On the grand scale—a Saro London in the 140 ft.-wide doorway of the main erecting shop at Cowes; the interior, with partially built Londons amid the erecting scaffoldings, is seen at the foot of this page. (*Flight* photographs.)

FLYING-BOAT PRODUCTION

Meeting the Demands of the Expansion Programme in the Large-scale Manufacture of Big Aircraft : Some Notes on Building by "Rationalised" Methods in a Plant Ideally Equipped from the Outset

By G. F. ANDERSON, M.I.Mech.E. (Works Manager, Saunders-Roe Ltd.)

GIVEN an ideal geographical situation, with broad slipways reaching down into the waters of the Solent, and with a modern works recently described as "one of the biggest aircraft construction sheds in the world"—what of the works organisation and production methods necessary to fulfil the requirements of aircraft expansion programmes of to-day?

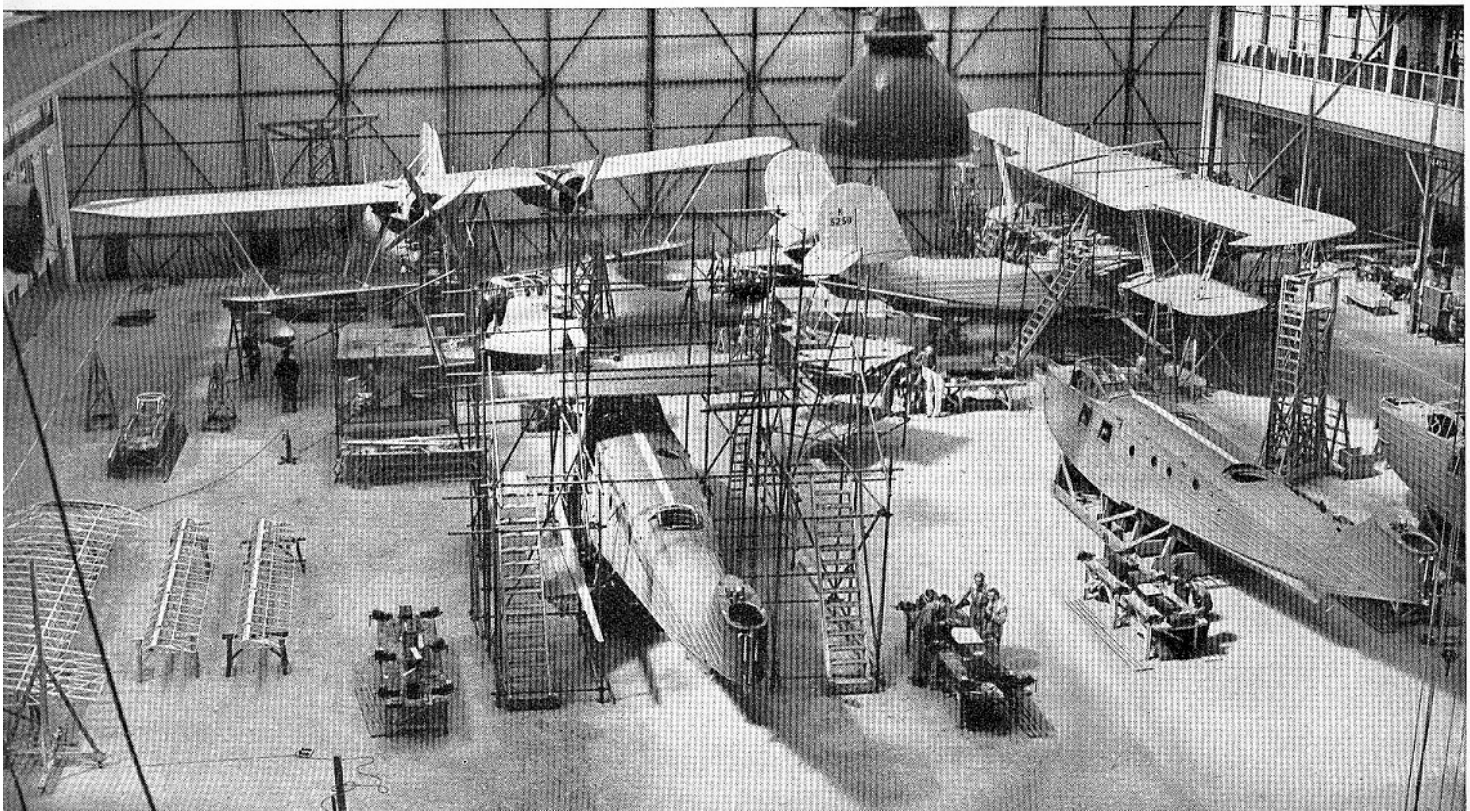
It is certain that the special problems facing the flying-boat manufacturer must be appreciated at the outset if initial layout and production facilities are to be clearly visualised and the production correctly planned and pursued to maximum achievement.

