APPENDIX II: Details of Brabazon "167" Aircraft.

Wing-span: feet	230
Gross wing-area: square feet	5,317
Overall length of fuselage: feet	177
Diameter (maximum) of fuselage:	16 feet 9 inches
Tailplane span: feet	75
Tailplane area: square feet	1,103
Height over rudder: feet	50
Rudder area: square feet	692
All-up weight: lb.	285,000 (127 tons approx.)
Main undercarriage wheel-base: feet	55
Main undercarriage C.L. to nose wheel: feet	64
Main undercarriage tire-pressure: lb. per square inch	90

APPENDIX III: Testing of Structural Materials.

Apart from the routine tests of materials carried out to ensure general conformity to specification, others of a special character were called for by the unusual nature of the structure. Among these were the following :—

1. Tests of ties and struts compounded before and after application of load.
2. Elongation tests on bolted joints to determine movement arising from bolt slip and embedment.
3. Strain measurement in main arch members by electrical resistance strain-gauge.
4. An investigation into the nature of vibration in catwalks.
5. Load testing and X-raying to welds of crane gantries.
6. Mechanical and corrosion tests on folding doors.
7. Testing of asbestos sheeting for anchorage, as mentioned in the Paper.
8. Examination of soil shear strength and modulus of sub-grade reaction.

Limitation of space has rendered it impossible, in a Paper of such wide scope, to describe these tests in detail. It is proposed, however, that at a later date the methods adopted should be reviewed and the results published at greater length.

Discussion.

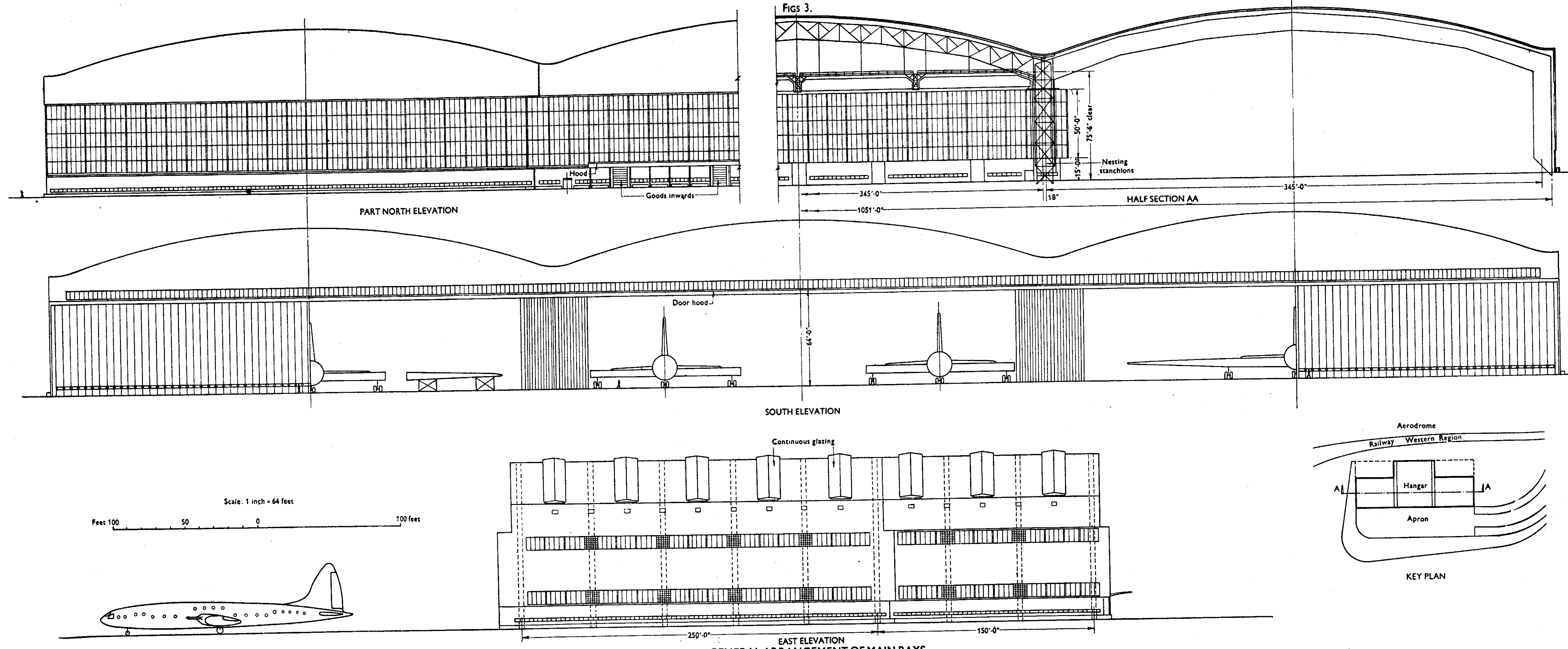
The Author introduced the Paper with the aid of a series of lantern-slides.

Mr. G. S. Hallas observed that he had been fortunate enough to be able to watch the growth of the structure from its early stages to its completion. Some indication of the magnitude of the scheme could be gained from the impressive list of contractors and sub-contractors given in Appendix I.

Unusually severe site conditions had prevailed during the first winter when the work was in progress. The rainfall in the early part of the winter was altogether abnormal, and the subsequent frost added to the problems with which the contractors were faced. In view of those conditions, the undertaking reflected the greatest credit on all concerned and showed the

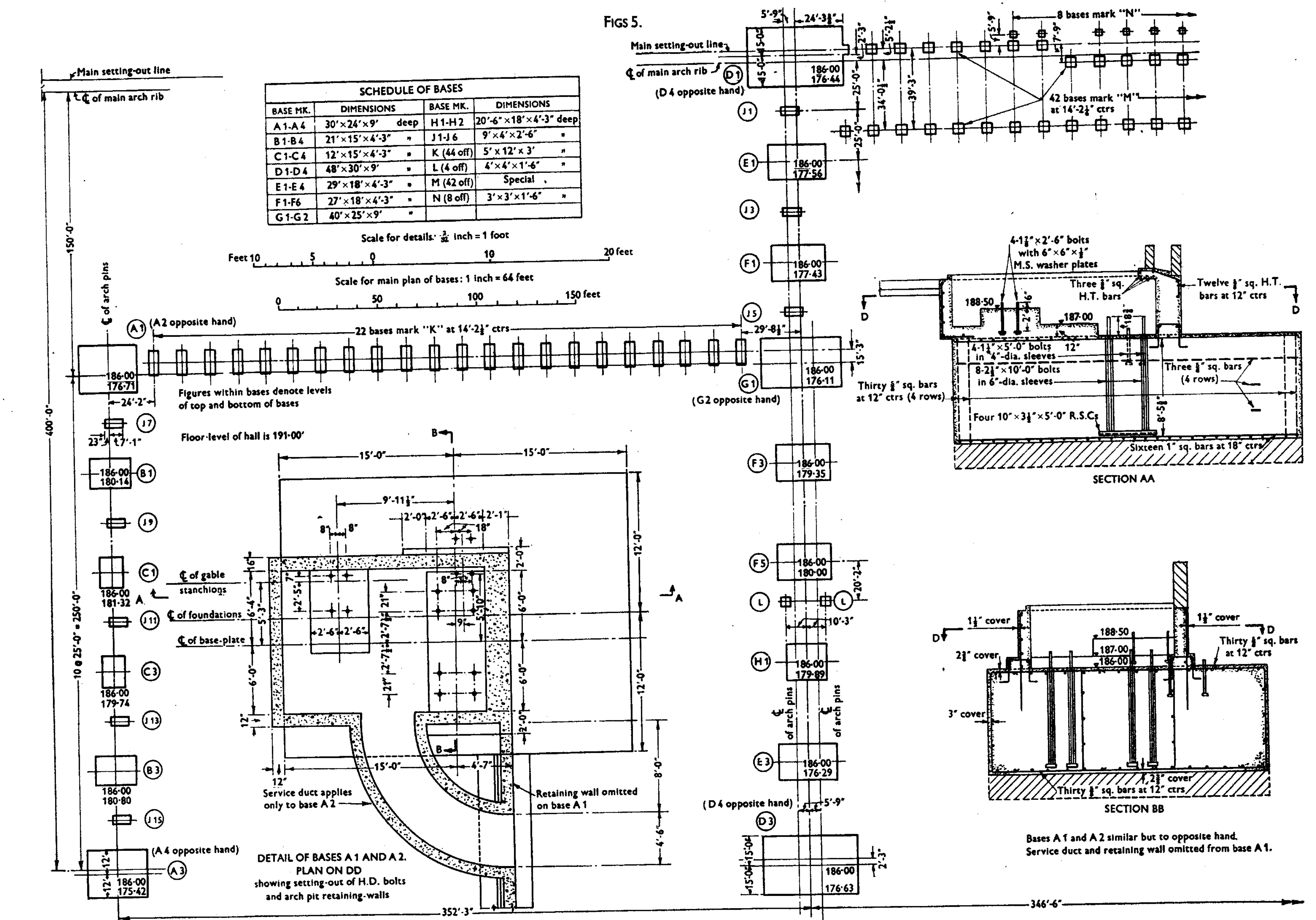
THE BRABAZON ASSEMBLY HALL AT FILTON.

