
18
11
6
2
1
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
SECOND STOREY SUPERSTRUCTURE
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
GLAZING
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 67



BLOCKS
40
46
49
48
44
41
17
42
36
43
37
47
34
29
38
30
32
45
39
35
33
27
25
22
13
26
23
10
20
7
21
12
16
14
8
4
9
5
3
31
28
24
19
18
15
11
6
2
1
MIN . TO START = 1 HOURS
ORDERING STAGE = GLAZING
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
ROOF COVERING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
GLAZING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 68

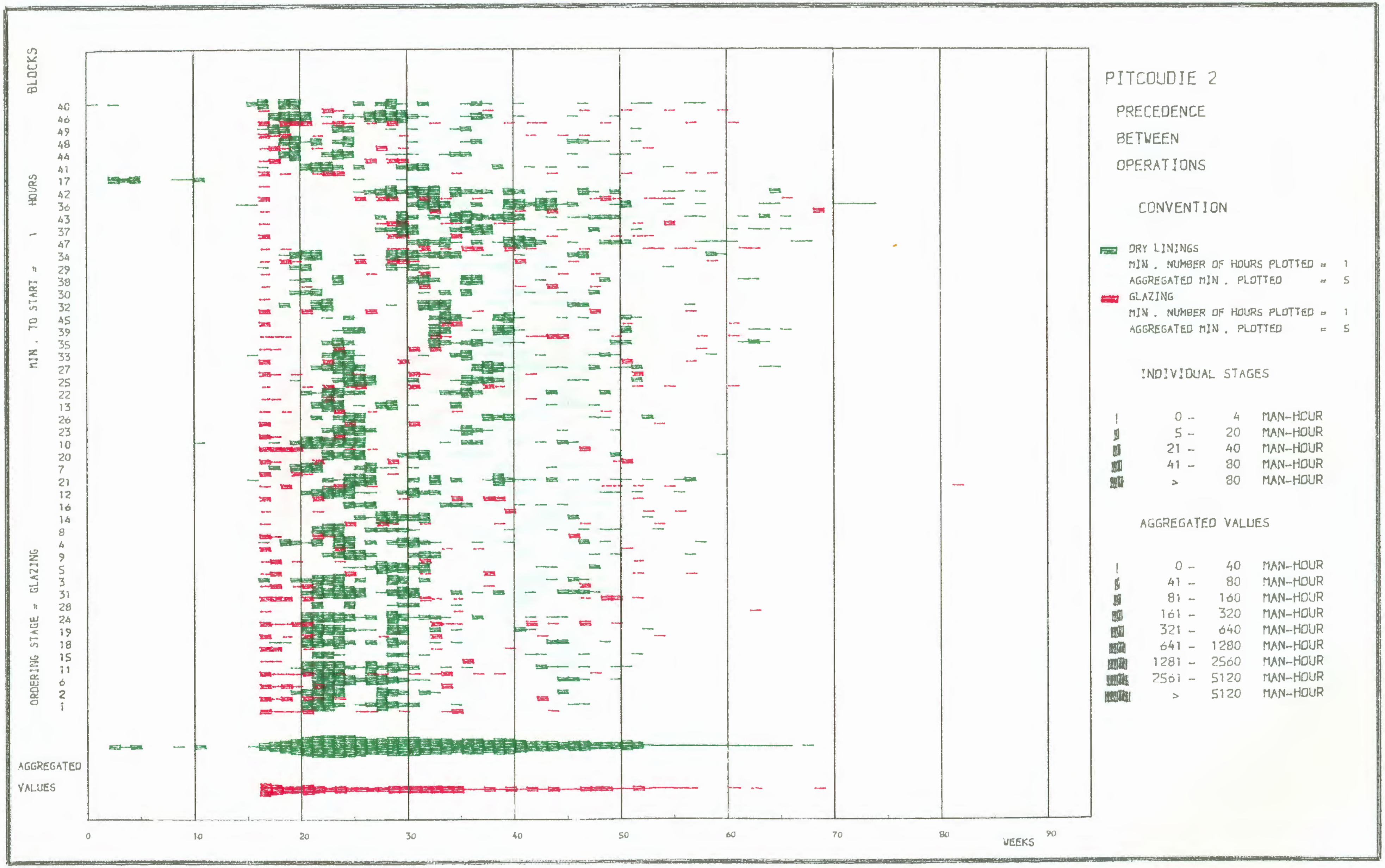

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
GLAZING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = GLAZING MIN . TO START = 1 HOURS
40 46 49 48 44 41 17 42 36 43 37 47 34 29 38 30 32 45 39 35 33 27 25 22 13 26 23 10 20 7 21 12 16 14 8 4 9 5 3 31 28 24 19 18 15 11 6 2 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 69


PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
JOINERY
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = DRY LININGS
41 36 46 40 48 47 44 49 42 43 37 45 39 34 29 38 35 30 33 25 32 27 23 13 26 22 17 14 5 20 16 21 10 12 9 8 7 28 4 31 24 15 19 18 11 3 6 2 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 70

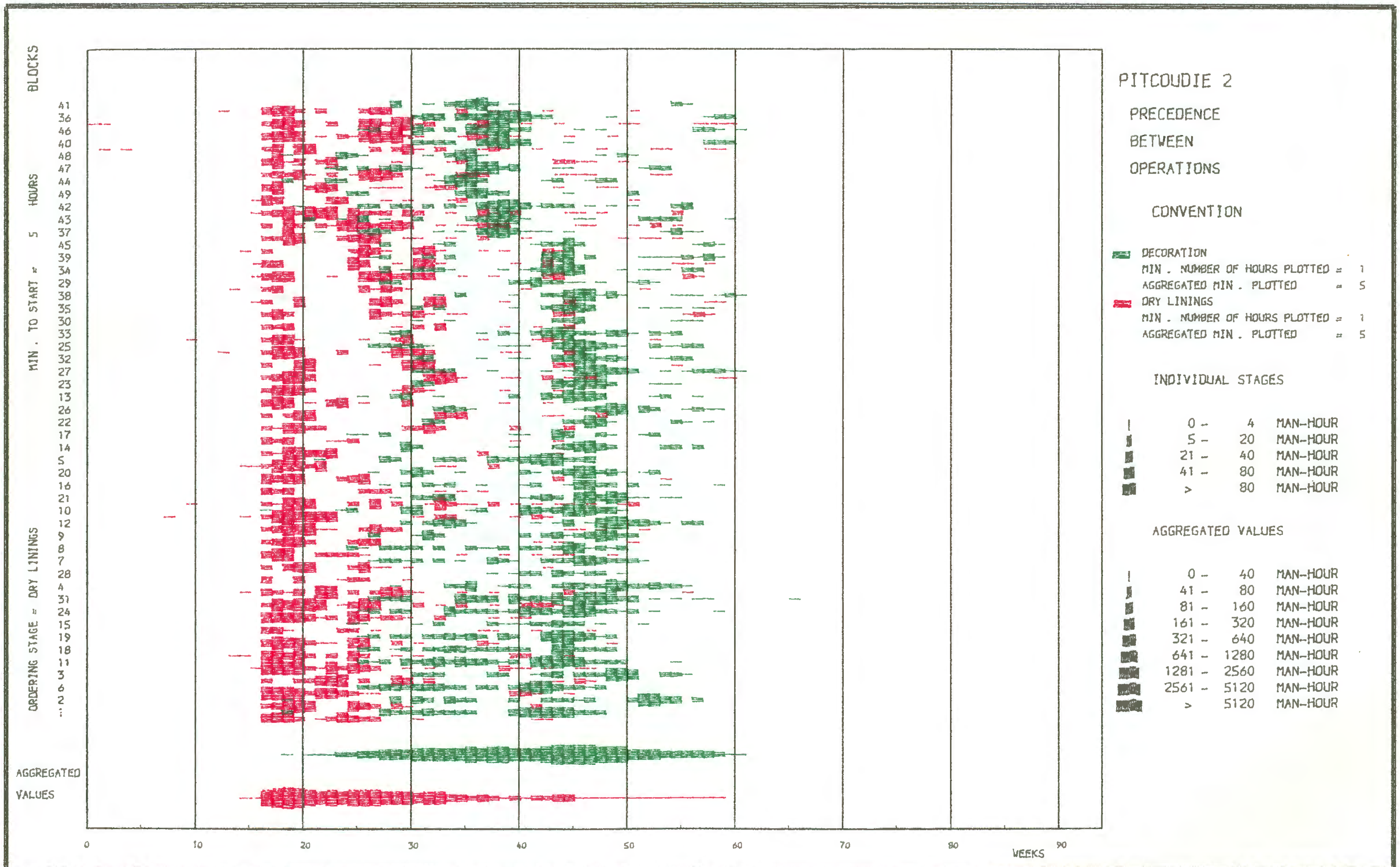
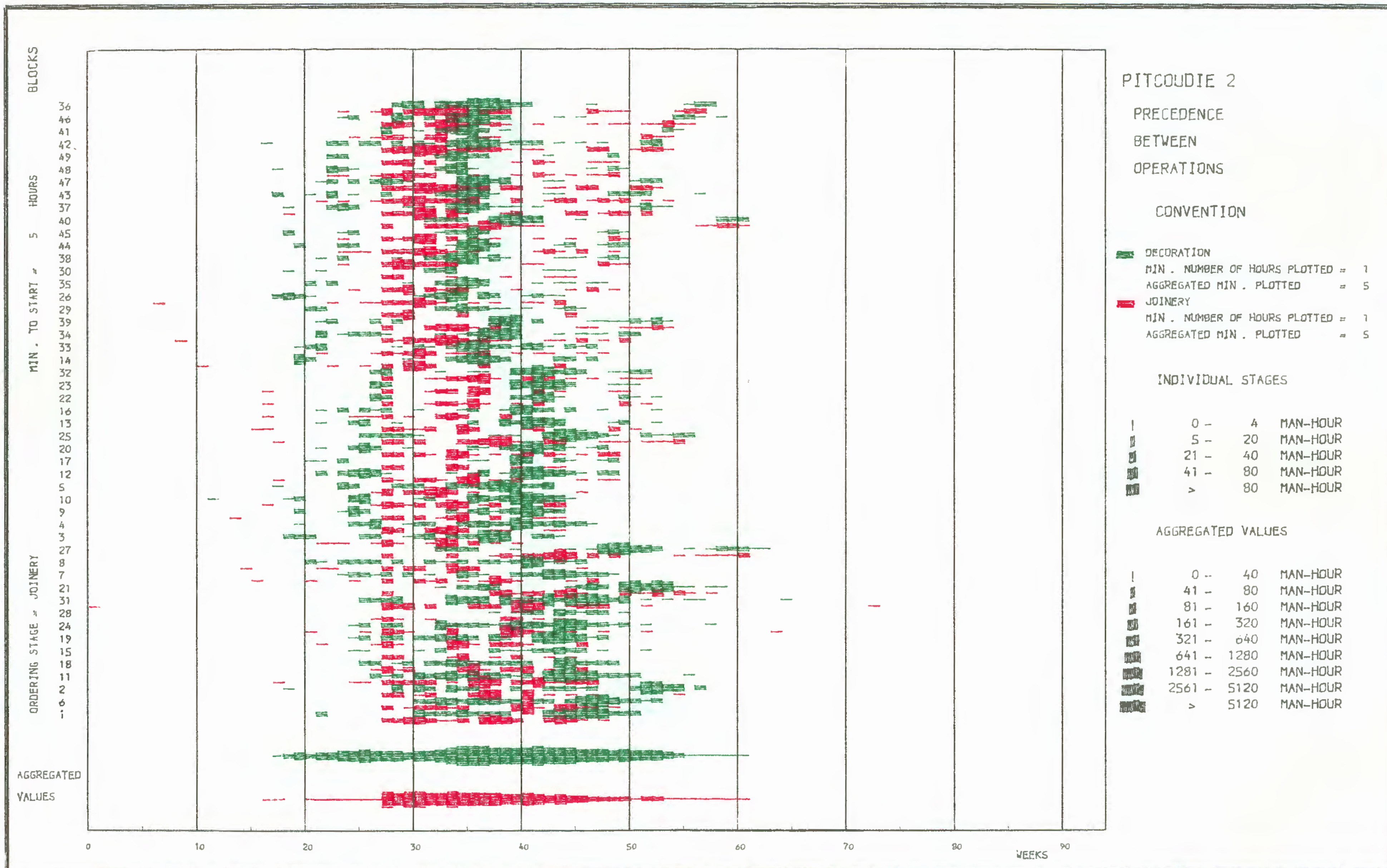
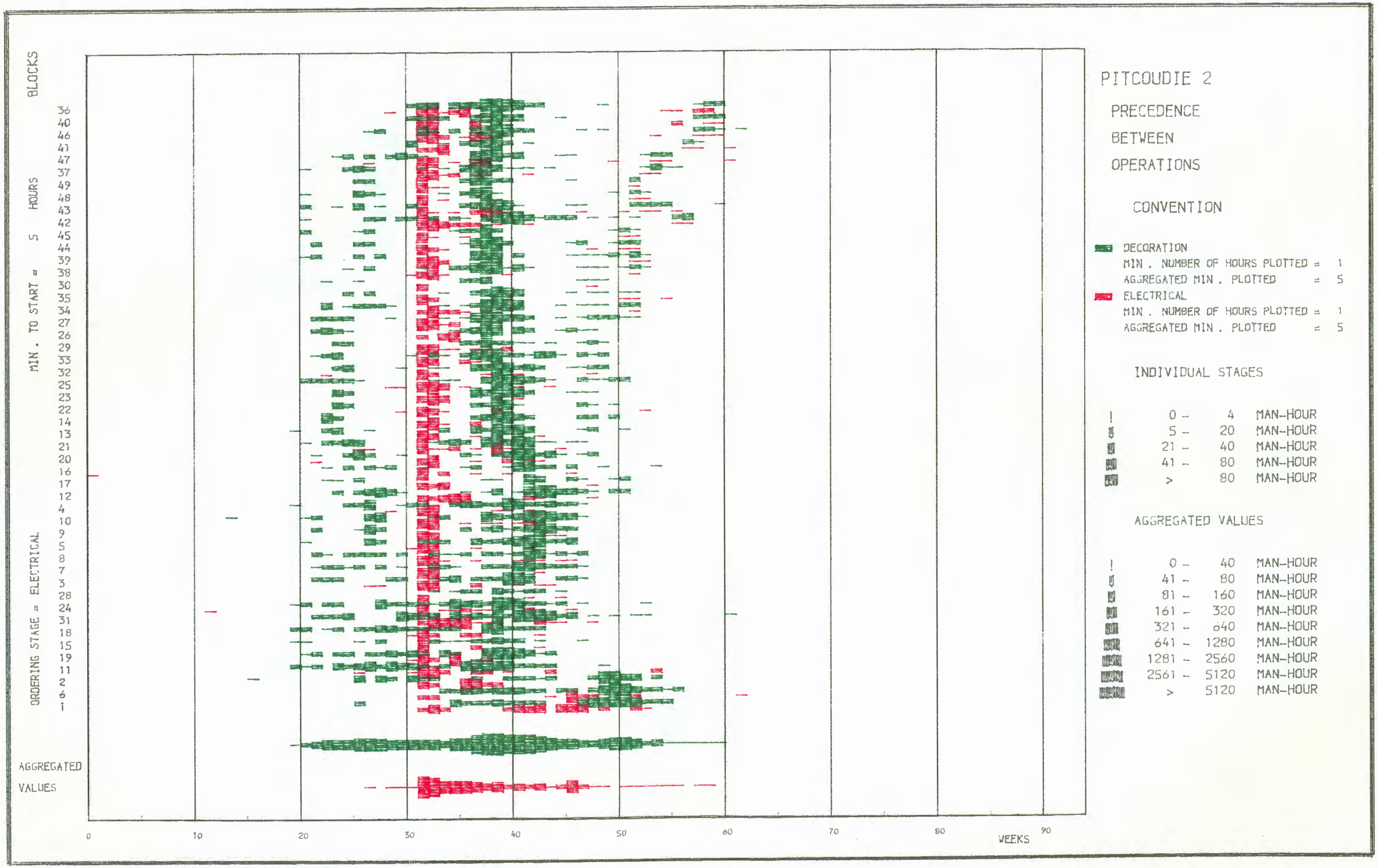