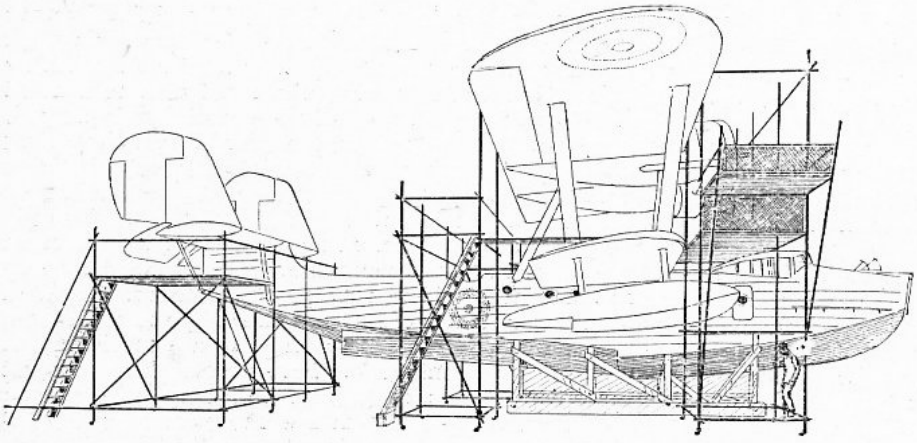
Unfortunately for the flying-boat manufacturer, few of the normal productive facilities and methods are easily applicable to an intensified expansion in large aircraft construction, although the application of improved methods and new materials should contribute largely towards the required acceleration in the immediate future.

In the Saro works the main aircraft sheds are situated on either side of the mouth of the River Medina, the extensive machine manufacturing and erecting shops for new aircraft production being on the east side, with the service erecting and testing shops on the west side. Finished flying-boats are launched from the production slipway, turning into the Solent for flight trials, and returning to the service slipway for final inspection prior to delivery. The intervening water area between the east and west sheds is well marked by numerous buoys and is actually regarded as part of the works productive area in final handling of completed flying-boats.

A definite slipway procedure is carried out for launching and handling in conjunction with Saro-built motor launches, whilst refuelling scows and slipway pier pumps keep in step with essential equipment features in the works proper.

Since the launched output of flying-boats and amphibians for Service or civil use is the determining capacity consideration from the productive standpoint, it will be con-





The layout of the steel erecting scaffolding described by the author. (Below) Subsidiary shops are laid out for progressive "line" production of components.

venient to trace back from the slipway some of the principal works departments.

The erecting shop layout and equipment is designed to secure intensified flying-boat erection at an output rate approximately ten to twelve times higher than that of pre-expansion days. With its main 40ft.-high door giving a clear width of 140ft. to the slipway, the erecting floor provides room for simultaneous erection of a dozen big boats. The slipway erecting berths are at present occupied with aircraft to an Air Ministry order for the Saro London.

Line Production

Line production is in full operation. The hulls travelling from the construction department follow a definite path, being moved between completion stages at regular intervals, when they receive covered components, internal fittings, engines and airscrews, and emerge *via* the weigh-bridges to the concrete apron for engine run.

From here the completed boats are launched with the aid of an electric winch for flight trials. The erecting shop embodies the most up-to-date conceptions to ensure perfect lighting conditions in the day, whilst a modern "Osira" electric discharge illumination is general for night working.

To facilitate expeditious handling and erection of large covered units, longitudinal and cross traverse electrical cranes of latest types are placed for operation from floor level and to enable withdrawal from dope shop for assembly straight to the machines under erection.

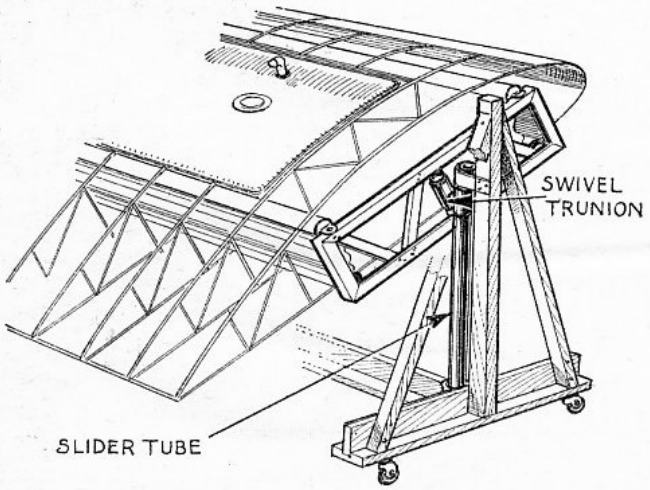
An interesting example of the application of new methods and employment of modern constructional materials is provided in the first use by Saunders-Roe of tubular steel scaffolding poles, couplings, swivel connectors and castors, etc., as illustrated in the first of the accompanying sketches. The older methods employed in erection of large aircraft involved the use of builders' and decorators' poles, trestles, and heavy planking, which was attended with considerable danger.