Figs 3.



GENERAL ARRANGEMENT OF MAIN BAYS

Figs 5.



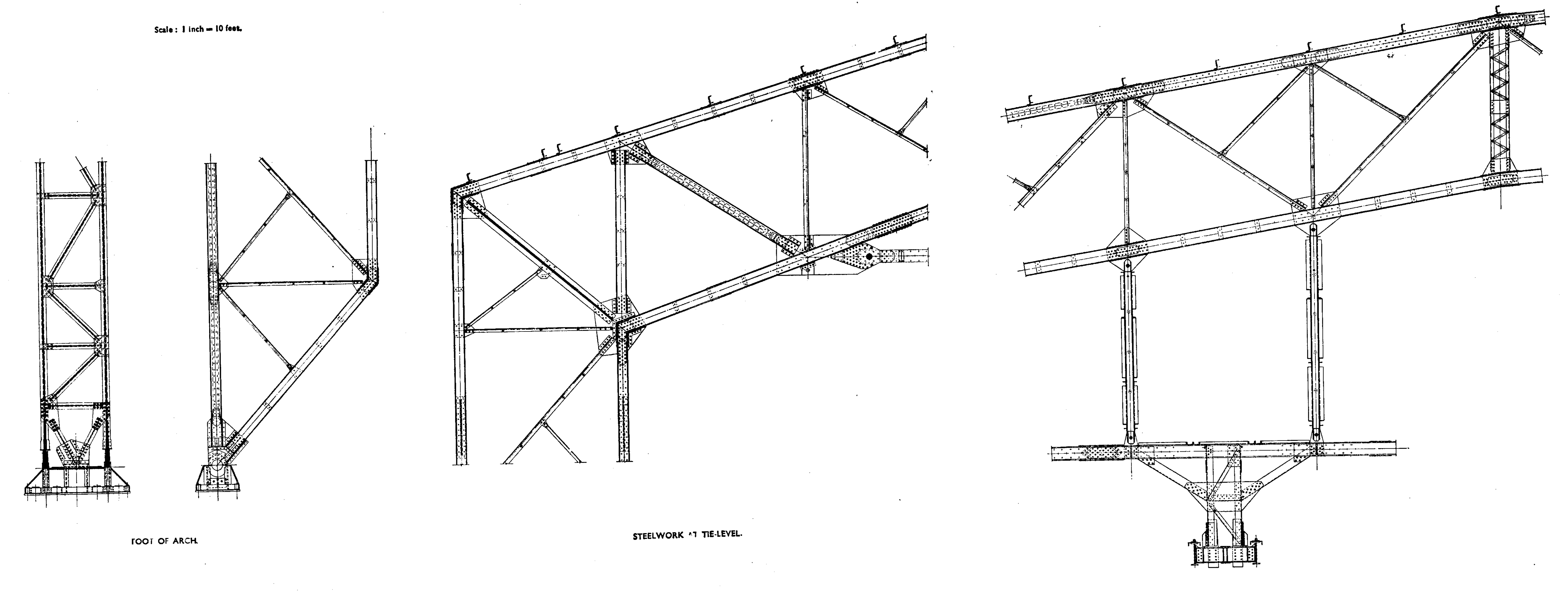
SCHEDULE OF BASES			
BASE MK.	DIMENSIONS	BASE MK.	DIMENSIONS
A 1-A 4	30′×24′×9′ deep	H 1-H 2	20′-6″×18′×4′-3″ deep
B 1-B 4	21′×15′×4′-3″ "	J 1-J 6	9′×4′×2′-6″ "
C 1-C 4	12′×15′×4′-3″ "	K (44 off)	5′×12′×3′ "
D 1-D 4	48′×30′×9′ "	L (4 off)	4′×4′×1′-6″ "
E 1-E 4	29′×18′×4′-3″ "	M (42 off)	Special
F 1-F6	27′×18′×4′-3″ "	N (8 off)	3′×3′×1′-6″ "
G 1-G 2	40′×25′×9′ "		

Bases A1 and A2 similar but no opposite hand. Service duct and retaining wall omitted from base A1.

GENERAL ARRANGEMENT OF STANCHION BASES AND DETAIL OF BASES A1 AND A2

Figs 7.

Scale: 1 inch = 10 feet.



TYPICAL STEELWORK DETAILS OF MAIN ARCH.

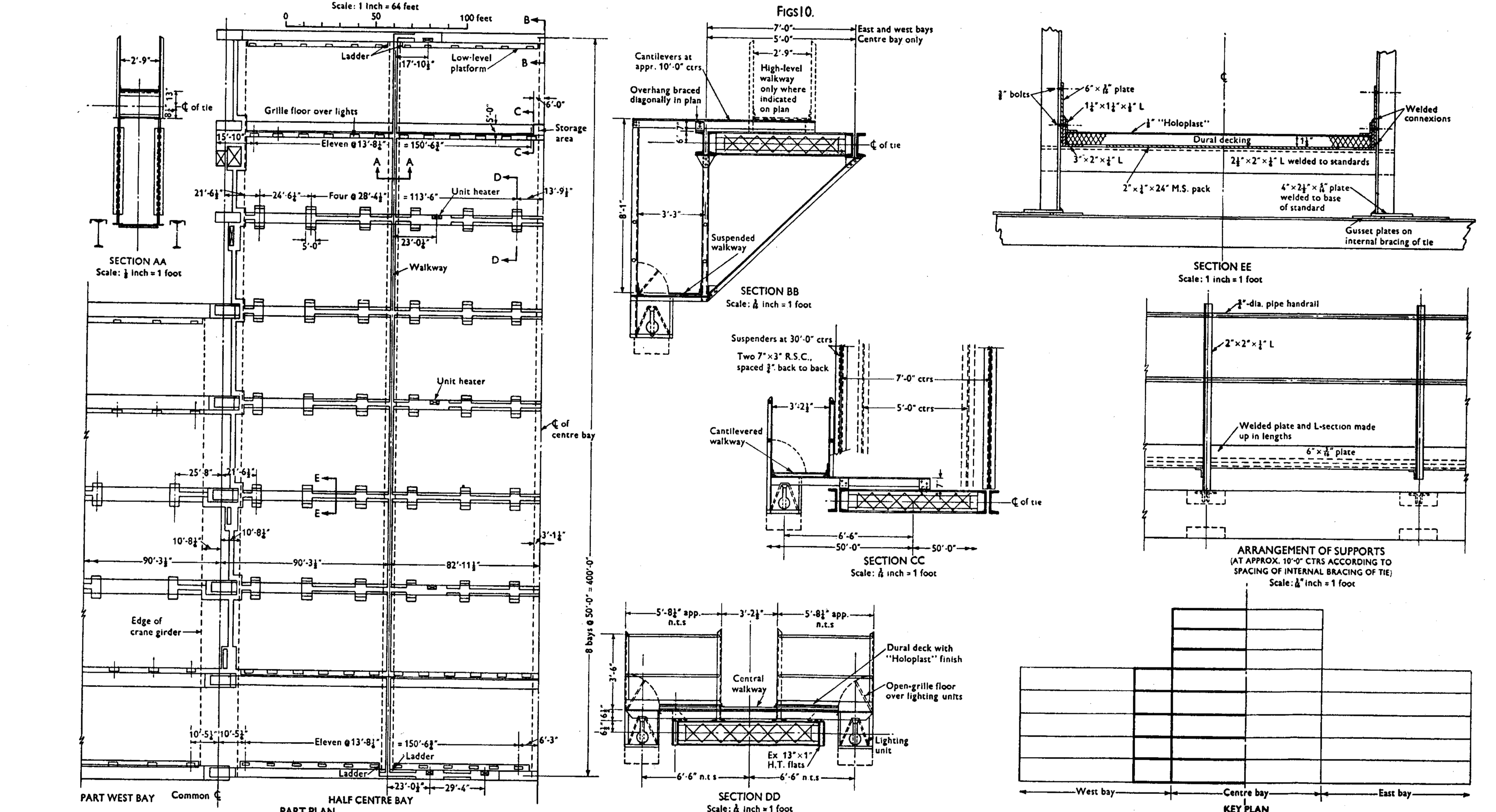
C. B. H. COLQUHOUN.

WILLIAM CLOWES & SONS, LIMITED: LONDON.

PLATE 2.

THE BRABAZON ASSEMBLY HALL AT FILTON.

Figs 10.

