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CHAPTER 2

STATION WORKSHOPS

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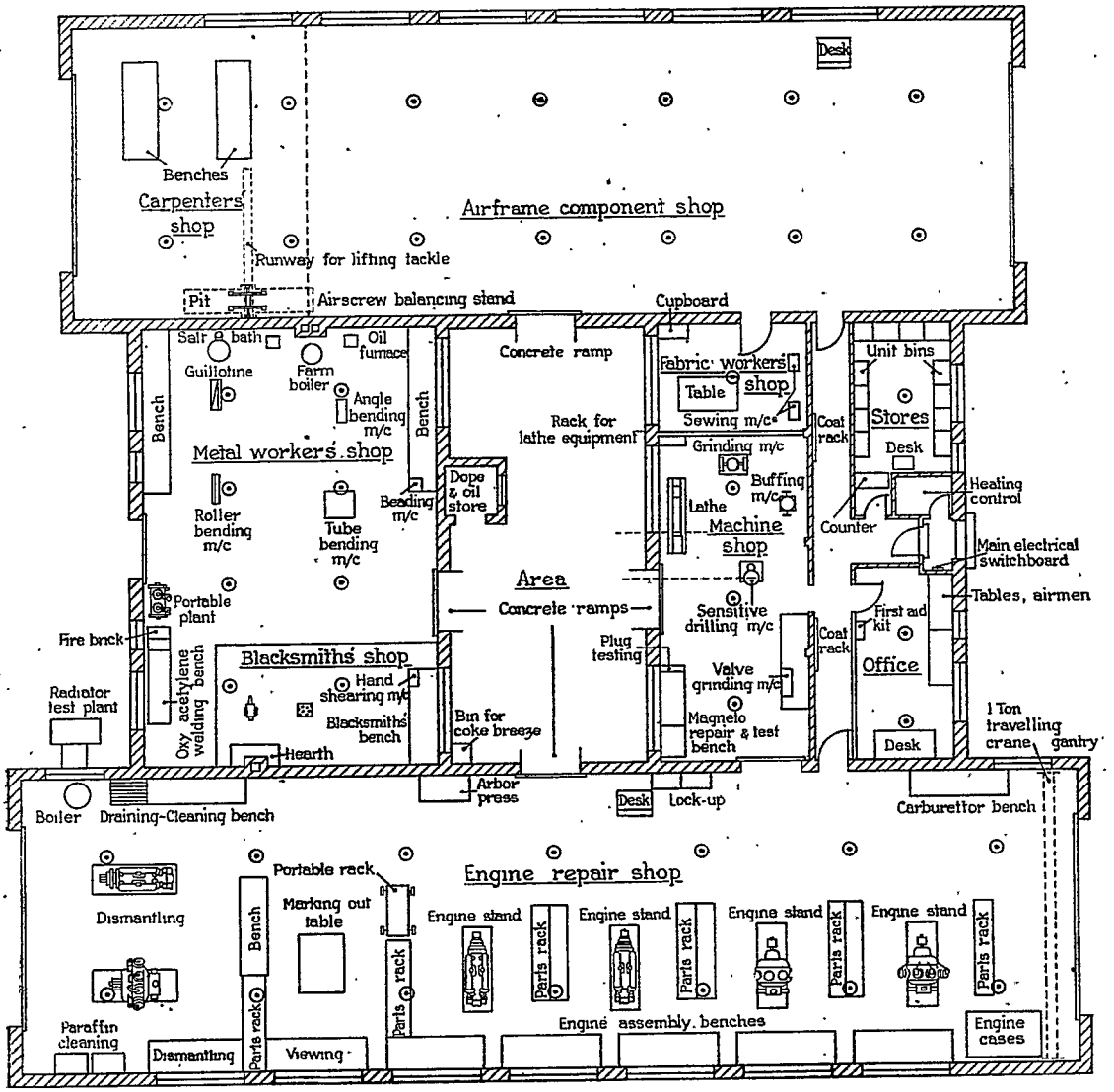

Fig. 1—Station workshops.

CHAPTER 2

STATION WORKSHOPS

General

1. Station workshops should be laid out and supervised in such a manner that all work undertaken in the shops will follow the approved working procedure as described in this and other chapters of this publication. A standard type station workshop has been introduced and in order to ensure that all station workshops conform to type as nearly as possible, the following description of a typical station workshop is given with a plan of the layout. This description deals first with the workshops and the layout of the Directorate of Works fixtures, followed by the recommended layout to be adopted in the disposition of available equipment with observations on the use of each shop. Although there are variations in the size, shape and relative positions of the separate shops at some stations, the main features described in this chapter apply to all station workshops.