In considering the greater security of workers operating in different positions and at considerable heights the aim was to provide the maximum of confidence and security to fitters, erectors, riggers, etc., in the interests of efficient and more rapid production. An exact scale model of the aircraft was prepared, with model platforms and workers to the same scale, and after full consideration in conference with interested employees a model system of steel erecting staging platforms and connecting gangways was devised. This was worked out in standard steel scaffold materials and fittings, the entire structure being mounted on castor wheels to enable sections to be readily moved when the machine was completed. Complete

fitters' benches with vices are accommodated high up on the work platforms near to engine mountings, thus enabling all kinds of fitters' bench work to be carried out *in situ*, with considerable time-saving as compared with the older method of repeated returns to ground level. The strength, steadiness and rigidity of steel staging has been amply confirmed by the absolute confidence of workers, and by the quickness and ease of their movements in transferring to all parts of the machine.

A parallel case may be found in the use of steel scaffold tubing, and particularly its extension to experiments in all forms of carrying frames, to provide maximum accessibility during erection. One example is shown in the second sketch; the sub-assembly on this particular covered component is completed with the aid of a swivelling stand, enabling the unit to travel through 360 degrees and permitting adjustment for fixing at any desired position to complete particular sections of work. The swivel trunnion "S" is formed from a standard swivel connector and the slider tube "T" of steel scaffold pole. The freedom with which the component can be positioned for convenient working has been found to produce a marked effect on the quality and speed of operators' work.

Numerous combinations of frames for expeditious handling of wing components in production have been made up by use of tubular steel scaffolding and coupling units, and, where tried out and proved, these have formed the basis for construction of permanent stands or frames.



Another Saro time-saver: One of the trunnions on which large components, such as wings, are supported in order that they may be instantly turned over to any required angle.

Turning now to the hull construction shop, full use has been made of the diagonal "car-parking" method of laying keels, and from the battery of hulls lying in close juxtaposition at an angle of 45 degrees to main shop gangway, any one can be conveniently withdrawn.

All sections for hull construction are formed from strip by the draw-rolling method, standard interchangeable rolls being used which permit sections of any dimensions to be produced within the capacity of the machines and with the use of the minimum number of rolls.

As in other main works buildings, considerable importance is attached to the careful layout of productive areas by means of well-defined gangways linking up with correct operational sequence and production flow between adjacent departments. Among the latter may be mentioned heat treatment and special process rooms, anodic department (with cadmium and degreasing plant), and modern paint shops replete with special booths and spraying apparatus for the application of protective finishes.

Metal Spraying

A large detail fitters' department is located alongside hull construction and process sections, and separate view rooms are placed in special positions to ensure inspection at all stages without interruption of the logical flow of work. Metal spraying in its most modern applications has been developed in a special department adjacent to a shot-blast room, and the process is successfully applied to the protection of ferrous components, such as exhaust manifolds, collectors, etc., and in the preparation of non-slip roughened surface for walkways or platforms.

In connection with the latter, experiments carried out to enable the metal spraying of non-slip walkways *in situ* on the aircraft have resulted in the development of a complete portable metal spraying plant carried on a loose stillage which can be immediately picked up and transported by Lister truck and left at any desired location where the work is in progress. This apparatus embodies both sandblast and spraying equipment.

The machine shop provides for a progressive layout in which raw material enters at one end, passing through machining and inspection processes to emerge as finished components. The machine tool plant has been arranged in batteries of similar machines, each battery having its own setter and complete range of equipment. To provide for correct classification and organised handling of various machined components during manufacture, work stands are provided for each machine, while all work passes through the machine sections in standard pressed steel trays and containers to the main view room conveniently situated midway on the production floor for process inspection.

Stellite cutting tools, found by exhaustive experiment to be the most efficient, are standardised and cutting speeds in the order of 110 ft. per minute have been maintained on stainless steel. Screwing at 60 ft. per minute is achieved with the aid of Landmatic equipment, Dixol coolant being used for all turning, screwing and forming.

Jig boring is carried out on Thiel Universal mills. Hole centres, with the aid of slip gauges, are regularly held to within plus or minus 0.0005 in. All plug and ring, snap and slip gauges for use of works and inspection are ground on most modern universal grinding equipment, and finally hand lapped to size.