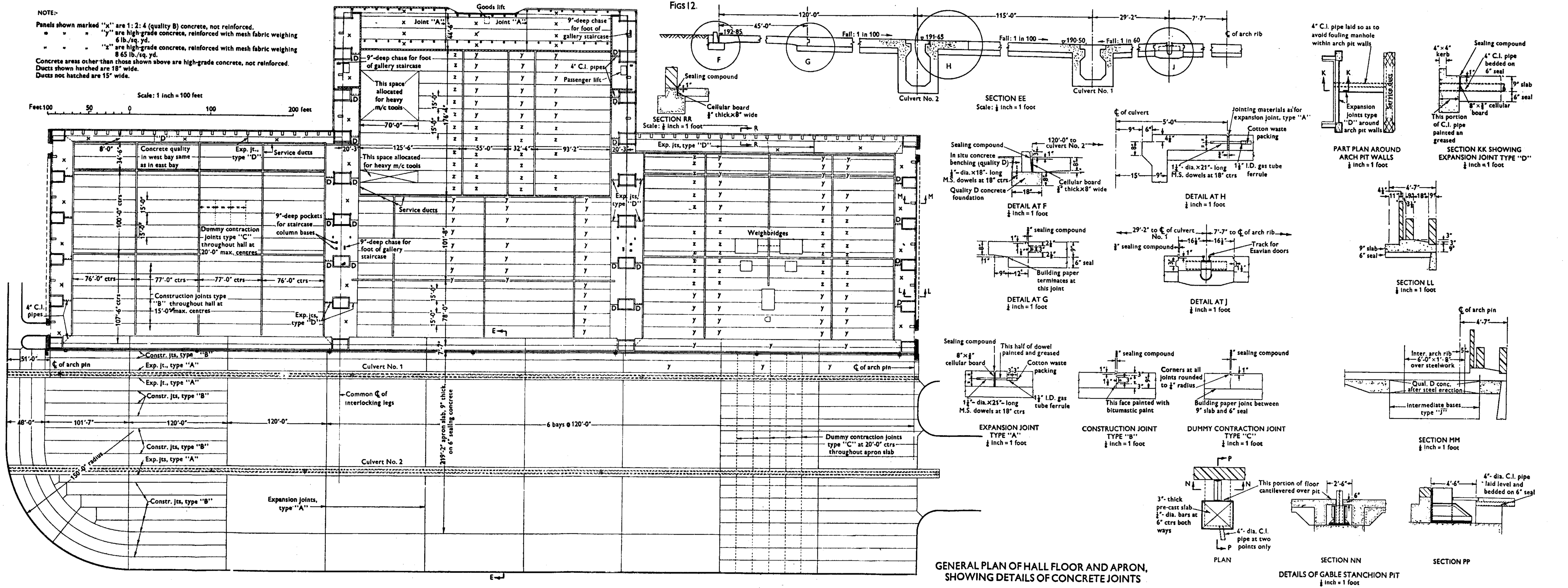


GENERAL ARRANGEMENT AND DETAILS OF WALKWAYS

C. B. H. COLQUHOUN.

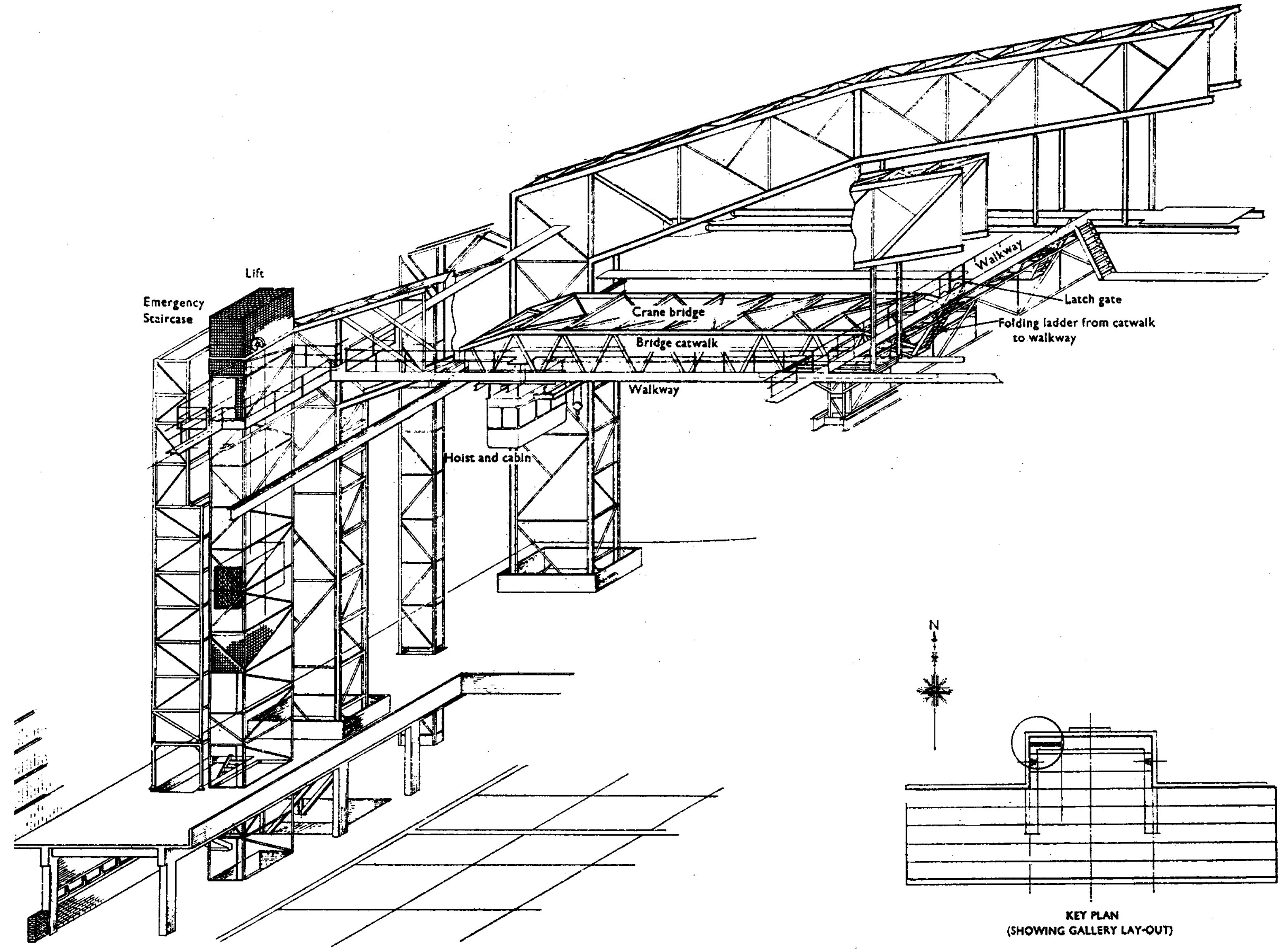
THE BRABAZON ASSEMBLY HALL AT FILTON.

Figs 12.