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
DRY LININGS
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = DRY LININGS MIN . TO START = 5 HOURS
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 71



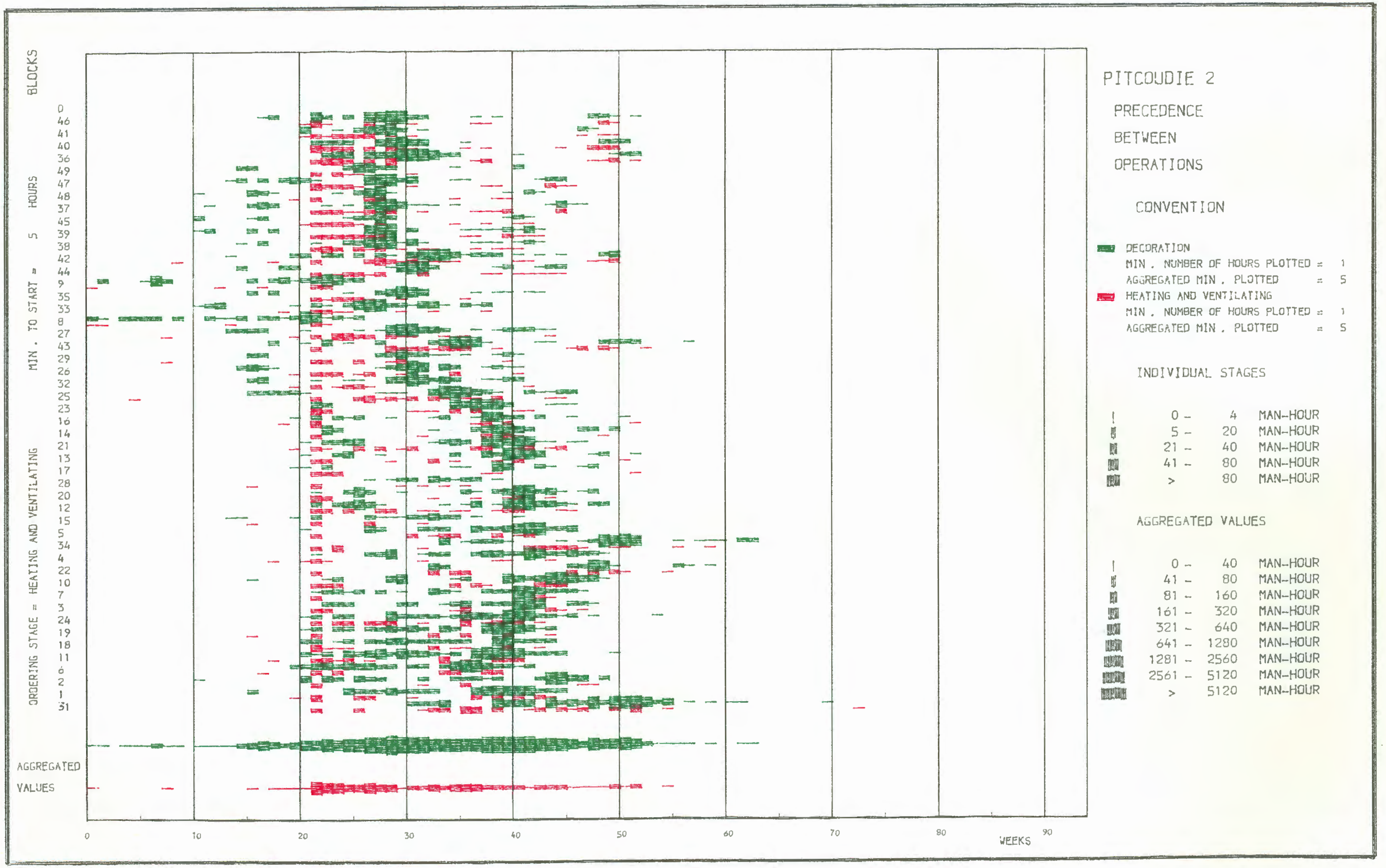
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
JOINERY
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = JOINERY
36 46 41 42 49 48 47 43 37 40 45 44 38 30 35 26 29 39 34 33 14 32 23 22 16 13 25 20 17 12 5 10 9 4 3 27 8 7 21 31 28 24 19 15 18 11 2 6 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 72



BLOCKS
MIN. TO START = 5 HOURS
ORDERING STAGE = ELECTRICAL
36
40
46
41
47
37
49
48
43
42
45
44
39
38
30
35
34
27
26
29
33
32
25
23
22
14
13
21
20
16
17
12
4
10
9
5
8
7
3
28
24
31
18
15
19
11
2
6
1
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DECORATION
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
ELECTRICAL
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 73



BLOCKS
ORDERING STAGE = HEATING AND VENTILATING MIN . TO START = 5 HOURS
0
46
41
40
36
49
47
48
37
45
39
38
42
44
9
35
33
8
27
43
29
26
32
25
23
16
14
21
13
17
28
20
12
15
5
34
4
22
10
7
3
24
19
18
11
6
2
1
31
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DECORATION
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
HEATING AND VENTILATING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 74

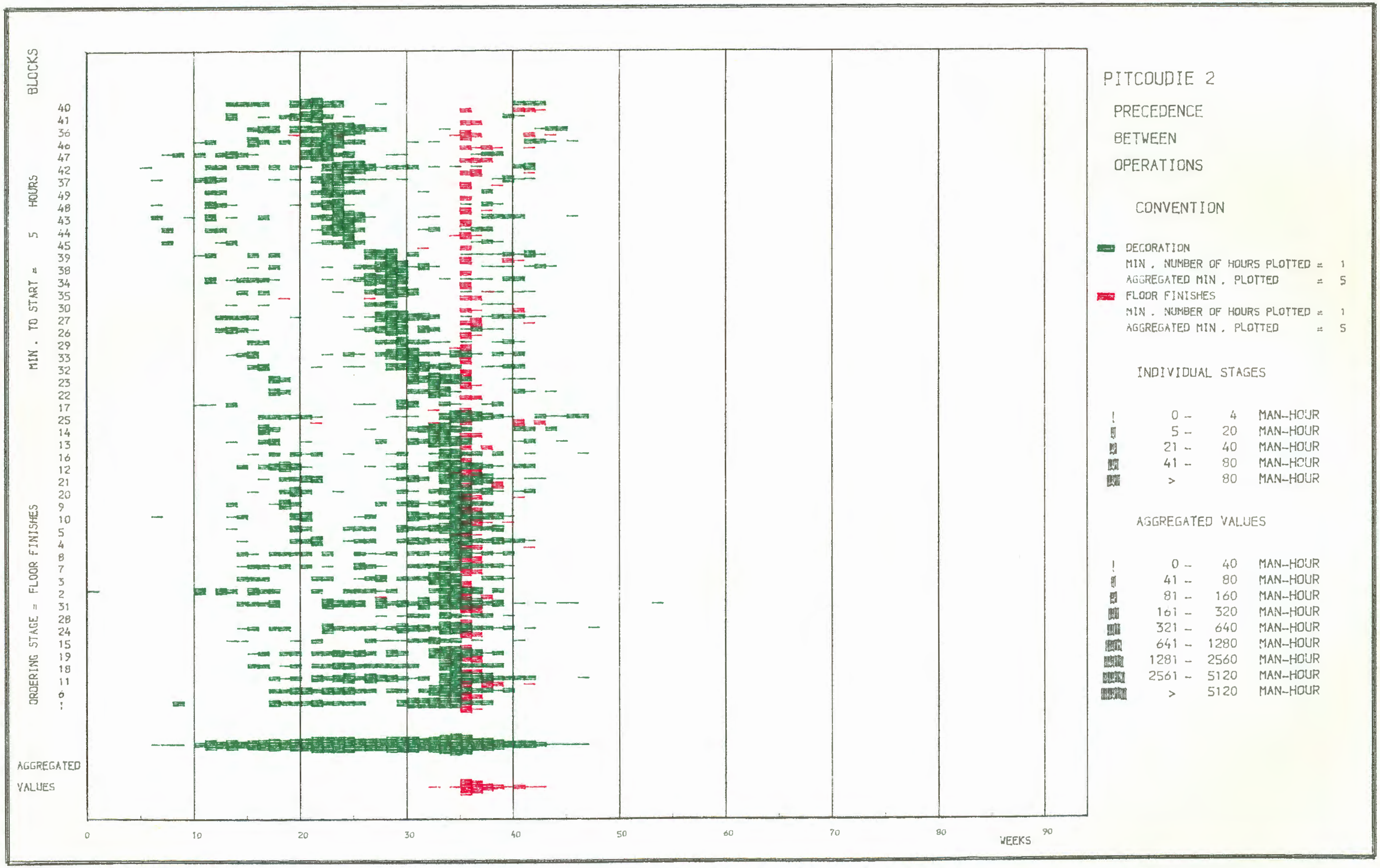

BLOCKS
MIN. TO START = 5 HOURS
ORDERING STAGE = FLOOR FINISHES
AGGREGATED VALUES
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
DECORATION
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
FLOOR FINISHES
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 75

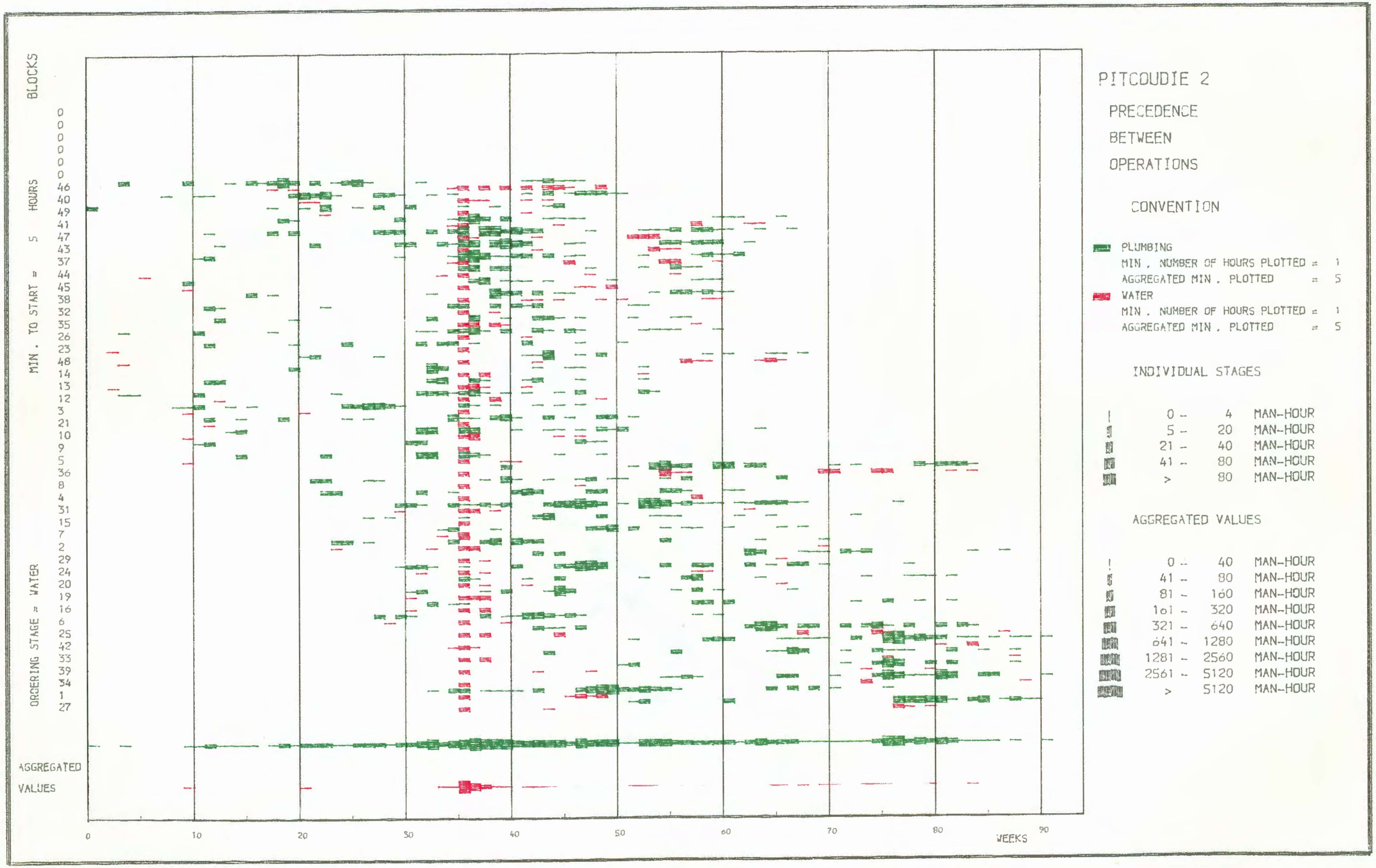

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
PLUMBING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
WATER
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = WATER
0
0
0
0
0
0
46
40
49
41
47
43
37
44
45
38
32
35
26
23
48
14
13
12
3
21
10
9
5
36
8
4
31
15
7
2
29
24
20
19
16
6
25
42
33
39
34
1
27
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS

FIG. 76

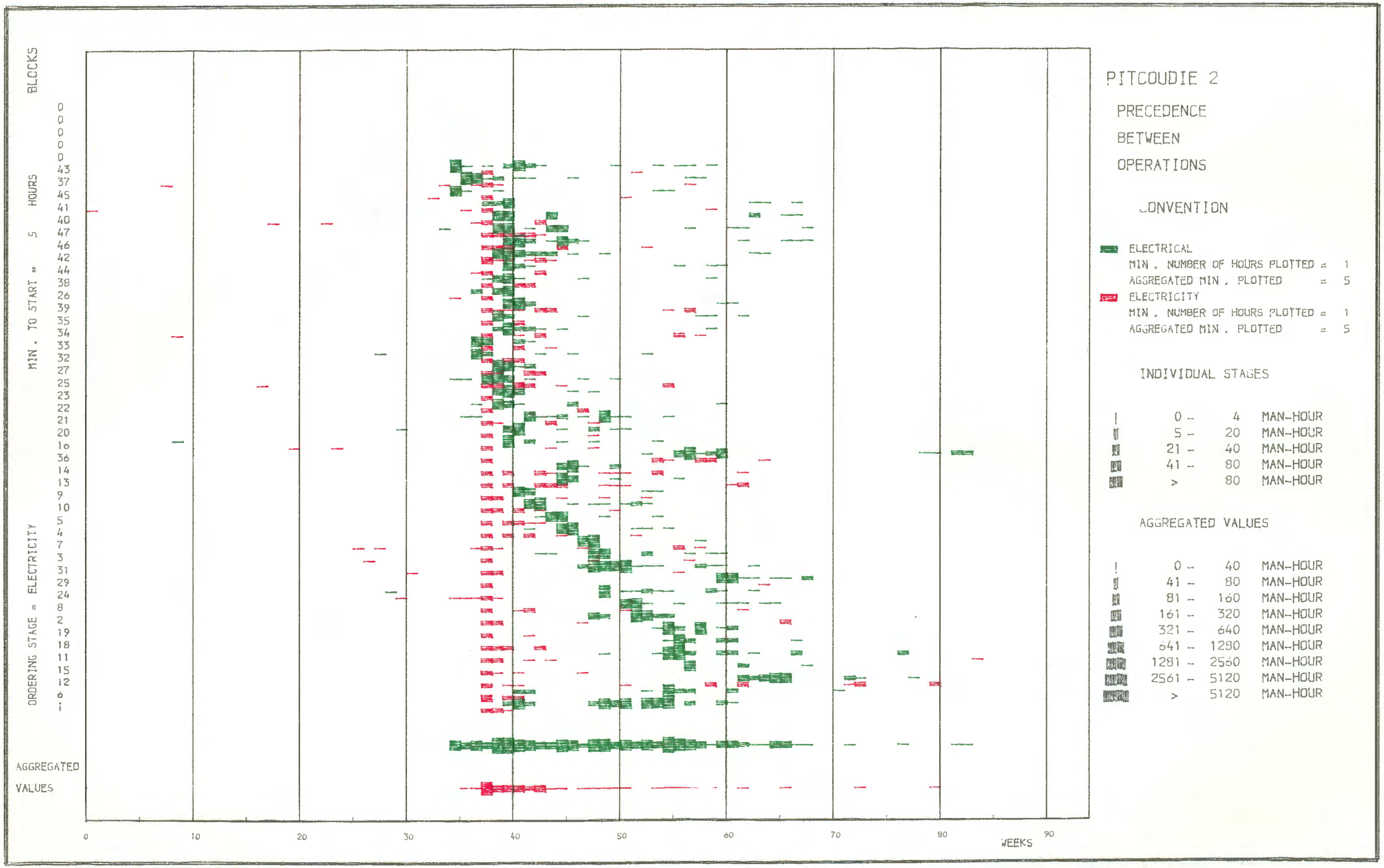
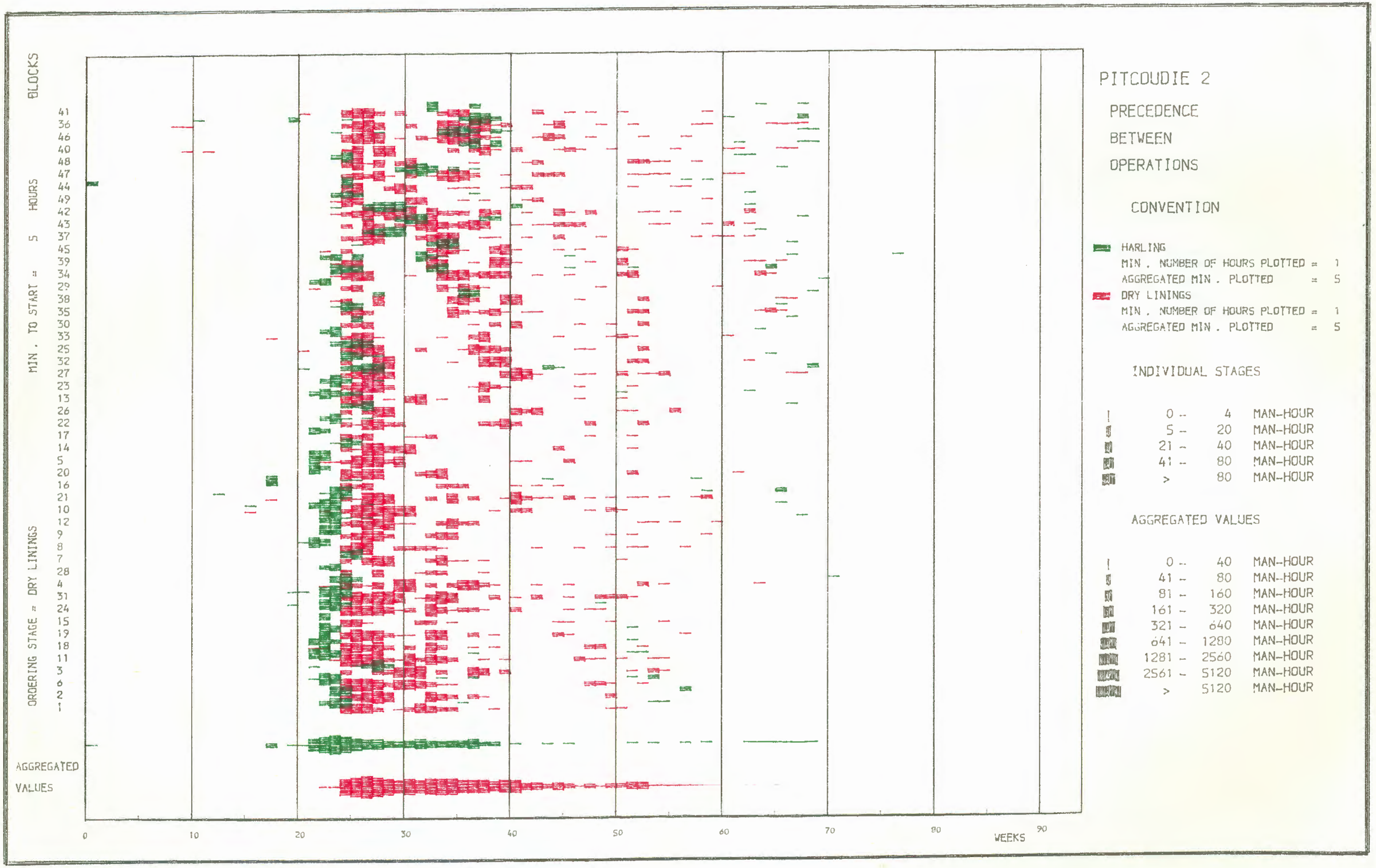
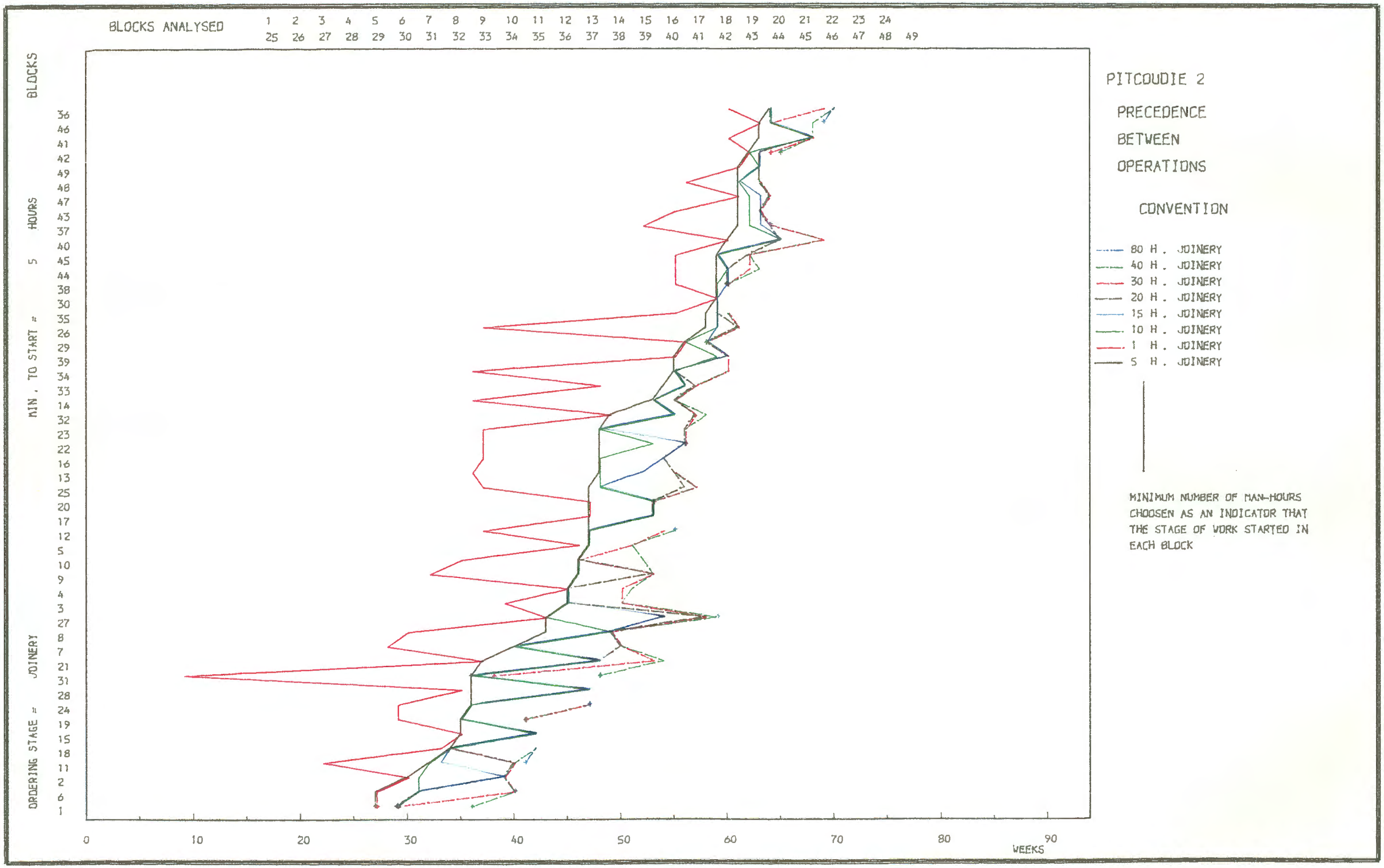

PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
ELECTRICAL
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
ELECTRICITY
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = ELECTRICITY
AGGREGATED
VALUES
0
10
20
30
40
50
60
70
80
90
WEEKS

FIG. 77



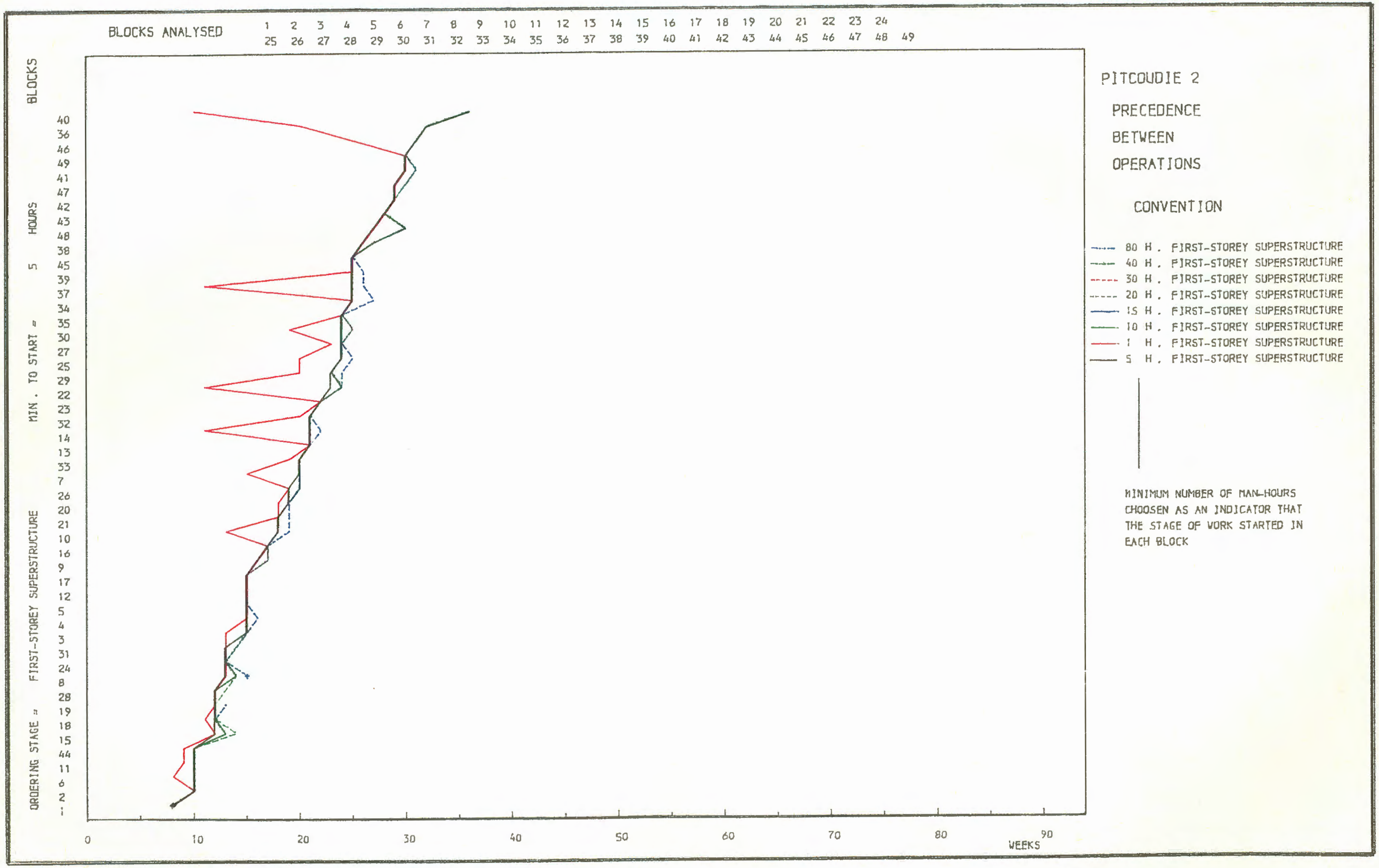
BLOCKS
MIN. TO START = 5 HOURS
ORDERING STAGE = DRY LININGS
41 36 46 40 48 47 44 49 42 43 37 45 39 34 29 38 35 30 33 25 32 27 23 13 26 22 17 14 5 20 16 21 10 12 9 8 7 28 4 31 24 15 19 18 11 3 6 2 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE BETWEEN OPERATIONS
CONVENTION
HARLING
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
DRY LININGS
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR

FIG. 78



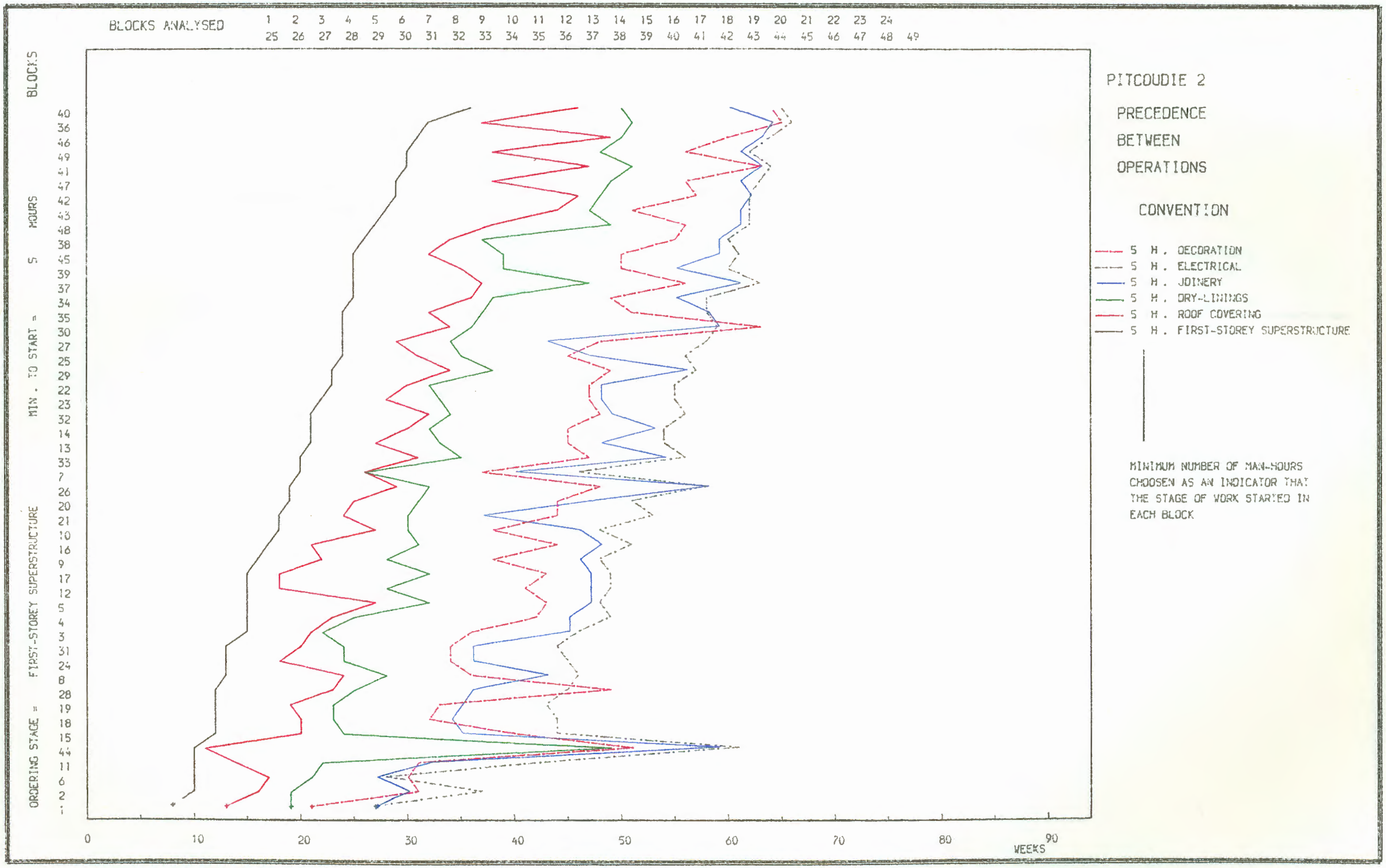
BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
ORDERING STAGE = JOINERY
MIN. TO START = 5 HOURS
36 46 41 42 49 48 47 43 37 40 45 44 38 30 35 26 29 39 34 33 14 32 23 22 16 13 25 20 17 12 5 10 9 4 3 27 8 7 21 31 28 24 19 15 18 11 2 6 1
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
80 H. JOINERY
40 H. JOINERY
30 H. JOINERY
20 H. JOINERY
15 H. JOINERY
10 H. JOINERY
1 H. JOINERY
5 H. JOINERY
MINIMUM NUMBER OF MAN-HOURS CHOOSEN AS AN INDICATOR THAT THE STAGE OF WORK STARTED IN EACH BLOCK

FIG. 79



BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
40 36 46 49 41 47 42 43 48 38 45 39 37 34 35 30 27 25 29 22 23 32 14 13 33 7 26 20 21 10 16 9 17 12 5 4 3 31 24 8 28 19 18 15 44 11 6 2 1
ORDERING STAGE " FIRST-STOREY SUPERSTRUCTURE MIN. TO START " 5 HOURS
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
80 H . FIRST-STOREY SUPERSTRUCTURE
40 H . FIRST-STOREY SUPERSTRUCTURE
30 H . FIRST-STOREY SUPERSTRUCTURE
20 H . FIRST-STOREY SUPERSTRUCTURE
15 H . FIRST-STOREY SUPERSTRUCTURE
10 H . FIRST-STOREY SUPERSTRUCTURE
1 H . FIRST-STOREY SUPERSTRUCTURE
5 H . FIRST-STOREY SUPERSTRUCTURE
MINIMUM NUMBER OF MAN-HOURS CHOOSEN AS AN INDICATOR THAT THE STAGE OF WORK STARTED IN EACH BLOCK

FIG. 80



BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
40 36 46 49 41 47 42 43 48 38 45 39 37 34 35 30 27 25 29 22 23 32 14 13 33 7 26 20 21 10 16 9 17 12 5 4 3 31 24 8 28 19 18 15 44 11 6 2 1
ORDERING STAGE = FIRST-STOREY SUPERSTRUCTURE MIN. TO START = 5 HOURS
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
5 H. DECORATION
5 H. ELECTRICAL
5 H. JOINERY
5 H. DRY-LININGS
5 H. ROOF COVERING
5 H. FIRST-STOREY SUPERSTRUCTURE
MINIMUM NUMBER OF MAN-HOURS CHOOSEN AS AN INDICATOR THAT THE STAGE OF WORK STARTED IN EACH BLOCK

FIG. 81

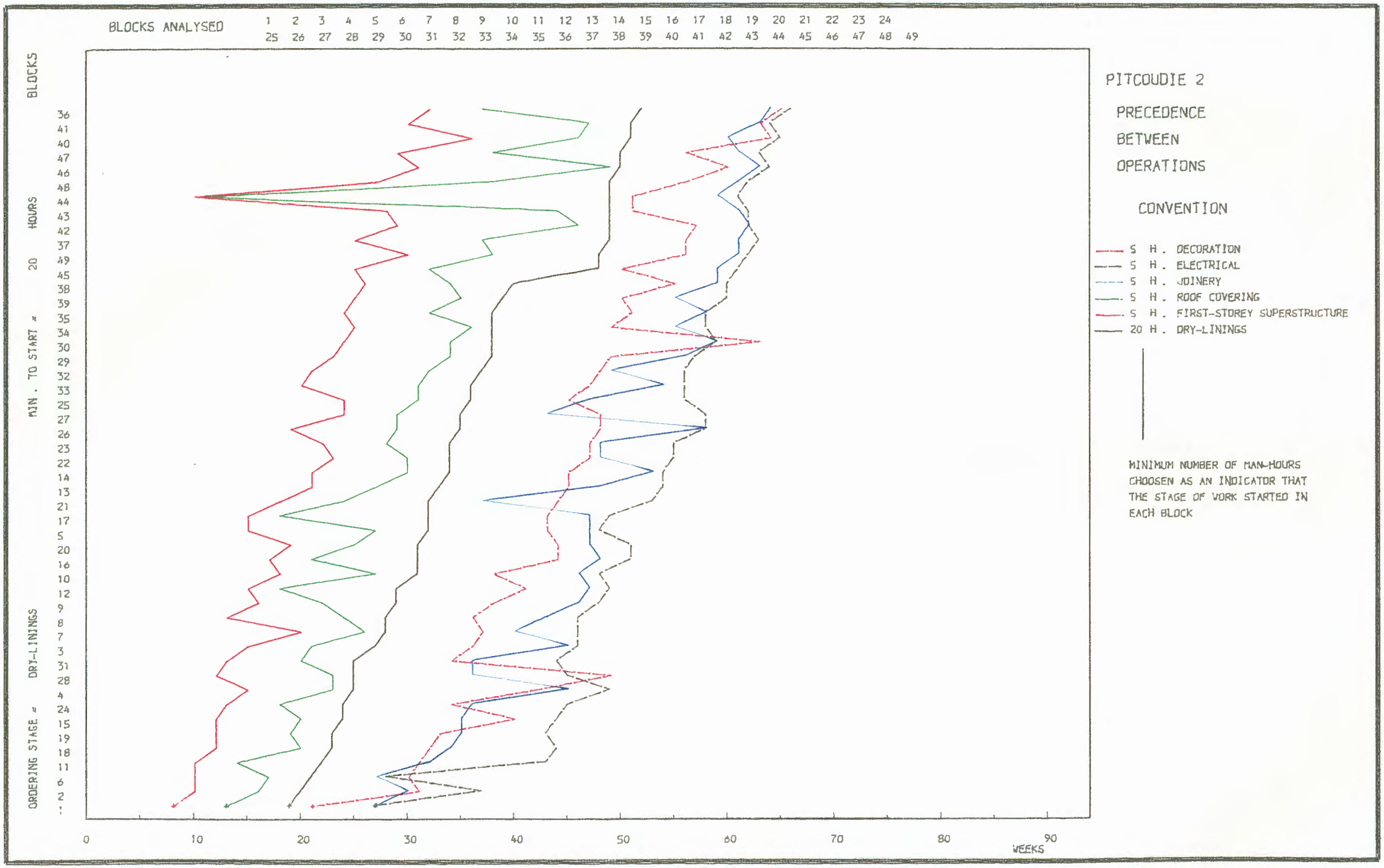
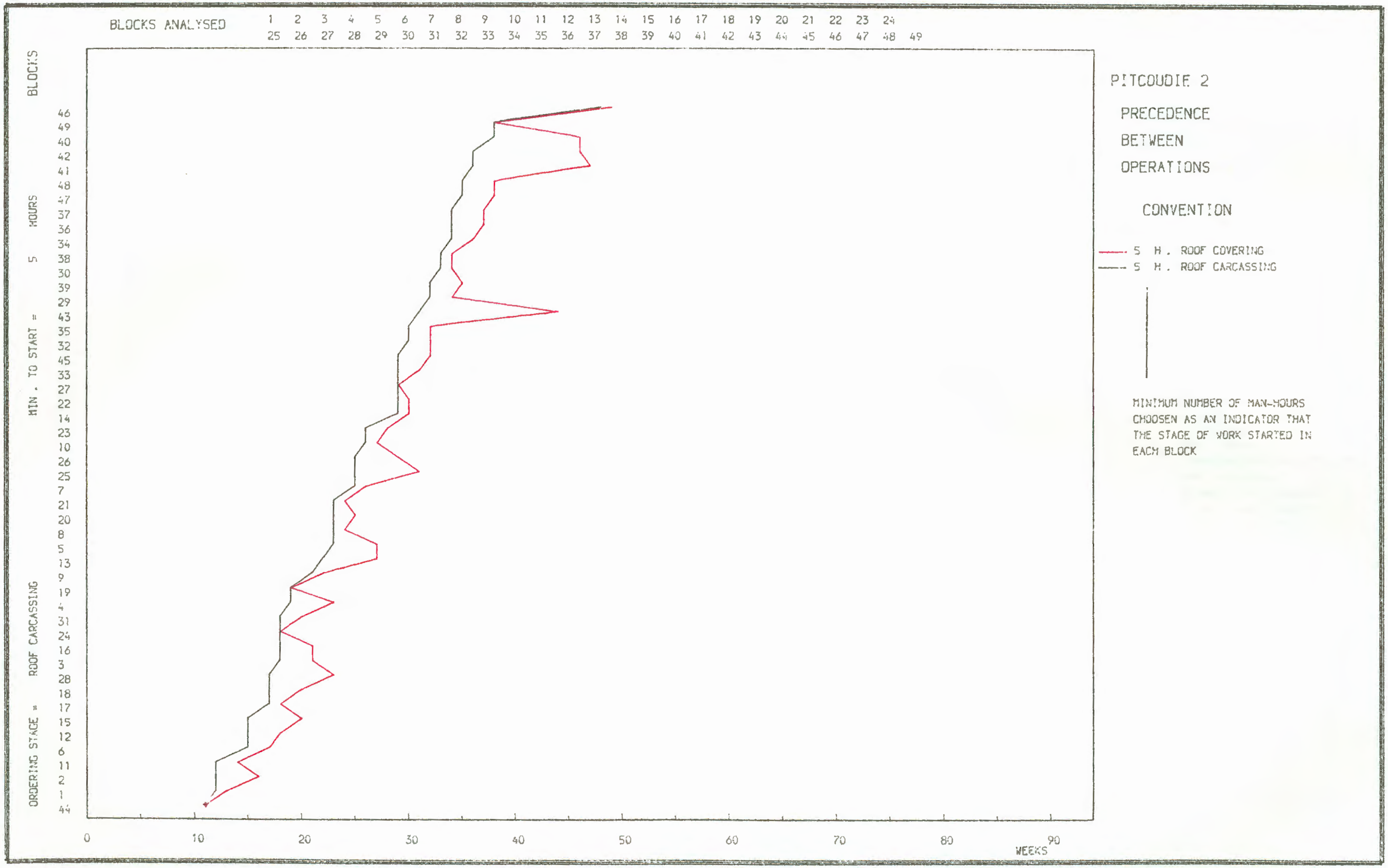

BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
ORDERING STAGE = DRY-LININGS
MIN . TO START = 20 HOURS
36 41 40 47 46 48 44 43 42 37 49 45 38 39 35 34 30 29 32 33 25 27 26 23 22 14 13 21 17 5 20 16 10 12 9 8 7 3 31 28 4 24 15 19 18 11 6 2 1
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
5 H . DECORATION
5 H . ELECTRICAL
5 H . JOINERY
5 H . ROOF COVERING
5 H . FIRST-STOREY SUPERSTRUCTURE
20 H . DRY-LININGS
MINIMUM NUMBER OF MAN-HOURS
CHOOSEN AS AN INDICATOR THAT
THE STAGE OF WORK STARTED IN
EACH BLOCK

FIG. 82



BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
ORDERING STAGE = ROOF CARCASSING
MIN. TO START = 5 HOURS
46 49 40 42 41 48 47 37 36 34 38 30 39 29 43 35 32 45 33 27 22 14 23 10 26 25 7 21 20 8 5 13 9 19 4 31 24 16 3 28 18 17 15 12 6 11 2 1 44
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
5 H. ROOF COVERING
5 H. ROOF CARCASSING
MINIMUM NUMBER OF MAN-HOURS
CHOOSEN AS AN INDICATOR THAT
THE STAGE OF WORK STARTED IN
EACH BLOCK

FIG. 83

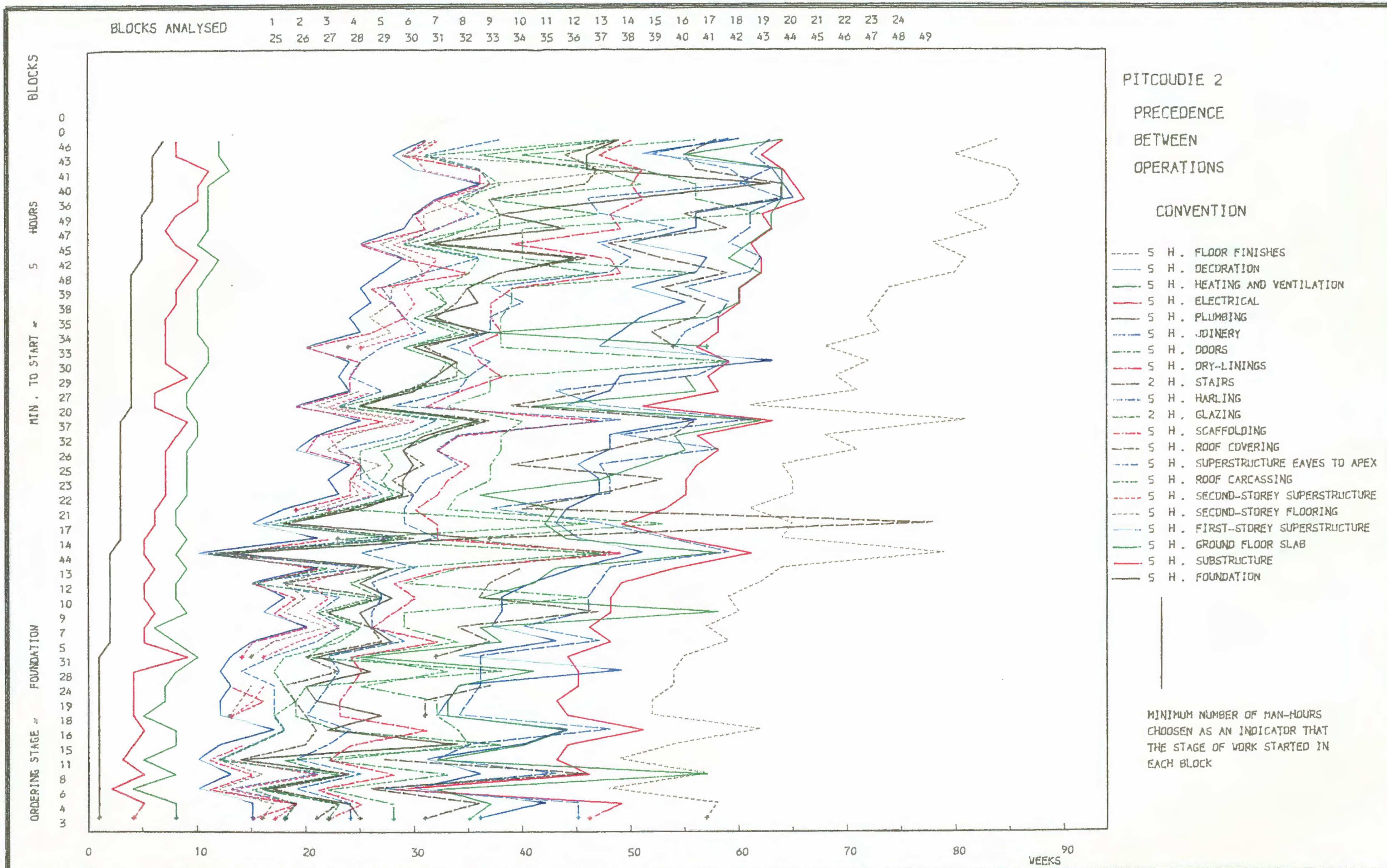
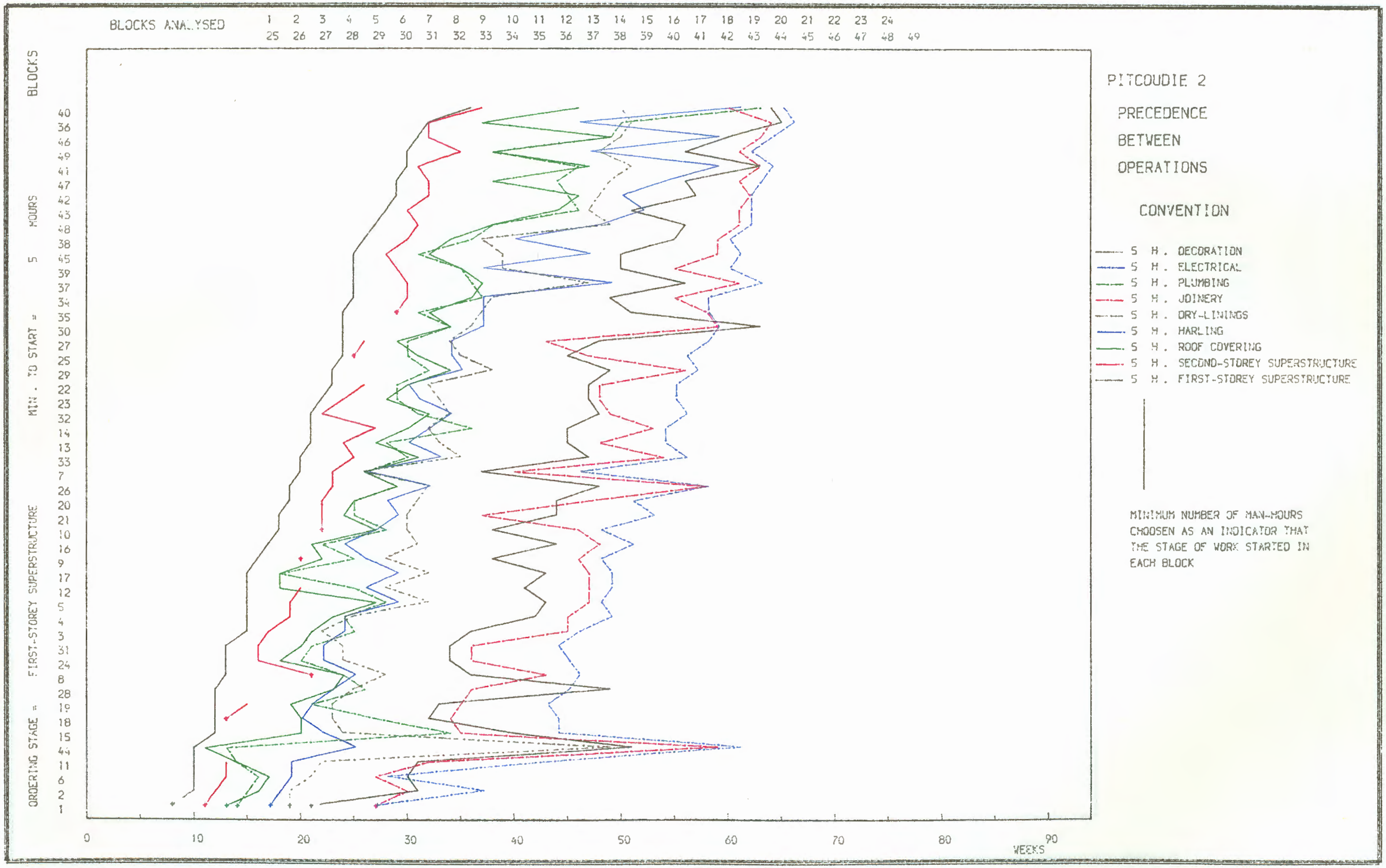

BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
MIN. TO START = 5 HOURS
ORDERING STAGE = FOUNDATION
0 0 46 43 41 40 36 49 47 45 42 48 39 38 35 34 33 30 29 27 20 37 32 26 25 23 22 21 17 14 44 13 12 10 9 7 5 31 28 24 19 18 16 15 11 8 6 4 3
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
5 H . FLOOR FINISHES
5 H . DECORATION
5 H . HEATING AND VENTILATION
5 H . ELECTRICAL
5 H . PLUMBING
5 H . JOINERY
5 H . DOORS
5 H . DRY-LININGS
2 H . STAIRS
5 H . HARLING
2 H . GLAZING
5 H . SCAFFOLDING
5 H . ROOF COVERING
5 H . SUPERSTRUCTURE EAVES TO APEX
5 H . ROOF CARCASSING
5 H . SECOND-STOREY SUPERSTRUCTURE
5 H . SECOND-STOREY FLOORING
5 H . FIRST-STOREY SUPERSTRUCTURE
5 H . GROUND FLOOR SLAB
5 H . SUBSTRUCTURE
5 H . FOUNDATION
MINIMUM NUMBER OF MAN-HOURS
CHOOSEN AS AN INDICATOR THAT
THE STAGE OF WORK STARTED IN
EACH BLOCK

FIG. 84



BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
ORDERING STAGE = FIRST-STOREY SUPERSTRUCTURE MIN. TO START = 5 HOURS
40 36 46 49 41 47 42 43 48 38 45 39 37 34 35 30 27 25 29 22 23 32 14 13 33 7 26 20 21 10 16 9 17 12 5 4 3 31 24 8 28 19 18 15 44 11 6 2 1
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
5 H. DECORATION
5 H. ELECTRICAL
5 H. PLUMBING
5 H. JOINERY
5 H. DRY-LININGS
5 H. HARLING
5 H. ROOF COVERING
5 H. SECOND-STOREY SUPERSTRUCTURE
5 H. FIRST-STOREY SUPERSTRUCTURE
MINIMUM NUMBER OF MAN-HOURS CHOOSEN AS AN INDICATOR THAT THE STAGE OF WORK STARTED IN EACH BLOCK

FIG. 85

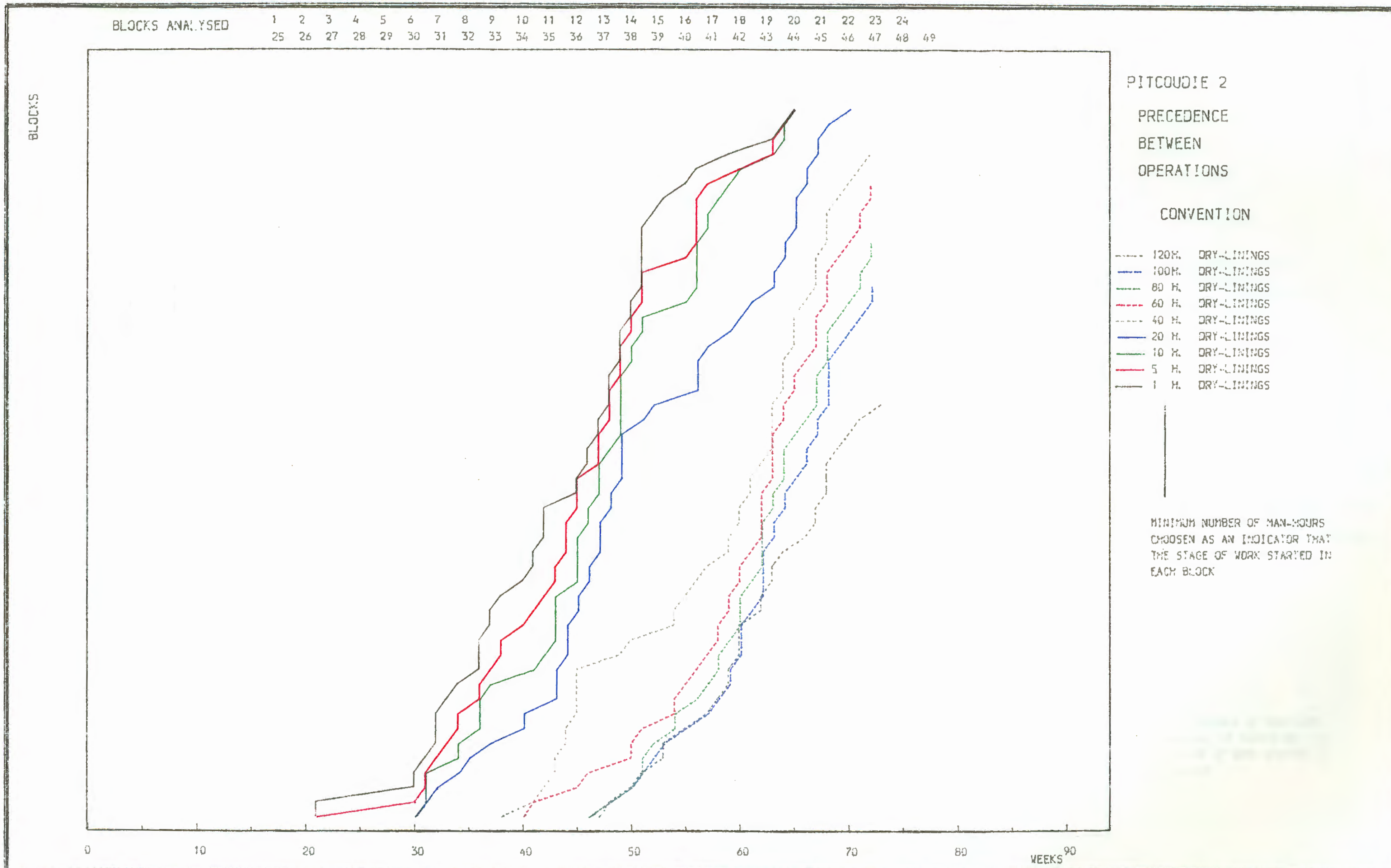

BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
120H. DRY-LININGS
100H. DRY-LININGS
80 H. DRY-LININGS
60 H. DRY-LININGS
40 H. DRY-LININGS
20 H. DRY-LININGS
10 H. DRY-LININGS
5 H. DRY-LININGS
1 H. DRY-LININGS
MINIMUM NUMBER OF MAN-HOURS CHOOSEN AS AN INDICATOR THAT THE STAGE OF WORK STARTED IN EACH BLOCK