In the press department much thought and development has been extended to the forming of large panels in small quantities, and an economical solution has been reached by the use of hardwood drawing dies faced with cold rolled steel. These, equipped with a hand-operated pressure pad, are used on the 150-ton press, the floor to floor time being approximately 20 minutes. Domed tank ends 6 ft. long, with a large flange all round, are regularly produced.

Refrigeration of dural rivets has been successfully developed in order to combat wastage due to repeated heat treatments and to make supplies of conditioned rivets available at particular points on the production floor. Standard household refrigerator cabinets modified by the addition of an external thermometer are kept at a temperature of minus 15 degrees centigrade. Rivets, normalised in a salt bath at 490 degrees centigrade, which will age harden in two hours, may be kept in a working condition for sixteen hours by use of the refrigeration method described.

In the mechanical test laboratory, testing is carried out with a strict impartiality on raw materials and new constructional arrangements. The equipment includes Brinnell and Rockwell hardness-testing machines, lever arm and other special test machines, and an Izod impact testing machine.

A central feature of the laboratory is a modern Avery 20-ton direct-reading hydraulic universal test machine for tensile, compression or deflection tests. This machine is also equipped to carry out tests of special specimens and rigs. Other equipment provides the usual facilities for metallurgical research. In a separate experimental laboratory there is a large specially designed testing rig capable of carrying out the usual tests on hull or wing structures.

The co-ordination of executive functions and the welding of an efficient team, each member of which is a positive progressive unit, goes without saying, whilst in a time of abnormal expansion many problems will arise in the endeavour to absorb and train the necessary additional labour, unused to aircraft work, which alone will call for special understanding and patience on the part of executives during probationary or training periods.

Even where equipment is of the finest, the success of an organisation is the measure of the effective pull of the productive team, which must be counted specially important in its contribution to the future expansion of the industry.

Saro Works Contractors

In addition to the machine equipment firms mentioned by Mr. Anderson in his article above, the following, by the parts they have played in the erection of the works, have contributed to the successful production methods described:

Boulton and Paul, Ltd., Norwich, *structural steelwork and building*; Sturtevant Engineering Co., Ltd., *heating and ventilating*; General Electric Co., Ltd., *lighting equipment*; Alliance Electrical Co., Ltd., *installation of lighting and power service*; Holst and Co., Ltd., *reinforced concrete foundations and slipway*; Pinchin, Johnson and Co., Ltd., *vigorised red lead primer paint*; Cellon, Ltd., *finishing paint*; Hills Patent Glazing Co., Ltd., *roof lighting*; Williams and Williams, Ltd., *metal windows*; Rollo Products, Ltd., *dustproofing and hardening*.

The consulting architect was Mr. A. Victor Heal, F.R.I.B.A., and the consulting engineer Mr. T. L. Bonstow, M.Inst.C.E.

A good idea of the extent of the works may be obtained from the aerial view—an R.A.F. official photograph—which appeared in the centre pages of last week's issue.

R.Ae.S. GARDEN PARTY GUESTS

THE foreign representatives and high officers of the Royal Air Force in the list of guests at the R.Ae.S. Garden Party (reported on pages 500-502) included the following:—

Capt. de Corvette Albertas (French Air Attaché); Capt. Natal Arnaud (Acting Naval Attaché, Brazilian Embassy); Major D. Carmelo de las Morenas Alcala (Spanish Air Attaché); Monsieur H. C. Berg (Norwegian Counsellor); Prince Otto Von Bismarck (German Counsellor); Air Marshal Sir F. W. Bowhill (Air Member for Personnel); Col. A. Calderara (Italian Air Attaché); Sir Hal Colebatch (Agent-General for Western Australia); Air Vice-Marshal C. L. Courtney (Director of Operations and Intelligence and Deputy Chief of Air Staff); Mr. John W. Dulanty (High Commissioner for the Irish Free State); Air Chief Marshal Sir Edward L. Ellington (Chief of Air Staff); Col. G. Gervassy (Assistant Air Attaché, Soviet Union); Comdr. H. Grondahl (Finnish Naval Attaché); Col. J. A. dos Santos Lucas (Portuguese Embassy); Mr. W. A. McAdam (Agent-General for British Columbia); Mr. C. F. G. McCann (Agent-General and Trade Commissioner for South Australia); Corps Comdr. V. K. Putna (Air and Military Attaché, Soviet Union); Sir Philip A. G. D. Sassoon, Bart. (Under-Secretary of State for Air); Col. M. F. Scanlon (American Assistant Military and Air Attaché); Lt.-Col. Sir Francis C. Shelmerdine (Director General of Civil Aviation); Lt. Comdr. L. C. Stevens (Assistant Naval Attaché for Air, American Embassy); Marshal of the Royal Air Force Viscount Trenchard; General R. Wenninger (German Air Attaché); Major L. F. E. Wouters (Belgian Air Attaché).