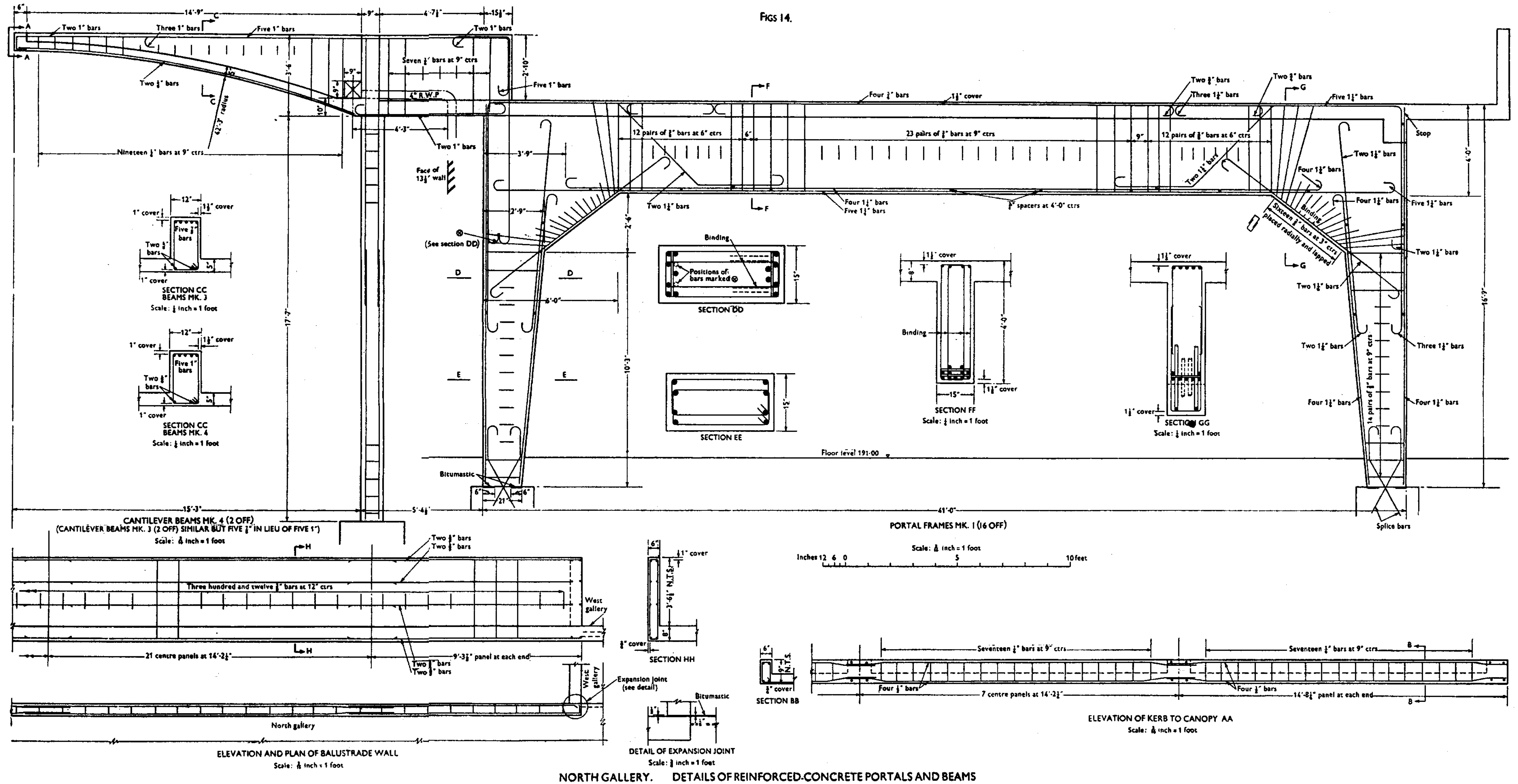
GENERAL PLAN OF HALL FLOOR AND APRON, SHOWING DETAILS OF CONCRETE JOINTS

FIG. 13.



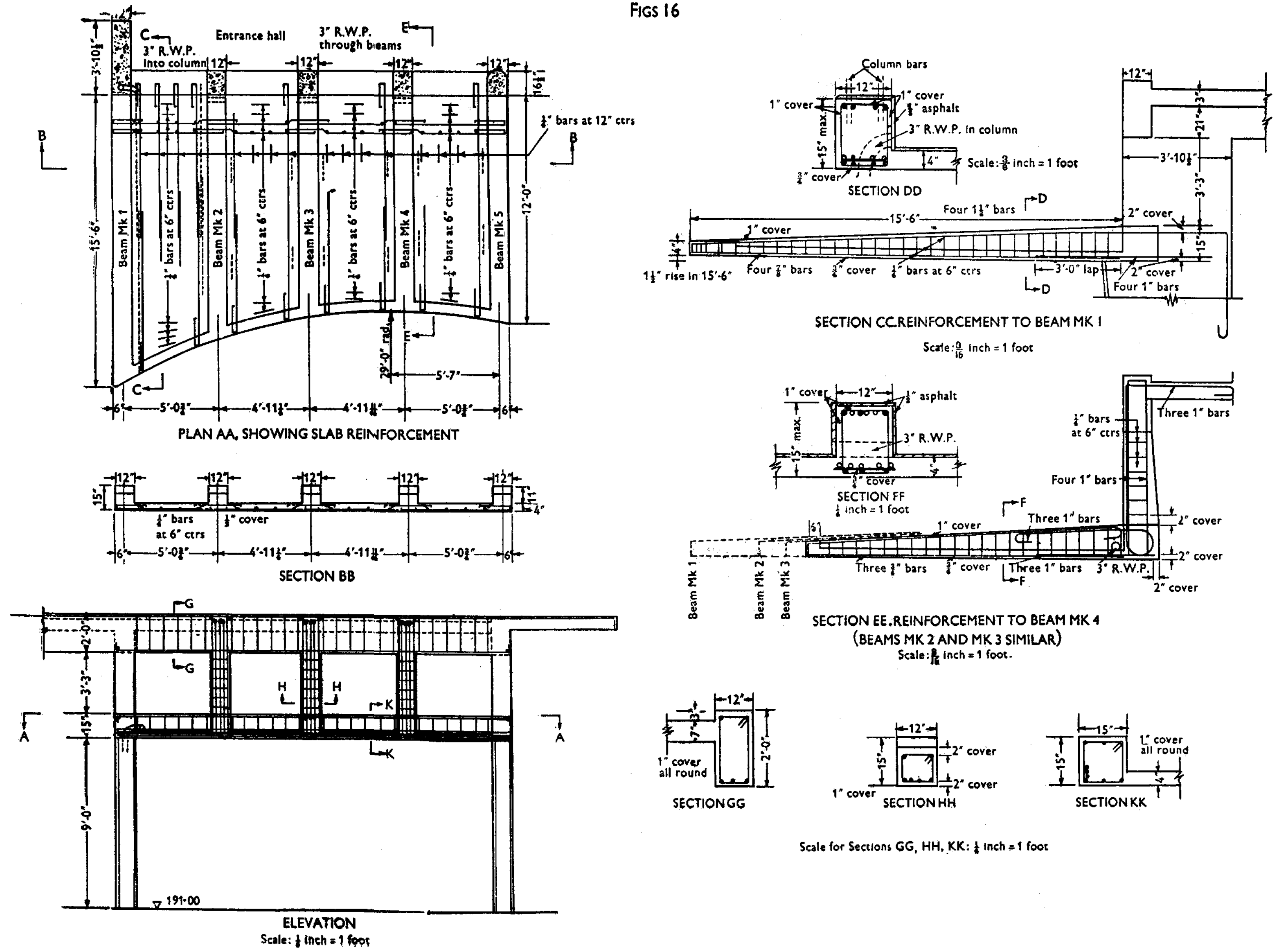
ACCESS ROUTE FROM HALL FLOOR TO CRANE CAB

FIGS 14.



NORTH GALLERY. DETAILS OF REINFORCED-CONCRETE PORTALS AND BEAMS

FIGS 16



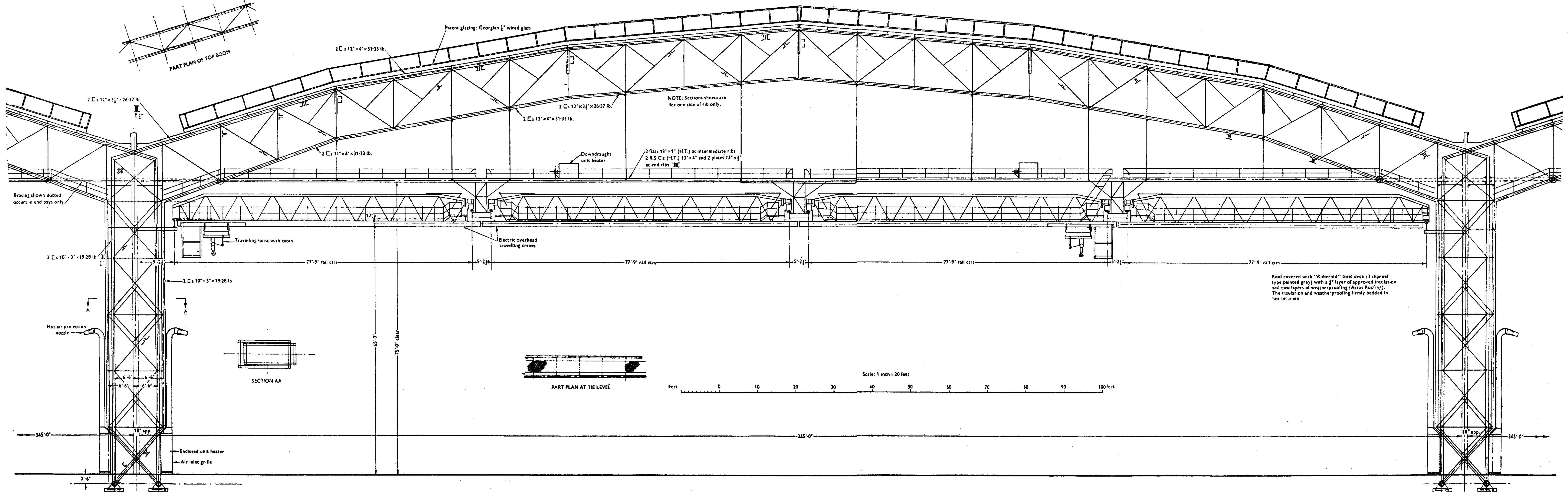
REINFORCED-CONCRETE CANOPY TO V.I.P. ENTRANCE

…liam Clowes & Sons, Limited: London.