Typical layout

2. A typical layout of a station workshop is indicated in fig. 1, in which the positions of the various shops are shown and the arrangement of the main items of equipment. Lighting and heating are supplied from a central source in the station. The electricity supply is led into the workshops to a main switchboard situated in a recess in the outer wall of the office whilst the heating supply is connected in a valve room placed on the opposite side of the entrance. These connections are outside the workshops entrance door in order that they may be accessible from the outside when the door is locked. Sub-fuses and switches are placed in each shop, with plug-in switches at various points to provide for the use of portable hand-lamps, electric drills, etc. The electric power supply is led to a distribution box in the machine shop from which it is taken to the separate machines. The heating of the shops is effected by means of single column type radiators spaced around the shops, each radiator being fitted with a control valve. The heating temperature of the workshops is regulated thermostatically. The central area which is enclosed by the workshop buildings is accessible to all shops. The separate shops are dealt with in the following sub-paragraphs:—

(i) *Engine repair shop.*—The engine repair shop is spanned by a hand-operated 1-ton travelling crane which may be traversed the full length of the workshop in such a manner that engines may be picked up at either main entrance and placed in any intermediate position. The doors in each end of the shop are of the sliding folding type giving a clear entry 20 ft. wide × 17 ft. high. Fitters standard type metal covered benches are placed opposite each window; the benches are recessed to allow clearance for the heating radiators which are placed below each window. Adjustable workshop lamps are mounted on wall brackets near the vice positions; these lamps may be extended to a maximum length of 2 ft. 6 in. and movement allowed by the universal joints permit the light to be projected on to the work at the required angle. Four plug-in switches are provided around the shop so permitting the use of inspection lamps, electric drills, etc. The roof lamps are controlled by seven switches, one switch for each pair of lamps.

(ii) *Airframe component shop.*—The airframe component shop is similar in construction to the engine repair shop. One end of this shop is allotted for use as a carpenters' shop.

(iii) *Carpenters' shop.*—The carpenters' shop is situated as shown in the plan, but as no partition separates it from the remainder of the airframe component shop, the space occupied may vary according to the amount of work in either shop. The equipment supplied consists of two carpenters' benches.

(iv) *Fabric workers' shop.*—The fabric workers' shop is a small workroom 10 ft. 6 in. × 15 ft. 3 in. placed conveniently near the airframe component shop.

(v) *Metal workers' shop.*—The metal workers' shop is allotted for the use of the metal workers including blacksmiths and welders. The sheet metal workers are provided with two benches underneath which are cupboards for the safe keeping of fluxes, solder, etc. There is a flue at each end of the workshop to take the fumes from the farm boiler heater and the blacksmiths' hearth. The blacksmith and oxy-acetylene welder, each provided with a fitter's standard bench, occupy one end of the workshop for a distance of 15 ft.; this portion of the shop floor is made up of rolled fine ashes. Sliding doors 7 ft. high × 6 ft. wide are placed in each side wall.

(vi) *Machine shop.*—The machine shop is arranged as shown in the plan, for the reception of machinery and for the benches, to be provided, on which magneto repairs and valve grinding may be undertaken. Three doors open into this shop so facilitating communication with the workshops.

(vii) *Stores and office.*—The stores and office are placed one on each side of the front entrance and adjacent to the workshops. The heating system valve room is built into part of the stores and the main electrical switchboard is recessed into the outer office wall. The office floor is laid with linoleum.

(viii) *Dope and workshop oil store.*—A small outbuilding is provided in the area for the purpose of the safe storage of dope, oil for workshop use, paraffin, etc.

WORKSHOPS, EQUIPMENT AND WORKING PROCEDURE

General

3. The standard type station workshops are intended to be used and equipped in the manner described in the following paragraphs. The equipment required will vary according to the type of aircraft held on the station, but the general principles will apply to all workshops. Standard tool kits and lock-ups are available for workshops and also for workshop personnel according to trade; these kits are listed in Air Publication 1086 and are in accordance with scales given in Volume III of Air Publication 830. Equipment which is general to all shops, such as ladders of various types, portable hand trollies, general purpose fixed trestles, lifting tackle, etc. should be obtained and kept in a position where they will be accessible without causing obstruction.