FIG. 86

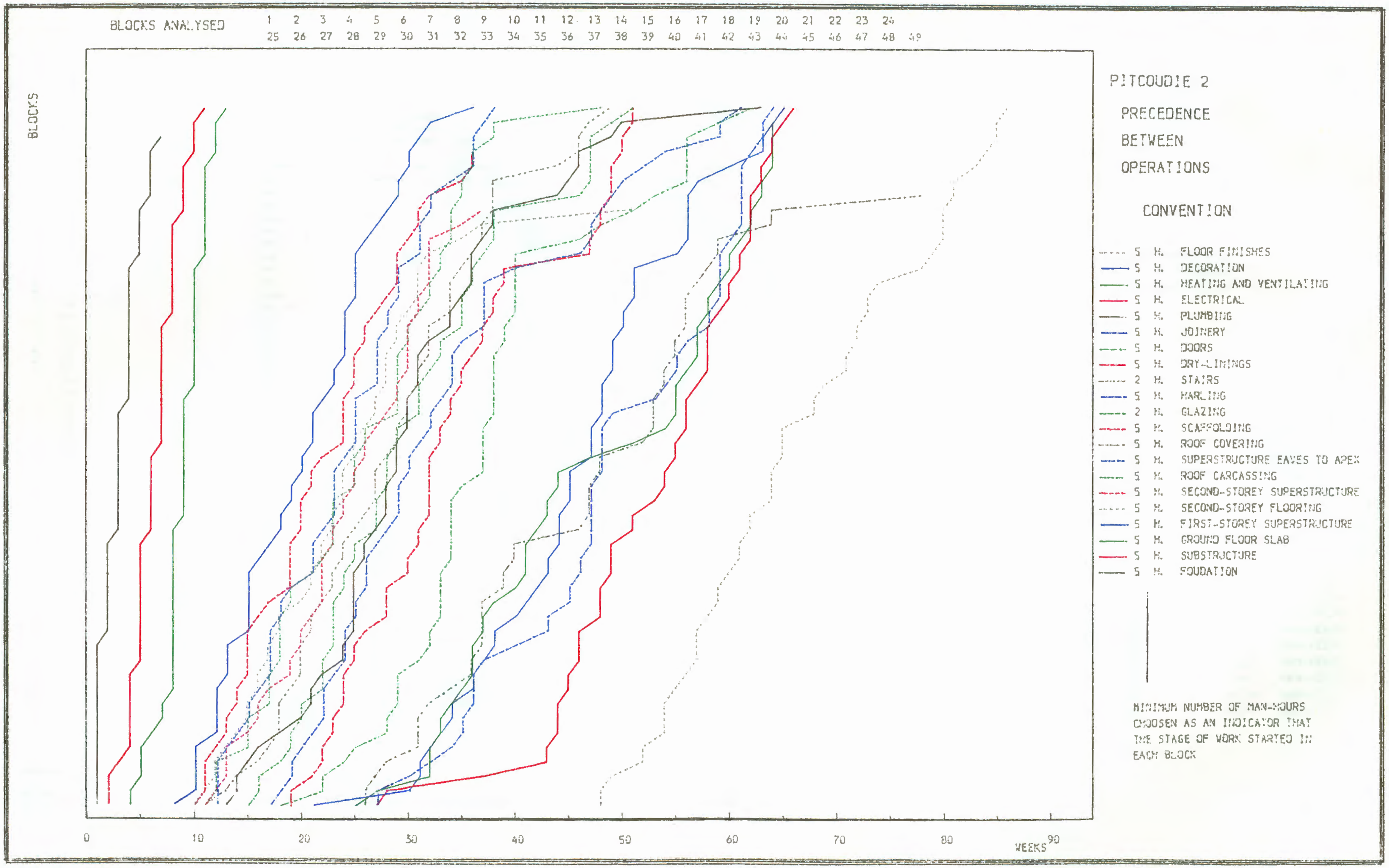
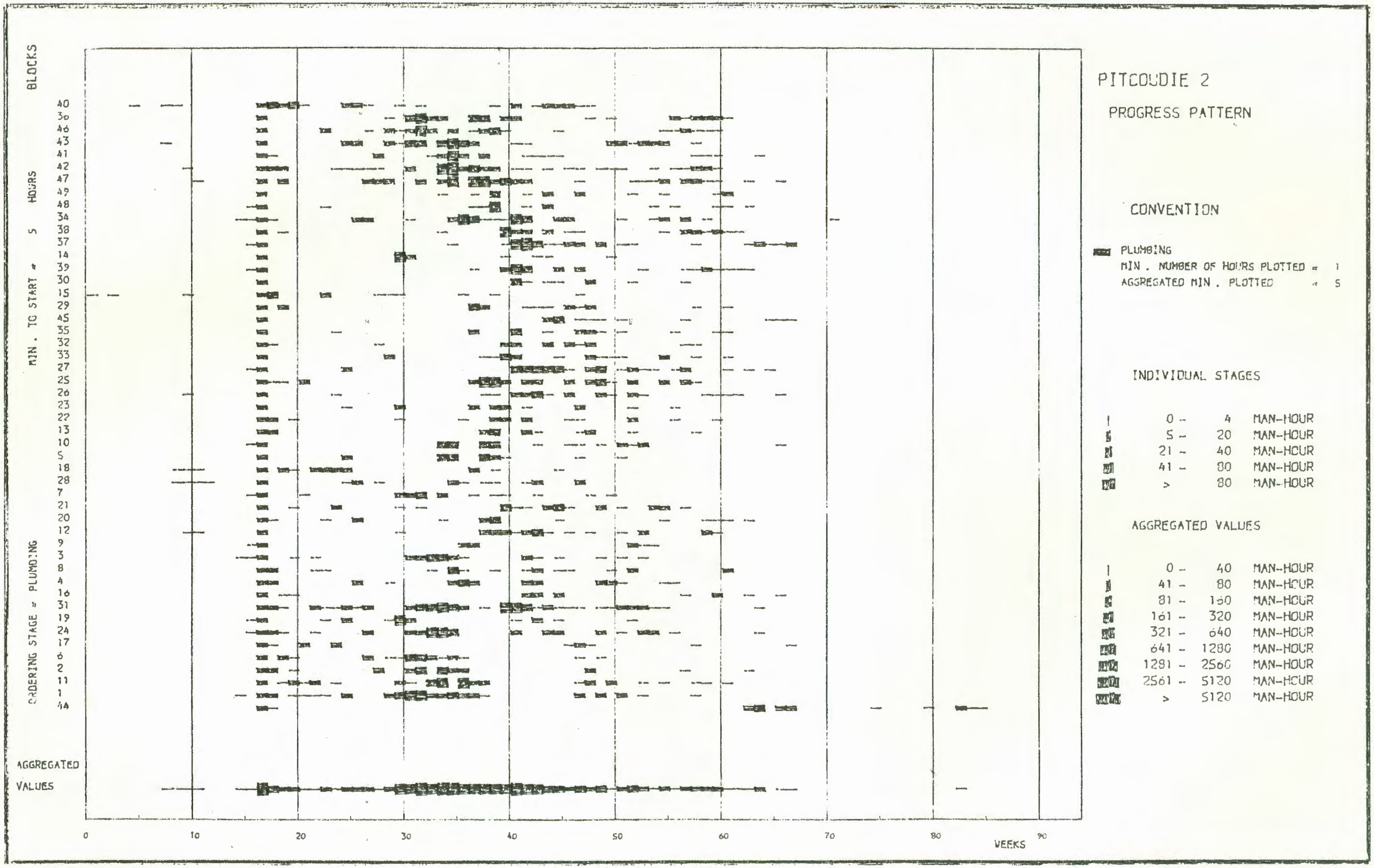

BLOCKS ANALYSED
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
BLOCKS
0 10 20 30 40 50 60 70 80 90
WEEKS
PITCOUDIE 2
PRECEDENCE
BETWEEN
OPERATIONS
CONVENTION
5 H. FLOOR FINISHES
5 H. DECORATION
5 H. HEATING AND VENTILATING
5 H. ELECTRICAL
5 H. PLUMBING
5 H. JOINERY
5 H. DOORS
5 H. DRY-LININGS
2 H. STAIRS
5 H. HARLING
2 H. GLAZING
5 H. SCAFFOLDING
5 H. ROOF COVERING
5 H. SUPERSTRUCTURE EAVES TO APEX
5 H. ROOF CARCASSING
5 H. SECOND-STOREY SUPERSTRUCTURE
5 H. SECOND-STOREY FLOORING
5 H. FIRST-STOREY SUPERSTRUCTURE
5 H. GROUND FLOOR SLAB
5 H. SUBSTRUCTURE
5 H. FOUDATION
MINIMUM NUMBER OF MAN-HOURS
CHOOSEN AS AN INDICATOR THAT
THE STAGE OF WORK STARTED IN
EACH BLOCK

FIG. 87



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
PLUMBING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 – 4 MAN-HOUR
5 – 20 MAN-HOUR
21 – 40 MAN-HOUR
41 – 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 – 40 MAN-HOUR
41 – 80 MAN-HOUR
81 – 160 MAN-HOUR
161 – 320 MAN-HOUR
321 – 640 MAN-HOUR
641 – 1280 MAN-HOUR
1281 – 2560 MAN-HOUR
2561 – 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = PLUMBING
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 88

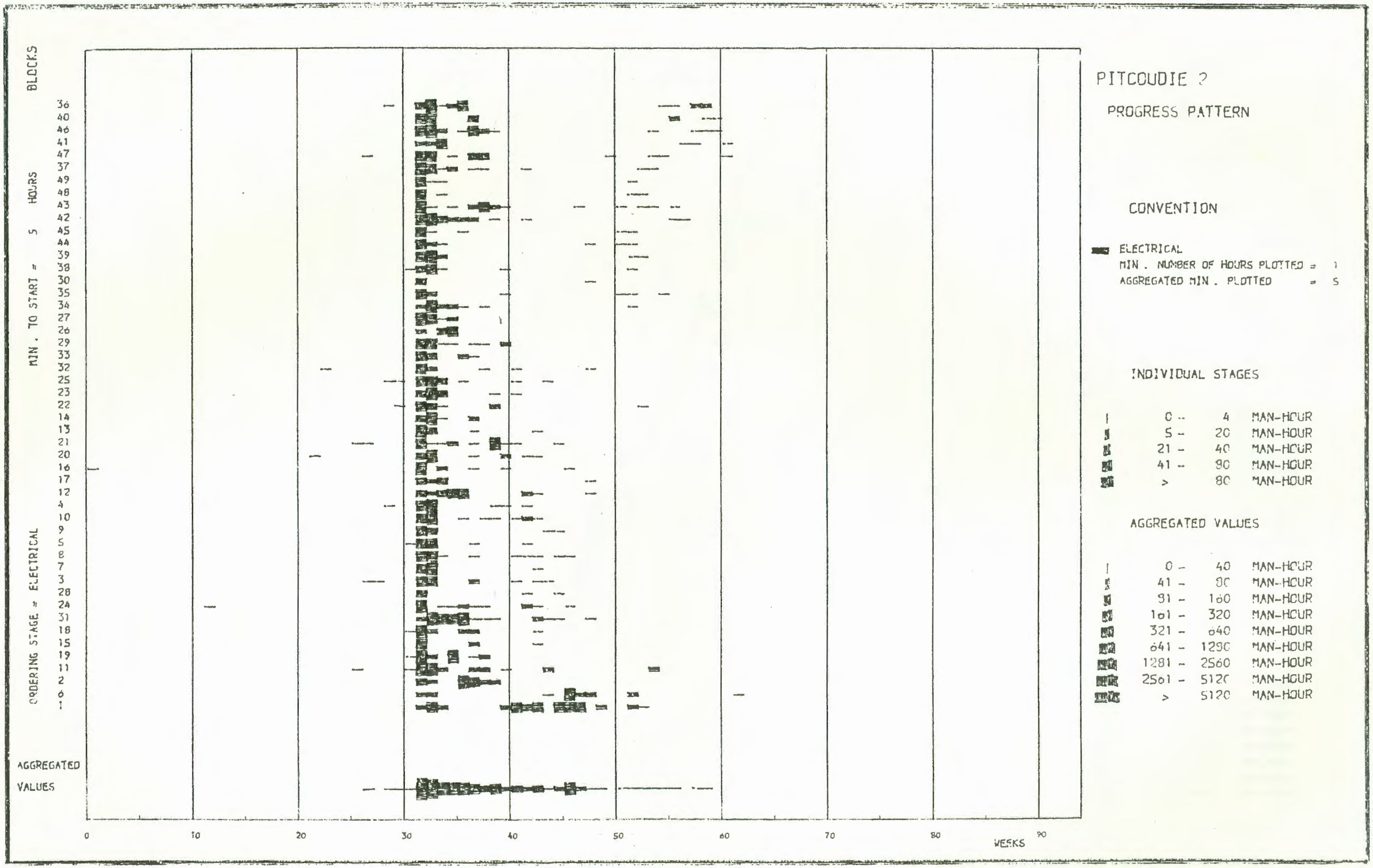
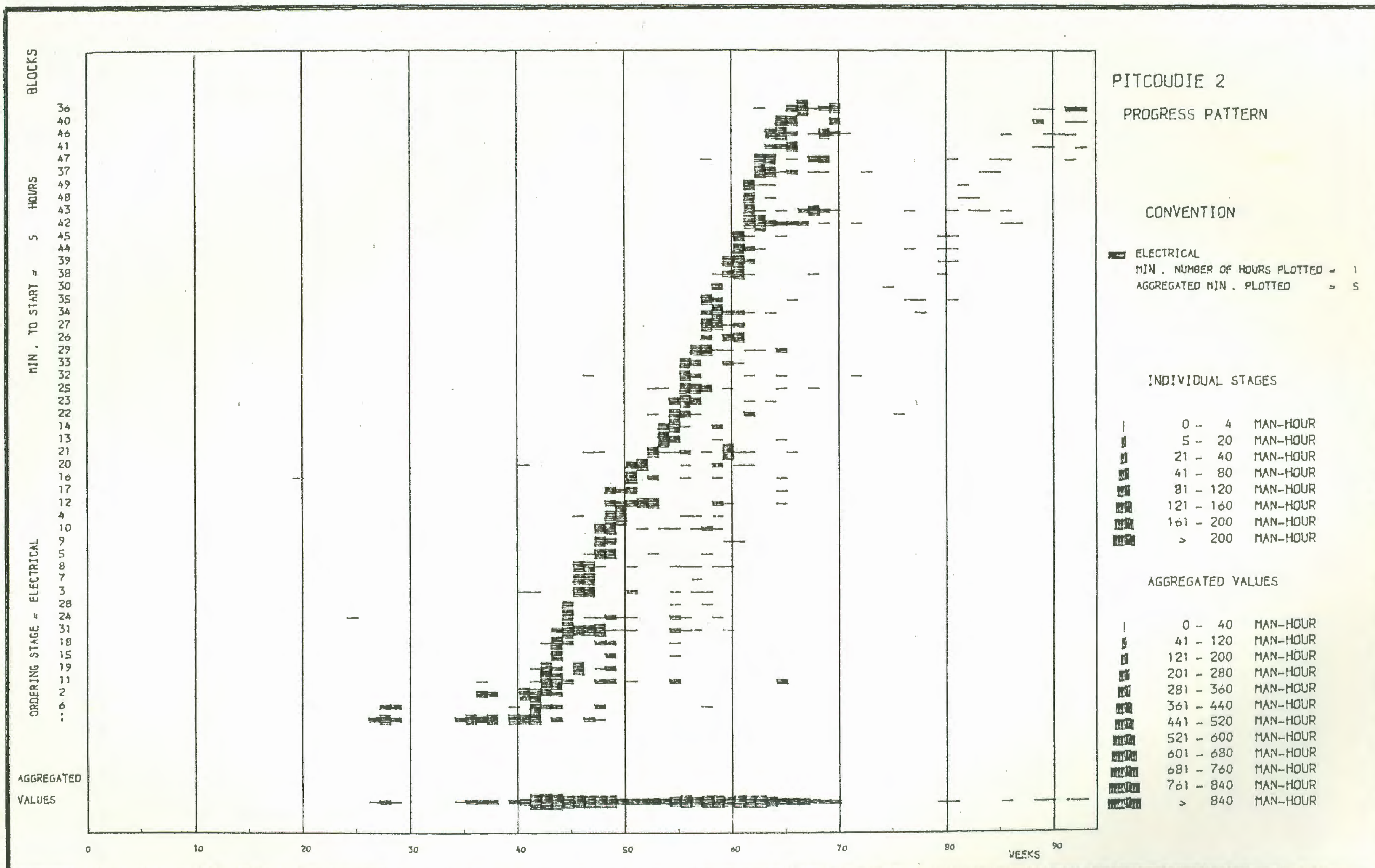