C. B. H. COLQUHOUN.

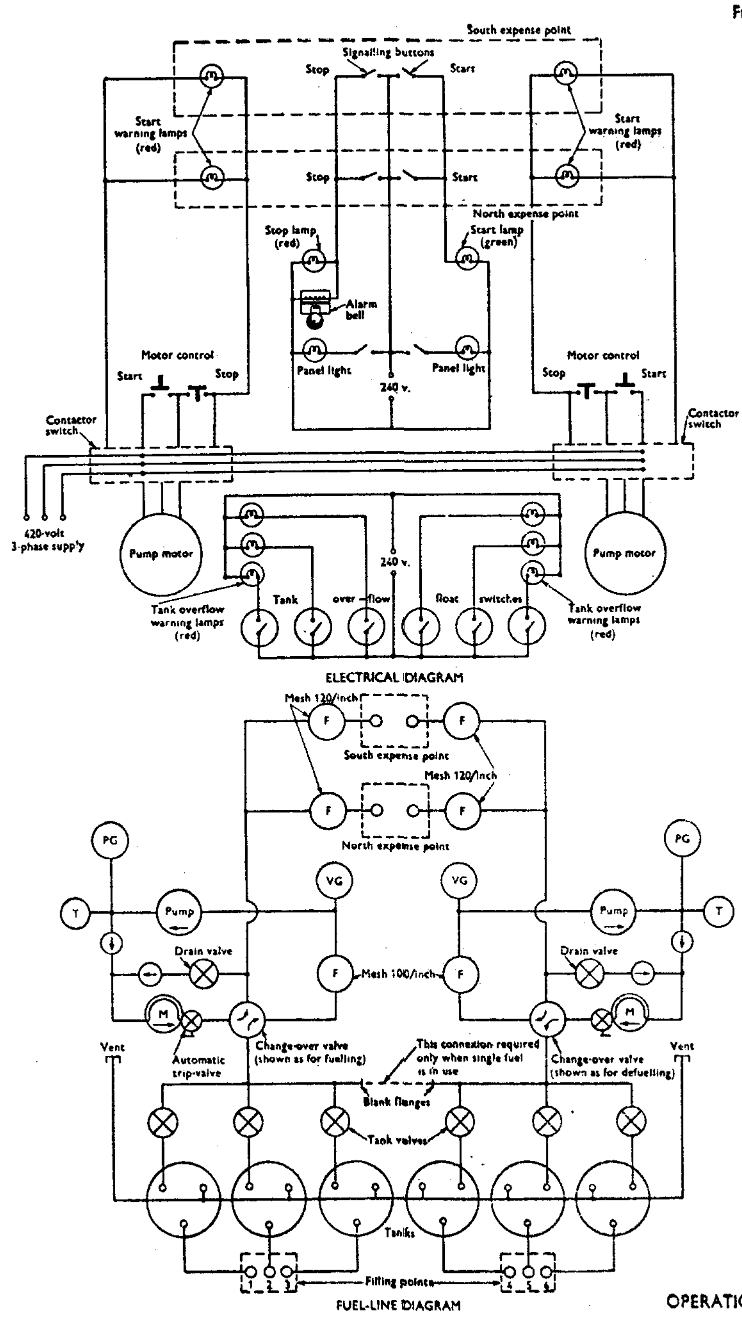
THE BRABAZON ASSEMBLY HALL AT FILTON

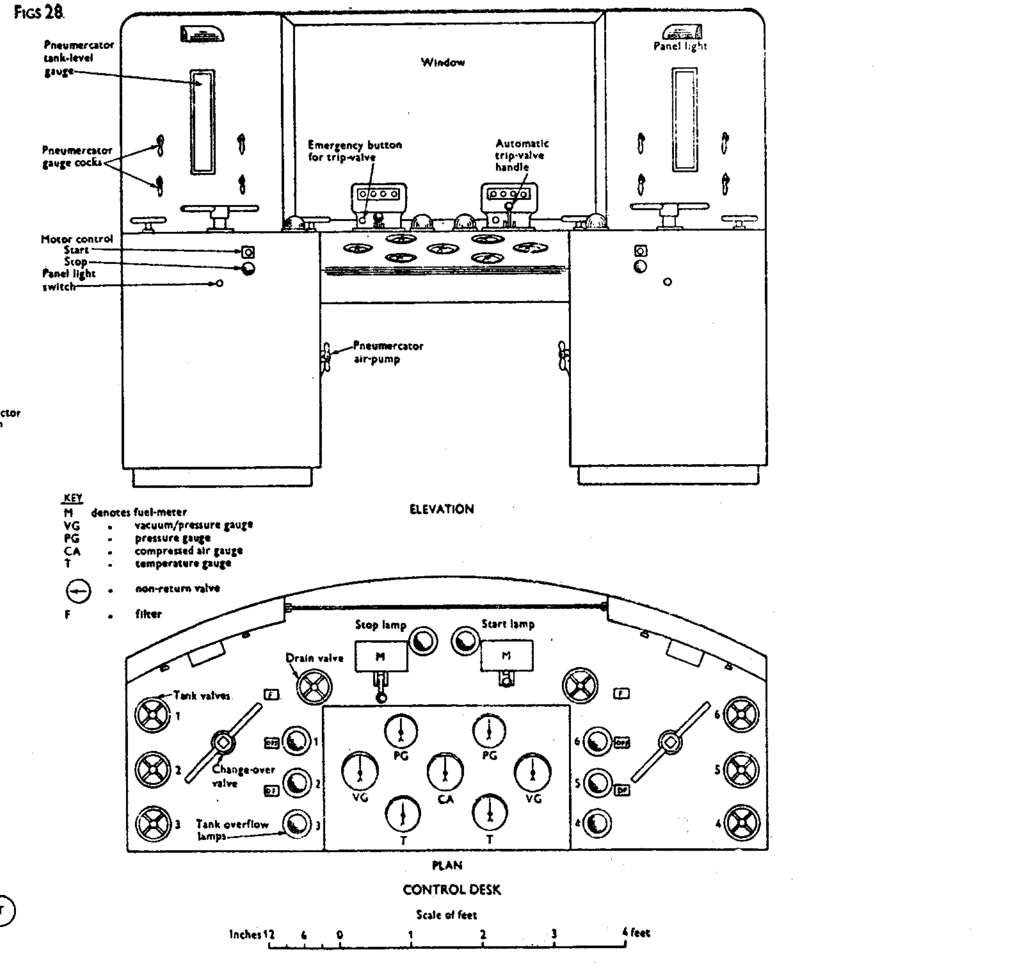
FIGS 25.



CROSS-SECTION OF CENTRE SPAN

FIGS 28.





OPERATION

FUELLING
Open tank valve of selected tank
Set change-over valve to "FUEL" position.
Set meter trip reading to number of gallons required
Start motor when "START" signal has been received.
Open automatic trip-valve slowly
Trip-valve will stop flow when required amount has passed through meter.
NOTE: Prime the line to expense points before setting meter trip reading.

DEFUELLING THROUGH PUMP.
Open tank valve of selected tank.
Set change-over valve to "DEFUEL" position
Start motor when "START" signal has been received
Open automatic trip-valve slowly

DEFUELLING BY GRAVITY.
Open tank valve of selected tank.
Set change-over valve to "DEFUEL" position.
Open drain valve
Open automatic trip-valve slowly when "START" signal has been received

EMERGENCY STOP:
Press meter "STOP" button.
Stop motor.

OPERATION OF FUEL INSTALLATION

C. B. H. COLQUHOUN.

WILLIAM CLOWES & SONS, LIMITED: LONDON.

care with which the work was organized and the resource displayed in its execution.

It was difficult to treat a scheme of such magnitude in a single Paper with the detail that it merited, and further information on many aspects of the design and work would be of interest. For instance, the provision of a cross-tie at haunch-level in the main two-pin portal frame was an interesting feature and it had probably had the effect of lightening the rib section; but it had also presumably complicated the stress calculations considerably. In Appendix III it was stated that strain measurements in the main arch members had been taken, but that limitations of space prevented inclusion of the details. How closely had the test results agreed with the mathematical stress analysis of the design?

Apparently the original proposal had been to lay the final concrete floor on a hardcore foundation, but the weather and site conditions during construction had led to the provision of a lean-mix concrete base slab immediately under the floor slab proper. If the original design had been to provide that lean-mix slab, would the same design have incorporated dowels and rebates for the transference of the load at the edges of the main slab in the design? Possibly it would have been less difficult from the execution point of view, and perhaps more economical, to lay the floor in two thicknesses.

For insulation it was admittedly necessary to line the walls of the Hall, but the use of fibre board seemed to introduce a fire risk. Doubtless that had been considered, but such information had not been given in the Paper. Further, the Paper contained no reference to fire precautions or fire protection arrangements. In view of the value of the structure itself and of its contents, the aircraft, that was of considerable importance.

Mr. Hallas's observations were intended merely as a request for information, and no criticism was implied.