Squadron hangar for workshop use

4. In order to ensure that the greatest advantage is obtained from the workshops, full use should be made of the allotted space in the Squadron Hangar. Aircraft to be repaired in the workshops should be taken on charge by the Engineer Officer and dismantled in the squadron hangar as required. Component parts for repair should be taken to the workshops concerned, whilst the fuselage remains in the hangar. Lockups are provided and these should be utilised for the safe keeping of instruments, etc. during the period that the aircraft is under repair. Repairs that may be completed without dismantling major components should be undertaken in the hangar. After repair in the workshops, components should be returned to the squadron hangar for assembling, doping and rigging operations. For the purpose of dismantling and assembling aircraft components in the squadron hangar, tail and plane lifting gantries will be required in some instances. Jacking trestles, axle trestles, fixed trestles, jacks, platform ladders, plane storage racks, portable storage racks and inspection platforms should be obtained as required; a description of this equipment is given in Air Publication 1464G, Volume I, Part 2, Section 5, whilst information regarding special equipment which is available according to type will be found in the relevant aircraft handbook. Equipment will be required for the doping scheme laid down in Volume II leaflets of this Air Publication. Portable air compressors are available for operations such as tyre inflation and spraying, whilst hot air blowers are available for dope drying, etc.

Engine repair shop

5. The engine repair shop should be so arranged that the sequence of operations is followed as described in A.P.1464C, Vol. I, Part 2, Sect. 2. The separate bay system should be adopted as standard with any slight modifications that may be necessary when different types of engines are dealt with; the layout of the complete workshop is shown in fig. 1. The separate bays should be made up as follows:—

(i) *Engine dismantling.*—Engine dismantling operations should be done in the dismantling bays according to the methods laid down in A.P.1464C, Vol. I, Part 2, Sect. 2. A fitter's standard metal covered bench with vice is provided and sufficient space to accommodate two engines and stands is allotted. Drip trays should be used underneath engines whilst dismantling. A portable storage rack should be used for the reception of dismantled parts to be passed for cleaning.

(ii) *Engine cleaning.*—Cleaning operations should be undertaken according to instructions given in A.P.1464C, Vol. I, Part 2, Section 2. A hot-water boiler, two paraffin tanks, a draining rack and cleaning bench comprise the main items required; the layout of this equipment is shown in fig. 1. After the parts are cleaned they should be handed over to the viewing bay, complete in groups of components, for which purpose a portable rack should be provided.

(iii) *Viewing.*—A bay is provided where viewing operations may be undertaken. Two benches, two part racks, a marking out table and viewers' instruments should be obtained. The viewing procedure and the instruments required are described in A.P.1464C, Vol. I, Part 2, Section 2. The marking out table should be placed in a central position in the bay. A bench and a part rack should be obtained for the reception of parts from the cleaning bay and a portable type rack should be provided and arranged to receive parts that have been viewed, whilst a fixed rack should be used for the reception of rejected parts. Special lighting has been provided in this part of the shop (see para. 33).

(iv) *Engine assembling bays.*—The assembling bays are laid out as shown in fig. 1 with the engine stands in a central position and part racks on either side, opposite the fixed benches supplied. Slatted footboards should be provided at the benches, by means of which small adjustments for difference in height of personnel may be made. Drip trays should be used when possible underneath all engines that are being assembled. Engine tool kits, jigs and gauges should be supplied according to the type of engines held on the station. Further information regarding engine assembling equipment will be found in A.P.1464C, Vol. I, Part 2, and in detail in the relevant engine handbook.

(v) *Carburettor bay.*—The carburettor bay is situated in the engine repair shop. A fitter's standard metal covered bench with vice should be provided for the purpose of dealing with carburettors according to instructions in A.P.1464C, Vol. I, Part 2, Section 2, and in appropriate aero-engine handbooks. Fuel feed pumps may also be dealt with in the carburettor bay. Light wooden trays should be made up locally with suitable partitions in each tray to accommodate a dismantled carburettor or fuel feed pump, in order to avoid the loss of small parts as they are dismantled. The necessary test equipment should be provided as required.

Airframe component shop

6. The airframe component shop is provided for the repair of such components only as main planes and tail units. This shop should be kept as clear as possible to facilitate the work in hand and any plane racks and trestles that are not in use, or completed components, should be removed and stored in the squadron hangar. No doping other than for small patching operations should be undertaken in this shop. Portable benches are available for use in this workshop as required. The equipment will include a portable flight desk, main plane repairing trestles, storage racks, adjustable tail trestles and portable wooden benches. A propeller metal balancing stand with centring cones to suit the type of propeller concerned should be obtained and placed in the position indicated in fig. 1; this apparatus is fully described in the A.P. "1538" series.