PITCOUDIE ?
PROGRESS PATTERN
CONVENTION
ELECTRICAL
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 -- 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = ELECTRICAL MIN . TO START = 5 HOURS
36 40 46 41 47 37 49 48 43 42 45 44 39 38 30 35 34 27 26 29 33 32 25 23 22 14 13 21 20 16 17 12 4 10 9 5 8 7 3 28 24 31 18 15 19 11 2 6 1
AGGREGATED
VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 89



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
ELECTRICAL
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
ORDERING STAGE = ELECTRICAL MIN . TO START = 5 HOURS
36 40 46 41 47 37 49 48 43 42 45 44 39 38 30 35 34 27 26 29 33 32 25 23 22 14 13 21 20 16 17 12 4 10 9 5 8 7 3 28 24 31 18 15 19 11 2 6 1
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 90

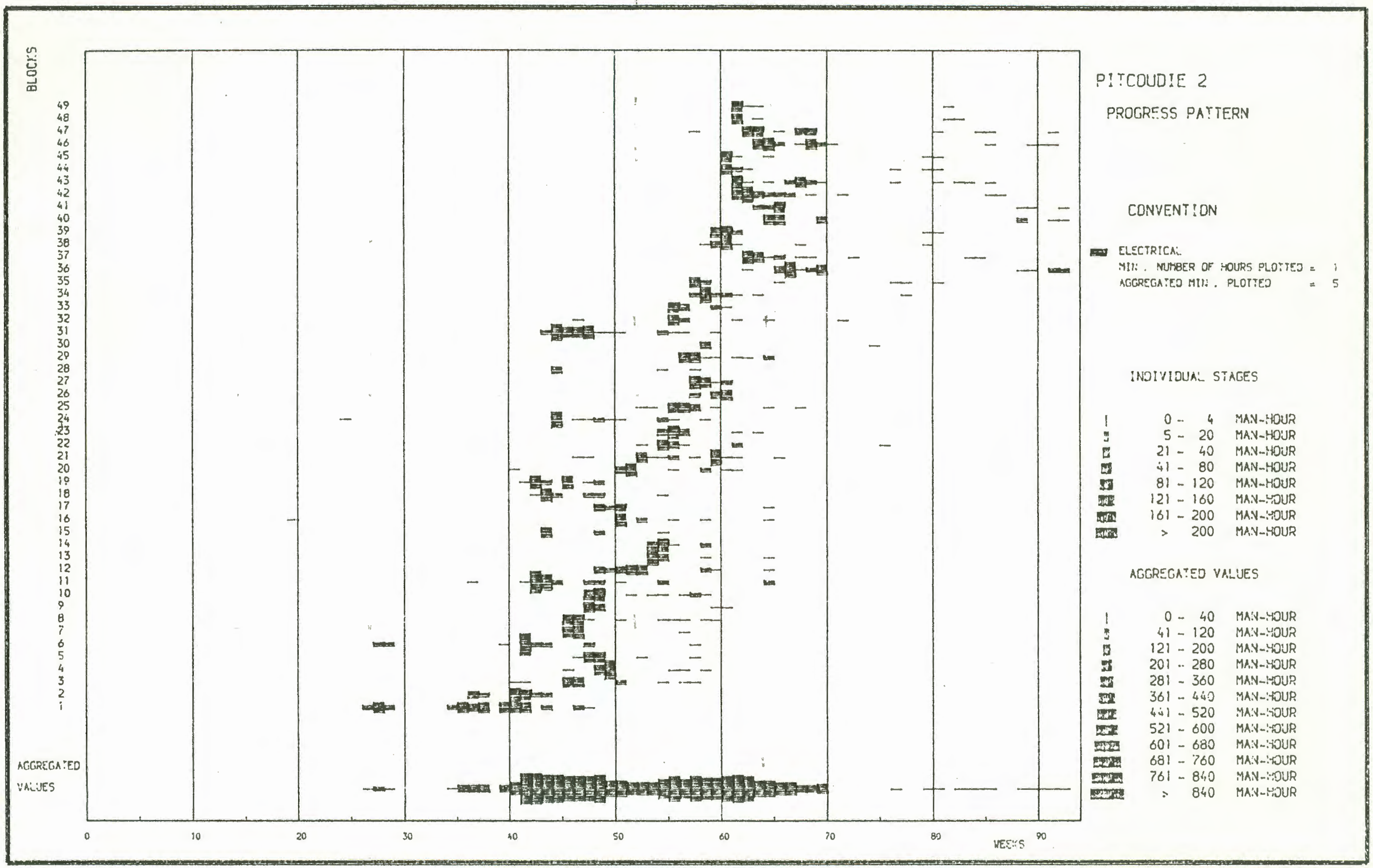
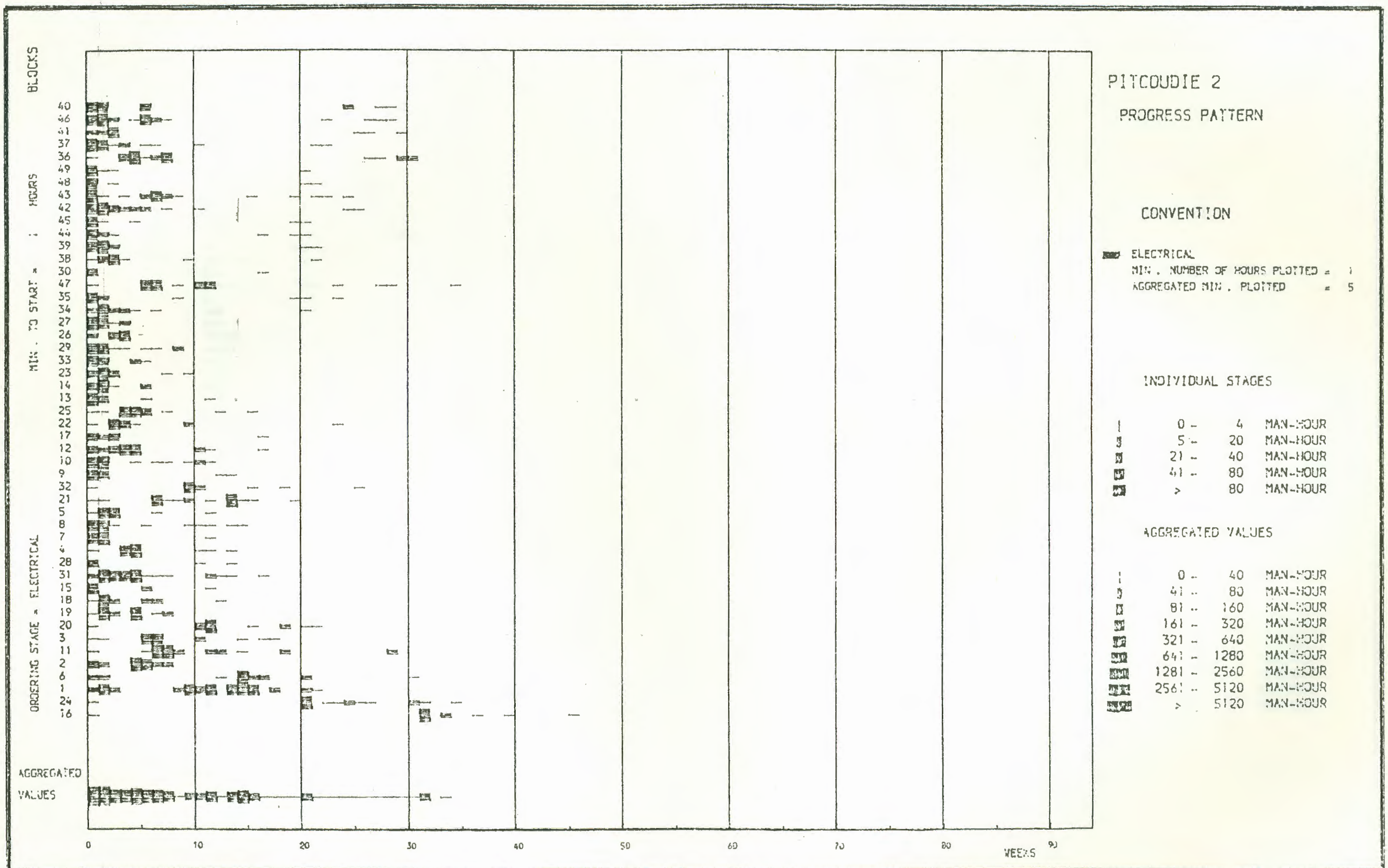

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
ELECTRICAL
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
AGGREGATED VALUES
WEEKS

FIG. 91



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
ELECTRICAL
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN. TO START = 1 HOURS
ORDERING STAGE = ELECTRICAL
40 46 41 37 36 49 48 43 42 45 44 39 38 30 47 35 34 27 26 29 33 23 14 13 25 22 17 12 10 9 32 21 5 8 7 4 28 31 15 18 19 20 3 11 2 6 1 24 16
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 92

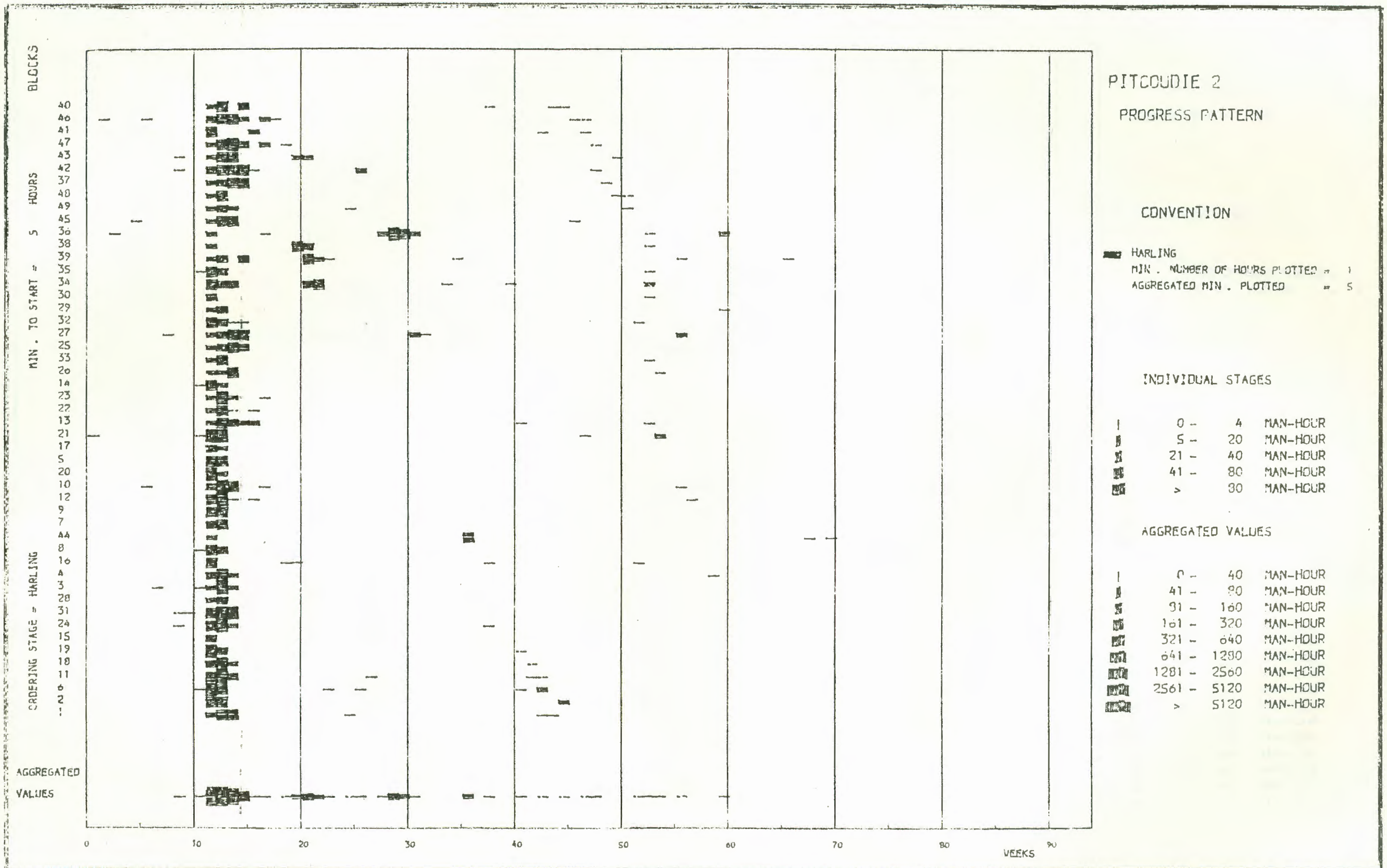

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
HARLING
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
ORDERING STAGE = HARLING MIN . TO START = 5 HOURS
AGGREGATED VALUES
WEEKS
0 10 20 30 40 50 60 70 80 90