Mr. Eric Ross observed that the use of reinforced concrete had been very seriously considered in the early stages of the design of the Hall, but the circumstances at that time had imposed the use of structural steelwork owing to the difficulties and uncertainties in the delivery of cement and suitable aggregates, the shortage of formwork and shuttering, and—not least important—the necessity for providing the crane system suspended from the roof.

From the outset it was considered that something better than a mere shed or hangar should result from the labours and money to be expended on the undertaking, and therefore those concerned had set out from the beginning to try to create in the vast structure something that would not spoil the countryside, would be pleasing to the eye, and at the same time would introduce certain humanizing and other elements into the structure —in fact, to create something creditable both to architecture and to engineering; and those conditions were to be co-ordinated and interwoven with the purely functional and structural aspects of the project.

Although, basically, the building was designed for a specific purpose, in considering the general lines to be adopted, not only in respect of the structure but also in regard to the disposition of its services and in other directions, it was felt that a potentially wider field of user should be envisaged, so that any new requirements or changed conditions in production could be accommodated both rapidly and economically. That action had already been justified by the advent of B.O.A.C. and its occupation of the west bay for a purpose very different from that for which the building was originally intended. The consequential complete rearrangement of the production lay-out in the other two bays had been facilitated considerably, if not rendered possible, by the measures to which he had referred.

Following the trying conditions of the summer, the winter had also been extremely severe, whilst the imposition of railway embargoes had resulted in some thousands of tons of steel arriving at the wrong time and in the wrong place.

He hoped that a not unpleasing effect had finally been achieved. The lantern-slides could not illustrate that adequately, because colour had been introduced to give a varying vigour to the scene when the main structure was considered in conjunction with the smaller ancillary buildings grouped about it, which formed an essential part of the architectural composition.

First, the earthworks and deep excavations had been treated as a series of terraces sloping gently down from the existing hillside to the edge of the concrete apron on the south side of the building. Those terraces and slopes had been sown with grass and later would be planted with trees and shrubs to give a park-like atmosphere.

The Assembly Hall itself faced south on to the apron and the whole of that elevation was occupied by the vast sliding and folding doors which gave access to each of the three bays. Those doors were painted a pale green and were surmounted by a neat canopy painted ivory white, which was continued in the return ends down to the ground-level, thus forming a frame to the doors. The gable ends were enclosed with corrugated asbestos treated in a pleasing shade of pink. The end elevations were pierced with clerestory lighting at various levels convenient to the internal lay-out, and that part of the building was clad externally with corrugated asbestos sheeting finally coloured cream. The scheme of pink and cream was continued on the north elevation, where the main feature was the vast window, the proportions of which had proved extremely satisfactory in every way.

The ancillary buildings, grouped on three sides of the Assembly Hall, consisted of the substation and other service buildings on the north, the canteen, boiler-house, and other buildings on the east, and the buildings for the B.O.A.C. base on the west.

The particular problem in respect of these relatively small-scale buildings was not only to make them of individually good design but also to impart a calculated dramatic effect in their lightness and grouping as they moved panoramically across the towering and elegant severity of the main hall; in fact, to create a group in which the overpowering effect of the central mammoth hall on the smaller buildings was reduced as much as possible.

The Assembly Hall provided an example of what could be achieved by co-operation between the architect and the engineer, and Mr. Ross hoped it would be agreed that the combined effort had produced a pleasing result. Despite the difficult conditions with which they had had to contend, the engineers and architects concerned had endeavoured to avoid the unfortunate state of affairs that not infrequently occurred, in which either a good engineering job was masked by an architectural façade or the architectural aspect was subordinated to an unaesthetic solution of the engineering problem.

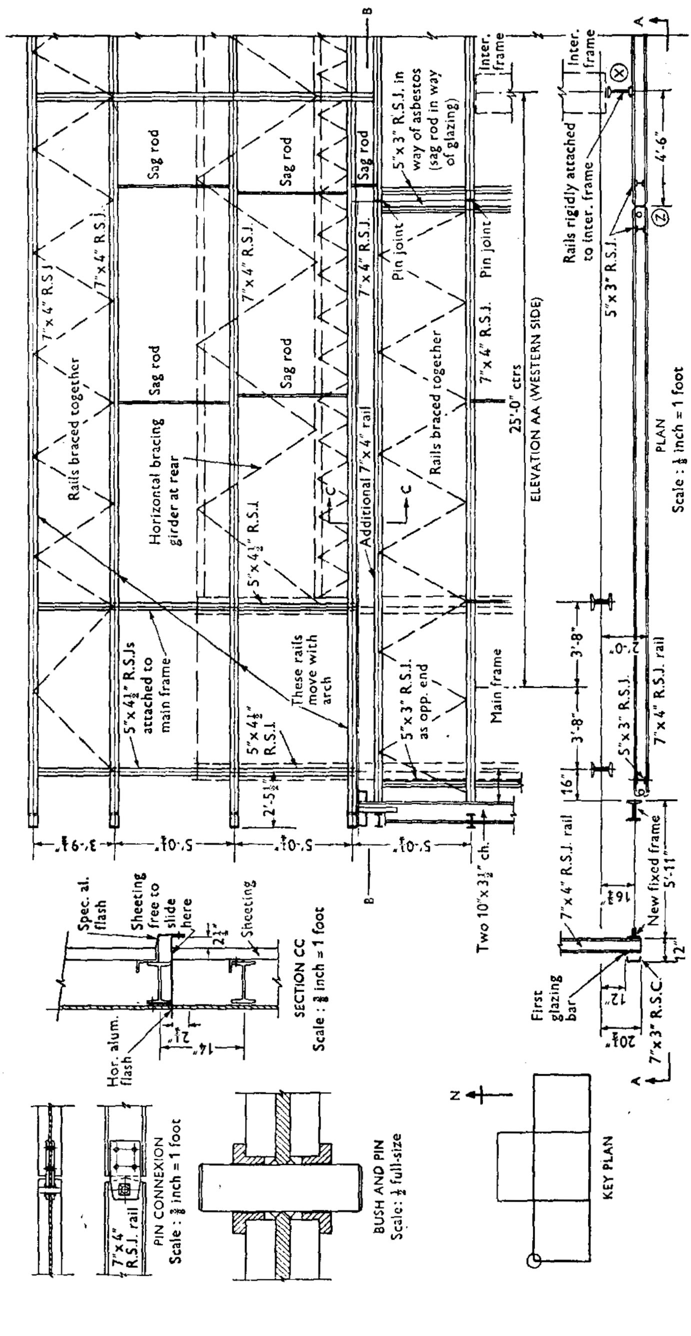
Dr. T. P. O'Sullivan observed that *Fig. 13* gave a good impression of the general contour of the structure and of the problems encountered in arranging cranage facilities. The perspective showed the gantries running at a height of about 65 feet and the very arduous design conditions under which, at that height, the full area had to be covered, so that a load could be transferred from any one point to any other point. That had led to what might be regarded as an excessive provision of steel, namely, 9,000 tons, in the structure. If those exacting requirements had not existed and no cranes at all had had to be provided, a considerable saving could have been made. The Consulting Engineers had been approached by people—some very nebulously connected with the work—who fell into two schools, the light school and the heavy school, each of which was approximately equal in numbers. The light school raised objection to an extravagant waste of steel, whilst the heavy school contended that the structure was so flimsy that it was liable to collapse.

A rather unusual technical problem was met in the course of completing the design, in regard to the methods adopted for suspending the steel sheeting-rails which carried the asbestos sheeting which, by its very nature, was rather fragile.

Figs 29 showed a key plan and certain details of the solution at the corner ringed in the key plan. It should be understood that the wind-pressure arising from the design velocity of 75 miles per hour caused an anticipated sway of the structure of ± 5 inches at tie-level. In view of the fact that it was thought necessary to maintain the framing for the glazing on the north walls absolutely rigid, it was apparent that provision for considerable differential movement at tie-level should be made at the northern corners.

Figs 29 (*a*) showed the general arrangement adopted from approximately tie-level downwards. At point X the sheeting rails were fixed to the arches subject to sway up to the intermediate frame next to the end arch (the northernmost arch in the Western Bay). At point Y the main frame formed part of the glazing supports and was not subject to sway.

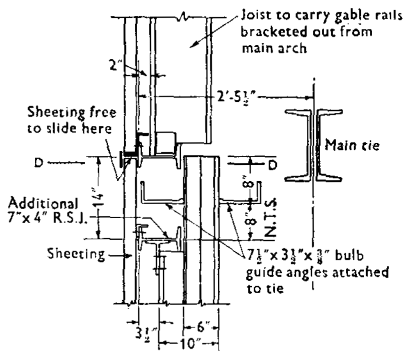
Fig. 29 (a).



Detail of Movement Joints in West Bay Wall.