Carpenters' shop

7. The carpenters' shop occupies a position at one end of the airframe component shop, and is equipped with carpenters' benches and general purpose trestles. This shop is intended for handwork only, and machined timber of which the demand must be anticipated in varying types and cross-sections cut to size should be requisitioned from depots and held in the main stores until required by the workshops. This workshop is not partitioned off but will generally occupy a space 30 ft. × 20 ft.

Fabric workers' shop

8. The fabric workers' shop should be kept solely for the purpose of dealing with fabric and allied materials, cutting out, machine sewing, etc. The main items of equipment required comprise a work table, a sewing machine and a chair. No equipment or material should be stored in this shop other than that necessary for the work in hand. Authorised work on parachutes and safety harness may also be undertaken in this workroom in accordance with the methods laid down in Vol. II leaflets of the A.P. "1182" series.

Metal workers' shop

9. The metal workers' shop should be laid out as shown in fig. 1. The manually-operated metal working machines should be so situated that ease of access is permitted to each machine and at the same time ensuring that personnel may walk past with safety and without interfering with the operator. The work undertaken in this workshop varies and should be dealt with in the appropriate part of the shop as indicated by the layout of the equipment (see fig. 1). The blacksmiths and welders should occupy one end of the shop and one half of the remaining portion should be suitably equipped for repairing fuel tanks, radiators, oil coolers, and the like, the other half being allotted for the use of the sheet metal workers doing such work as panel beating, riveting, and the authorised fabrication of light metal fittings. The following sub-paragraphs deal separately with the equipment required by each group in this workshop:—

(i) *Metal working equipment.*—Four benches equipped with vices are supplied in this workshop. Two of these benches are fitted with cupboards which are built in beneath them for the reception of such items as fluxes, solder, mallets, etc. The other two benches are the fitters' standard metal-covered type fitted with revolving head vices for the use of the blacksmiths and welders. Two muffles heated by means of 5-pint blow lamps should be obtained for various heating processes, also a salt bath suitable for the heat treatment of duralumin rivets.

A 30-gall. farm boiler is supplied for the purpose of washing fluxes from work which has been soldered or welded. Tinmen's stakes, mandrels, shears and various soldering irons are available as listed in Air Publication 1086. Lead blocks and sand bags, which may be made up locally, should be provided. The manually operated machine tools supplied comprise a roller bending machine, a 36 in. guillotine, a 30 in. angle bending machine, a beading and swaging machine, and a tube bending machine with $\frac{1}{4}$ in. to $\frac{7}{8}$ in. formers; these should be positioned as shown in fig. 1. Riveting sets suitable for solid and hollow type riveting, a portable electric drill and a breast drill should also be obtained for use in this workshop.

(ii) *Blacksmiths' equipment.*—The blacksmiths should be provided with a portable type hearth, an anvil, a swage block and a standard metal-covered bench equipped with combination vice and shearing machine. Other equipment such as sledge hammers, tongs, setts, fullers and hardies, as listed in Air Publication 1086, are available. An oil bath and water trough should be obtained for heat treatment and slaking purposes, whilst sand and slaked lime should be supplied for use in annealing operations. A bin should be used for the storage of coke breeze which should be kept outside the workshop.

(iii) *Oxy-acetylene welding equipment.*—A portable plant is provided for oxy-acetylene welding purposes and a fixed working position is allotted in a portion of the blacksmiths' shop. A standard metal-covered bench and a vice is supplied; part of this bench top should be protected by means of fire-bricks or slabs. A cupboard should be provided, in which goggles not in use may be stored safely, fluxes kept dry and welding rods kept free from corrosion. A metal stand should be made up to hold the blowpipe when necessary whilst work is in progress. Gas cylinders not in use should be stored in the approved manner. Welding equipment is dealt with fully in Air Publication 880. The regulations contained in para. 24 of this chapter should be observed.

Machine shop

10. The machine shop should be laid out as shown in fig. 1. The positioning of the machine tools should be done carefully in order to ensure that each machine may be used to full advantage and not limited by the close proximity of a wall or another machine. Tools and appliances for each machine should be obtained and kept in suitable racks. The main items in this shop should be arranged in accordance with the information contained in the following sub-paragraphs:—

(i) *Lathe.*—The lathe should be placed near the window with only sufficient clearance from the wall to allow for cleaning. The tailstock end should be as far away as possible from the end wall consistent with the lighting at the face plate. It should also be ensured that a clearance is allowed for the overhang of long lengths of material which may project through the lathe hollow spindle when end-facing or parting-off. Suitable receptacles should also be provided for the metal cuttings, scrap, etc.