FIG. 93

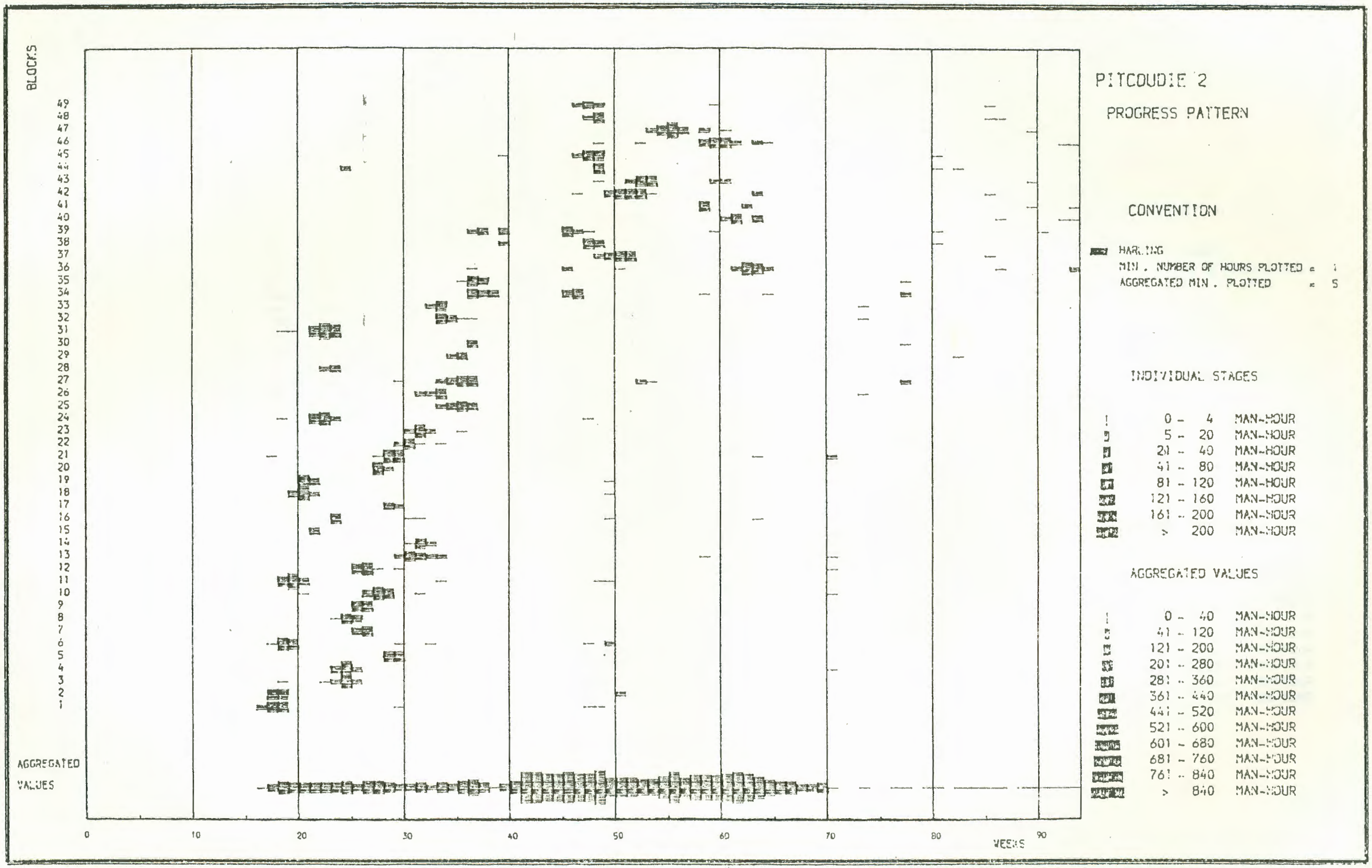
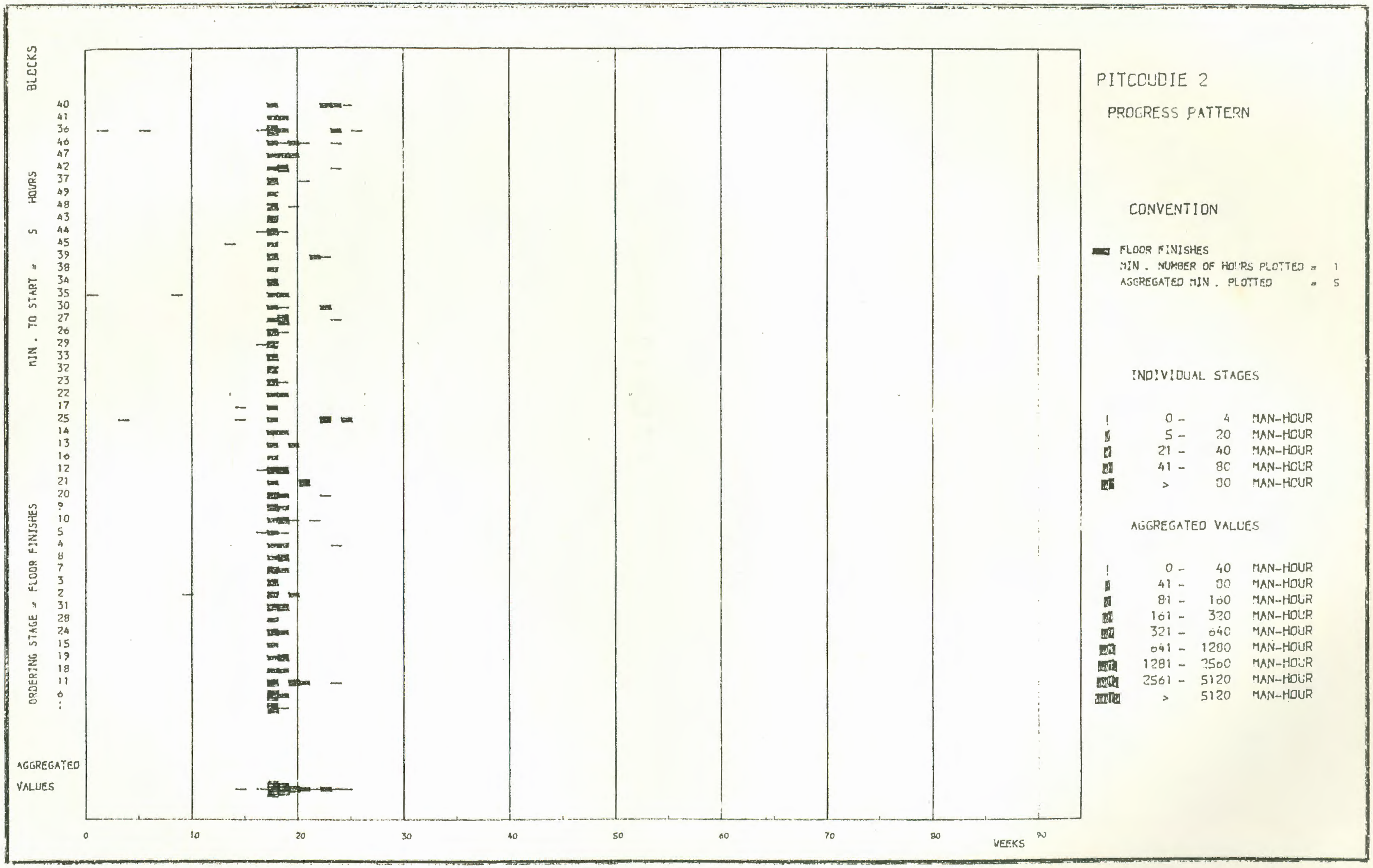

PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
HARLING
MIN. NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN. PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 120 MAN-HOUR
121 - 160 MAN-HOUR
161 - 200 MAN-HOUR
> 200 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 120 MAN-HOUR
121 - 200 MAN-HOUR
201 - 280 MAN-HOUR
281 - 360 MAN-HOUR
361 - 440 MAN-HOUR
441 - 520 MAN-HOUR
521 - 600 MAN-HOUR
601 - 680 MAN-HOUR
681 - 760 MAN-HOUR
761 - 840 MAN-HOUR
> 840 MAN-HOUR
BLOCKS
AGGREGATED VALUES
WEEKS

FIG. 94



PITCOUDIE 2
PROGRESS PATTERN
CONVENTION
FLOOR FINISHES
MIN . NUMBER OF HOURS PLOTTED = 1
AGGREGATED MIN . PLOTTED = 5
INDIVIDUAL STAGES
0 - 4 MAN-HOUR
5 - 20 MAN-HOUR
21 - 40 MAN-HOUR
41 - 80 MAN-HOUR
> 80 MAN-HOUR
AGGREGATED VALUES
0 - 40 MAN-HOUR
41 - 80 MAN-HOUR
81 - 160 MAN-HOUR
161 - 320 MAN-HOUR
321 - 640 MAN-HOUR
641 - 1280 MAN-HOUR
1281 - 2560 MAN-HOUR
2561 - 5120 MAN-HOUR
> 5120 MAN-HOUR
BLOCKS
MIN . TO START = 5 HOURS
ORDERING STAGE = FLOOR FINISHES
40 41 36 46 47 42 37 49 48 43 44 45 39 38 34 35 30 27 26 29 33 32 23 22 17 25 14 13 16 12 21 20 9 10 5 4 8 7 3 2 31 28 24 15 19 18 11 6
AGGREGATED VALUES
0 10 20 30 40 50 60 70 80 90
WEEKS

FIG. 95

Bibliography

Bibliography

1. Bishop, D. The background to Management Studies by BRS, Building Research Station Current Paper, Garston, BRE, August 1968.

2. Building Management and Marketing Consultant Ltd, " Key Trend Method of Project Control", Construction (published by the Department of Environment), n 15, September 1975, pp. 18, 19 and 20.

3. Building Research Establishment, Flow Charts to Control Progress on Housing Sites, Building Research Station Digest n 134, London, HMSO, October 71.

4. Calderbank, U.J.; Prior, W.A.J. The Ghost Graphical Output System - User's Manual - , Oxon, UKAEA Culham Laboratory, June 1977.

5. Carr, Robert Synthesis of Uncertainity in Construction Planning, Phd Thesis, Department of Civil Engineering, Stanford University, 1971.

6. Committee on Housing , Building and Planning, Economic Comission for Europe, United Nations, Effect of Repetition on Building Operations and Processes on Site, Report of an Enquiry undertaken by the Committee on Housing, Building and Planning, New York, United Nations, 1965.

7. Fine, Brian "Tendering Strategy", Building, 25 Oct. 74, pp. 115, 117, 119 and 121.

8. Forbes, W.S.; Skoyles, E.R. The Operational Bill, Building Research Station Design Series n 1, Garston, BRS, 1963.

9. Forbes, W.S.; Stjernstedt, R. The Finchampstead Project, Building Research Station Current Paper CP 23/72, Garston, BRS, 1972.

10. Forbes, W.S. The Rationalization of House Building, Building Research Establishment Current Paper CP 48/77, Garston, BRE, September 1977.

11. Forbes, W.S. House Building Productivity at Ladygate Lane, Hillingdon, Building Research Establishment Internal Note, Garston, BRE, March 1980.

12. Forbes, W.S. The Relevance of the BRE Productivity Studies to Estimating, Building Research Establishment note n 143/80, Garston, BRE, November 1980.

13. Forbes, W.S. The BRE Site Activity Analysis Package, Building Research Establishment note n 13/81, Garston, BRE, January 1981.

14. Hall, B.; Ball, S. Industrial Training Report - Report on Industrial Training at the Transport and Road Research Laboratory exploring Cost Models based on Precedence Diagrams, Sheffield, Sheffield City Polytechnic, 1978.

15. Hareli, M. "Optimizing the Execution Sequence in Construction Projects with Repetitive Processes", CIB - 65 Second Symposium on Organization and Construction Management of Construction, Haifa, Israel, October 31 - November 2 1978, 1978, Volume II, pp. II/217- II/230.

16. International Computers Limited (ICL), PERT DISC - User's Manual, London, International Computers Limited, 1972.

17. Lumsden, P. The Line of Balance Method, London, Pergamon Press, 1968.

18. Pigott, P. T. "Some Factors Influencing Productivity in House Building", CIB - 6th Congress - The Impact of Research on the Built Environment, Budapest, 1974, Vol. 2, pp. 269 - 274.

19. Pigott, P. T. A Productivity Study of Housebuilding, 2nd. Impression, Dublin, An Foras Forbartha - The National Institute for Physical Planning and Construction Research - , December 1974.

20. Price, K.; Horn, A. Industrialised Two-storey Housing - A Productivity Study - , London, The National Building Agency, August 1970.

21. Roderick, I. F. Examination of the use of Critical Path Methods in Building, Building Research Establishment Current Paper n 12/77, Garston, BRE, March 1977.

22. Scientific Applications Division - Logica Ltd - , Building Research Establishment Activity Analysis Package, London, Logica Limited, Vol. 1, August 1978.

23. Scottish Development Department, Urban Design and Research Division, Pitcoudie Housing Development for Glenrothes Development Corporation, Edinburgh, Scottish Development Department, March 1979.

24. Shanley, L. F.; Keaney, B. J. An Examination of Labour Content in Housing, Dublin, Ann Foras Forbartha, May 1970.

25. Stevens, A. J. Activity Sampling on Building Sites, Building Research Station Current Paper, CP n 16/65, Garston, BRE, May 1969.