Therefore, arrangements were made to cantilever out, in order to reduce the span of the sheeting rails, from point X to point Z, and to fix the last section of sheeting rail to that connected to the intermediate frame by means of a pin joint at that point, the other end of the link being fixed by another pin joint at point Y. That arrangement permitted a full parallel sway movement of ± 5 inches of the rail in a direction perpendicular to the line ZX, the rail on line YZ acting accordingly with fixed fulcrum at Y. The maximum angular movement to be permitted between YZ and ZX to safeguard the sheeting against fracture was estimated at 1 degree of angle. The linkage itself was shown at the top left of *Figs 29* (*a*).

Fig. 29 (*b*).



MOVEMENT JOINT AT HEAD OF MAIN NORTH GLAZING FRAMES.

Figs 29 (*a*) included a general elevation of that arrangement which applied line BB downwards. Above line BB it was necessary to alter the arrangement to ensure continuity in roof sheeting and gable; that was done by means of the sliding joint and flashing shown in section CC. *Fig. 29* (*b*) showed how the arrangement was carried along the north wall with provision for the sheeting above DD to move relative to the lower part. The bulb angles shown were fixed to the main tie and therefore were subject to upward and downward movement with load; thus they could slide vertically on the fixed stanchion of the glazing framework.

At the time of presentation of the Paper, whilst some panes of glass had been lost through negligence, there was no evidence of fracture of the asbestos sheet cladding. It might be considered, therefore, that a device such as that described for attaching sheeting had proved reasonably successful, having been in use for about 18 months, during which time severe gales had occurred.

Mr. C. S. Gray observed that the design had been worked out in detail well in advance of any really accurate information about what was eventually going to be required, other than the main features of height, width, and length. Crane details were altered. No information had been available as to the provision of services, so that the unfortunate designer, who, as Dr. O'Sullivan had stated, was alternatively tilted at for making the structure too light or too heavy, was forced at the outset to exercise engineering judgment in regard to the loads which he should allow to obtain the sizes of scantlings corresponding to the stresses that he adopted. That trebly indeterminate structure was a large venture, but the designers had taken their courage in both hands and had used an entirely unknown formula. That formula had subsequently been checked by a number of people on the more generally accepted bases, but so far they had not proved that the structure was deficient in any way, or that it was much too heavy: in fact, Mr. Gray regarded the structure as being rather light if due account were taken of what it really did. Movement was permitted in all directions. That the three bays were entirely separate entities resulted naturally from the width, as a watertight roof of 1,000 feet was an impossible proposition. The idea of nesting the stanchions one within the other had just grown. Independent stanchions were proposed, side by side, and it had seemed a small step to put them one within the other. The decision to do that was taken well in advance of any details being worked out, and the troubles subsequently encountered were best left to the imagination. Three designers were constantly watching for snags in the intersections of all the very complicated work, particularly near eaves-level. Dr. O'Sullivan had mentioned that the side sway was calculated to be about 5 inches. The main tie stretch from no load to full load was about 4 inches, but, despite that, the cranes could run quite successfully on the structure. The doors had been designed to suit the same conditions as the hangar; but the function of a door was to open and shut independently of whether the hangar rose or fell or moved sideways. All those features had caused the designers a good deal of worry, but Mr. Gray thought that they had surmounted the difficulties reasonably well.

Mr. F. D. Thomas observed that in normal circumstances the provision of scaffolding would have rested upon the principal contractor, or, alternatively, the fact that scaffolding had to be provided would have been made clear to the nominated and other sub-contractors when tendering. The Author and his staff had considered that further thought should be devoted to that matter, and it was decided to assess the scaffolding problem involved in order to determine the feasibility or otherwise of entering into a contract with a specialist contractor to provide the various sub-contractors with scaffolding, on the basis that scaffolding would be provided as and when necessary at the direction of the Consulting Engineers. The Author had concluded that a considerable saving in money and in material would be effected if scaffolding requirements were co-ordinated by the

Engineer-in-Charge at site. That principle was established and put into practice, and it subsequently proved to be correct.

The basis upon which to form a comparison in respect of competitive tendering was rather difficult to establish, but eventually it was decided to seek quotations on the assumption that the Assembly Hall would be completely scaffolded at least once. The contract was let, and discussions with the contractors were very helpful in the formulation of a policy, and the close and frequent contact between the scaffolding contractors and the site staff resulted in the programme being arranged and modified where necessary, and in co-ordination of the requirements of the various principal sub-contractors.

The general construction programme being known to the site staff, it became a relatively simple matter, in certain cases, to leap-frog the use of both tube and scaffolding boards; moreover, opportunity was taken from time to time to allow the use of a certain section of scaffolding for many sub-contractors and, since the scaffolding was not the responsibility of any particular sub-contractor, the use of a section by many of the contractors or sub-contractors was permitted on direct request and approach to the Engineer-in-Charge at site. That arrangement might seem rather complicated, but its application allowed of day-to-day consultation as to the best and most economical use of scaffolding in general. The assessment of the saving in timber alone was about 200–300 standards, with a proportionate economy in the use of skilled labour.

Mr. J. McHardy Young observed that the design of any roof of the magnitude of that at Filton presented a peculiarly fascinating problem to a structural engineer. The actual design seemed to be essentially a two-pin arch with an additional tie introduced above the haunch-level. The tie introduced a redundancy and Mr. Young considered that under some loading conditions it would cease to be an effective structural member and might have the effect of reducing the depth of the structure between the points of attachment of the tie. He belonged to the school which regarded 9,000 tons of steelwork as rather on the heavy side.

The erection of the roof had involved a considerable quantity of staging and he wished to inquire the cost of erection per ton.

He considered that the problem might have been solved by the introduction of a structure on the lines shown in *Fig. 30*, with the pins in the air. The virtue of that was that the vertical towers and the cantilevers could be erected and tied back and it would probably be possible to erect the central portion in one portion riveted complete on the ground. Again, the same design could have been adapted to meet the multiple-span condition at Filton simply by reflection.

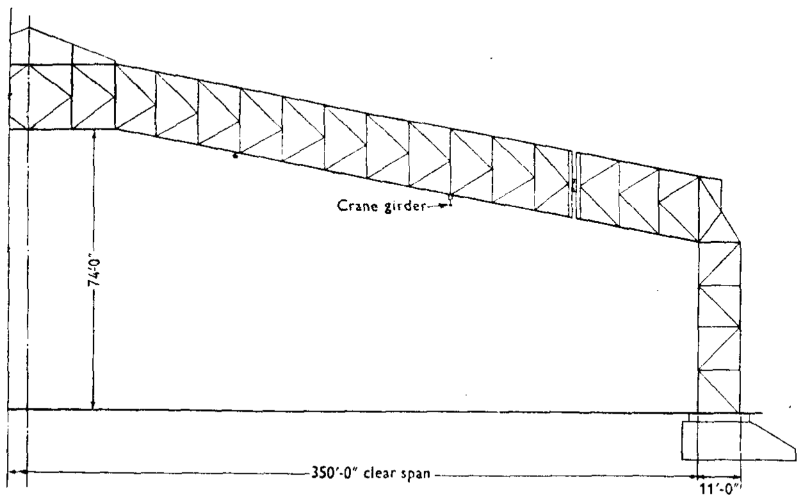
The Author had mentioned that the use of reinforced concrete had been considered, but had not mentioned light alloy. In any large structure the greater part of stresses in the members was due to the self weight and any alteration in the latter would have a cumulative effect on the structure.

It was not possible to give comparable figures for the steelwork design and for a similar design in light alloy, but probably the cost in light alloy would not have exceeded the cost in steelwork.

Another alternative which might have been adopted if the design with the pins above haunch-level had been considered would have been to make the central portion of light alloy, to save erection charges, and to keep the vertical parts in steel in order to reduce the lateral deflexion.

Apart from the first cost of the structure, the use of light alloy would have been worth consideration from the point of view of maintenance,

Fig. 30.



SUGGESTED ALTERNATIVE DESIGN OF ARCH RIB WITH PINS "IN THE AIR."

because with light alloy the cost of maintenance would have been negligible.

Some additional information about the doors would be welcome because designers might be faced with a similar problem at some future time. Mr. Young agreed with the Author's use of A.W.10B alloy for them. From one of the Author's slides it appeared that some lighting panels had been introduced near ground-level; was that actually the case?

Mr. I. M. E. Aitken observed that a project of so composite a nature as that of the Assembly Hall, involving design work in many branches of engineering, called for inspired co-ordination in an exceptional degree, so that every aspect of the complete design should be studied, not only in regard to its own function but also in regard to the other functions of the various aspects of the scheme. Close and continuous co-operation between all the designers concerned with the various contributory factors was, therefore, obviously essential, in order to avoid the disastrous effects of incomplete planning and the consequent delays in the progress of site construction.

As an example, the lay-out of the walkway system in the Hall, comprising nearly 2 miles of steel footpath, had been influenced by considerations of the accommodation of and access to main lighting units, switchboards, cable trunking, steam and condensate mains, valves, and stores-areas, while also serving as a means of access to overhead crane cabins under both normal and emergency conditions.

The Assembly Hall project not only called for unification of design planning in its very many aspects, but also required to be co-ordinated with the development of the Bristol Aeroplane Company's own production plans for the construction of aircraft of such leviathan dimensions as the Brabazon. Those plans were naturally modified as construction of the prototype aircraft proceeded, and the services which the Assembly Hall installations were designed to provide had perforce also to be modified from time to time to correspond. For that and many other reasons, close collaboration with the Company's officials was essential, and frequent joint staff meetings between the Consulting Engineers and the Company, under the chairmanship of their Chief Architect, Mr. Eric Ross, represented a valuable feature of the procedure adopted from the outset of planning development.

Another matter of significant interest had relation to the difficulties which were met on composite projects under present-day conditions of Governmental licensing procedure, materials supply controls, and so on. The Author had referred to the rapidity with which the project developed after the decision, in March 1946, to build the Hall at Filton. The Development of services and equipment design had proceeded concurrently with fabrication of the steelwork structure, and it had accordingly been found that many items of plant and equipment, subject to long-term periods of delivery under present-day conditions, could not be ordered until alarmingly late dates. The many hundreds of items affected in that way, both large and small, had necessitated the adoption of an intensified progressing procedure, particularly as the project had not enjoyed any overall Government priority sponsorship other than an ordinary building licence.

Every large engineering scheme called for the careful preparation of a programme of plant and equipment delivery, in order that items should arrive on site at the proper time and in the proper sequence, to obviate delays in construction work or expensive and awkward storage arrangements. The corresponding programme for the Hall services equipment had been complicated to an abnormal degree by difficulties in locating sources of supply which were able to comply with the essential delivery dates. It was to the credit of the Progressing Officers on the Author's staff that, despite frequently recurrent and seemingly insoluble problems in that field, the construction work on services had proceeded smoothly and continuously, without any major delays, and that the various services required had been made available when they were needed, with surprisingly little expenditure on temporary arrangements pending delivery of individual items of equipment. To achieve that result, the services of the Progressing Officers had been made available, not only in respect of direct orders for main items of plant, but also to contractors, to subcontractors, and even to the suppliers of raw materials for manufacture of assessories required by manufacturers of plant on order by sub-contractors. When materials supply licences were required to clear a manufacturing deadlock, the necessary official procedure received the special attention of the Author's Licensing Officers.

Such necessary attention to the problems associated with licensing procedure, materials control orders, and the progressing of manufactured supplies constituted aspects of consulting engineering work which had acquired accentuated importance under present conditions, in view of the fact that it was a normal function of the consultant to ensure that constructional work duly proceeded not only in accordance with the prepared designs but also in accordance with the planned time schedules.

Mr. D. V. Pike observed that he had felt for some time that aluminium alloys were the most economical materials for structural spans of the magnitude of the Brabazon Assembly Hall, and he would expect their use to produce a saving in weight of between 75 per cent. and 80 per cent. Whilst the cost of the frames, even with that saving in weight, would be rather higher than that of steel frames, the reduction in transportation and erection costs should easily offset it. Further, a considerable saving would result in the time for erection, which would have been particularly valuable where the time for completion was a primary concern, whilst a saving in the foundations might be expected, because of the reduction in dead loads, and maintenance costs, which would be very high in any case, would be reduced considerably. However, according to the foundation loads given in the Paper, a saving in weight would have a detrimental effect upon the economics, because under certain conditions uplift from wind exceeded the dead-weight motion. Those wind actions appeared to be extraordinarily high. The wind loads used, equivalent to those due to a 75-mile gale, seemed unduly high for such a large area, particularly as the structure was partly sheltered by the hillside. More detailed information in respect of the wind reactions would be of interest.

The sliding doors, which were the largest in the world, formed a comparatively small portion of the very great engineering project, but were themselves a notable feat. Mr. Pike understood from the designers and manufacturers that it was not possible to use any other material than aluminium alloy, owing to inertia considerations. A feature of the doors was that the sections used were specially designed for the particular functions to be served, and the extra cost of the special dies was comparatively small in relation to the quantity of the material used. Mr. Pike exhibited a section of one of the pilasters, to illustrate how mechanical requirements and structural requirements could be combined in one section which could be extruded in aluminium alloys.

Another point of interest in connexion with the doors was that hollow rivets of large diameter were used. The development of hollow rivets might be of considerable interest to all engineers in the future.

Mr. T. J. Upstone observed that, although the Paper covered a very wide field, there was room for amplification in certain directions. Thus, could a few more details be given of the alternative designs which were considered for the main supporting steel work ? The Author had exhibited a slide showing nine outline diagrams. Could some actual figures be given for the weights of those designs compared, say, as weight per square foot of covered area ?

A two-pin portal with a haunch tie was doubly indeterminate, and it was usually found, with the type of structure in question, that it was difficult to get all the sections working at their maximum stresses or at economical stresses. Without considerable work, which was seldom justified by the saving in material, some sections were inevitably under-stressed. What method of analysis had been adopted to obtain economical working stresses ?

The idea of nesting the upright sections of the main girders in adjacent bays was novel, but was the question of saving floor space the only factor that prompted the adoption of that feature ? It appeared that twelve out of twenty-one main frames were increased in width by 2 feet, with a consequent increase in the weight of all the subsidiary bracing to make the nesting feature possible, and possibly something more than just the saving of floor space was involved. Mr. Upstone's experience had shown that the interlocking of the columns added materially to the problems which had to be faced in the erection and that it increased the erection time by about 2 days for each girder, because one of the interlocking columns had to be put up practically piece-small.

In long-span bridges considerable economy could usually be effected by the use of high-tensile steel. The Hall was very similar to a bridge, but it had a high dead-load to live-load ratio, so it was not surprising that the designers had found high-tensile steel economical by reducing the dead weight. Had light alloys been considered for the construction of the main girders ?

A large quantity of ex-Army steel trestling had been used for the erection scheme and had been adapted to suit various purposes, which it had served admirably. Unlike purpose-made steel, it had a high recoverable value and could be used over and over again. Something like that might be used in the future as providing a more economical means of erecting structures.

Mr. John Faber observed that he wondered, as a taxpayer, how much attention had been paid to the cost when the form of construction for the Assembly Hall was being chosen. The Author had said that some trees shown in the background of one of his slides were about 40 feet or 50 feet higher than the ground from which the photograph was taken, and that raised the question whether the right site had been chosen for the building. Another slide had shown some expensive foundations which were very large and very deep.

Mr. Faber further wondered whether the use of the particular form of the arch itself was necessarily the cheapest way of doing the job. Mr. Eric Ross had described the different colours used for painting the structure, and how a park was to be laid out around it, with shrubs and trees. Was all that really in the interests of the taxpayers? Mr. Faber was interested in the type of door that had been adopted, but again he wondered whether it was the most economical type that could have been used. The Paper had described the special arrangements made so that the level-crossing gates could be operated from the nearest signal-box. The line did not appear to be a very important one, and Mr. Faber did not know how often Brabazon aircraft had to cross it; but he wondered whether some simpler and less extravagant arrangement could not have been made.

*** **Mr. W. T. Everall** observed that structures of such large dimensions as clear spans of 330 feet called for careful consideration as to the best methods to employ.

He had been impressed with the preliminary work, which included the consideration of eleven different types of structures, before arriving at a satisfactory solution.

Had consideration been given, in designing the main structure, to the use of aluminium alloys or to the use of welding in steel, both of which had considerable advantages in reducing weight?

The Author had stated (p. 13) that high-tensile steel was used wherever possible to lighten the structure, and had made a valuable reduction in weight.

He had also mentioned (p. 20) the steelwork erection and the extensive use of erection equipment made from Army standard steel trestling, which had formed the 60-foot-high tower on which the Wellman crane was mounted. Had any whippiness in the tower been found when the crane was fully jibbed out and loaded?

The trestling had also been used at quarter-point positions to support the main ribs during building operations. Some additional details of the erection procedure would be of considerable value.

Mr. Everall understood from Mr. Richard Pavry, M.I.C.E., the engineer largely responsible for introducing 800 tons of the trestling on to the job, that it had proved satisfactory and very economical, and that, being in stock and available, it had enabled the work to be speeded up and completed much earlier than had been anticipated.

*** This contribution was submitted in writing.—SEC. I.C.E.

Mr. Everall was interested in the post-war uses of that trestling because he had been concerned in its design and development for military purposes. The Light L and V types were very versatile, being adjustable in height, breadth, and width, and were capable of carrying railway loads ; the parts were interchangeable and could be manhandled, and they were easy to erect.

[Owing to the absence of the Author abroad, his reply to the discussion will be published in a subsequent issue of the Journal.]