(ii) *Drilling machine.*—The utility of the sensitive drill will be increased if the machine is placed in such a manner that long spars or similar objects to be drilled can project through the area door-way as indicated in fig. 1.

(iii) *Buffing and grinding machines.*—The buffing machine and the grinding machine should be fixed with sufficient clearance around each to permit access to both sides of the wheels. The wheels should not be in a direct line with the operator of any other machine; this is necessary in order to prevent injury by work accidentally thrown across the shop by the wheels when in use. The buffing machine polishing bobs, mops and brushes, buffing mediums, etc., should be placed on a rack on the wall near the machine. The stand type grinding machine should be fitted with two wheels, one for rough grinding and the other for finishing; a suitable receptacle for holding water should be kept near the machine for cooling purposes whilst grinding hardened steel tools.

(iv) *Magneto repair and test bench.*—One end of the machine shop should be equipped with fitters' standard benches in order that magneto repairs and valve-grinding may be undertaken therein. The sparking plug testing machine can be conveniently placed on the end of the bench provided for magneto repairs, but operations involving the use of petrol for plug cleaning should not be done in this shop owing to the risk of fire. A magneto testing set should be obtained and installed as indicated in fig. 1.

(v) *Valve grinding machine.*—The valve grinding machine should be secured to fitters' standard metal covered bench so providing for valve face grinding operations. The machine is electrically driven, and the current for the electric motor should be taken from the plug-in-switch, situated near the bench, using an extension lead. Portable hand racks should be made locally for the purpose of holding a complete set of valves and so keeping them together (see A.P.1464C, Vol. I, Part 2).

Stores

11. The store-bins should be placed around the walls and full advantage should be taken of the height of the room when placing them in position. These bins are available in various unit lengths and heights, as listed in Air Publication 1086. A small desk will be necessary for the use of the store-keeper. A hinged counter should be used for the issue of stores and so positioned as to prevent unauthorised entry of personnel.

Office

12. The office should be provided with tables, chairs, a desk and a filing cabinet. A telephone is installed for the use of the engineer officer. The first aid outfit should be kept in the office in a prominent position.

Area

13. In order to give easier access of trollies, etc. to the area, it may be necessary to make up a ramp to reach the height of the step of each workshop around the area.

MAINTENANCE OF WORKSHOPS AND EQUIPMENT

Maintenance of workshops

14. The maintenance of all workshops will be facilitated if portable equipment, surplus material and personal belongings not actually in use are removed from the working positions. Shelves, benches, floors, etc., should be swept daily. Tools, gauges and jigs should be returned to the tool stores or tool kit boxes after use. Suitable receptacles should be provided for rubbish and metal scrap, and all rubbish should be removed daily from the workshops after cessation of work; rubbish of an inflammable nature should be disposed of by burning in a safe place as laid down in the Royal Air Force Fire Manual, A.P.957. The floors should be kept clean and free from oil and grease. Sliding door runners and guides, door hinges, and window fastenings, should be examined periodically to ensure that they are secure and working freely. Any defects in the workshop building or fixtures should be reported to the Section Officer of the Directorate of Works without delay.

Maintenance of equipment

15. All equipment should be kept clean and free from corrosion and in a good state of repair. The fixtures and equipment supplied by the Directorate of Works are maintained and repaired by them. Other equipment should be maintained in good condition and returned to Stores when unserviceable. Painted equipment should be renovated when the paintwork becomes damaged. Cleaning, adjusting and lubrication of equipment and machinery should be attended to systematically by competent personnel; before commencing any of these operations to power-driven machinery, attention should be given to the precautions contained in para. 25 of this chapter. The following points should be noted:—

(i) *Benches.*—Benches should be kept in a clean condition; the metal covered and the portable types cleaned with paraffin rag, and the plain wooden benches by means of a stiff brush and by scraping if necessary. Punching operations should not take place on the bench tops without some form of protection for the bench surface such as a piece of hardwood or a lead block. Care should be taken to prevent nails and pieces of metal from becoming embedded in the bench surface. The portable type benches should be examined periodically and all nuts checked to ensure that they are tight; the wheel bearings should also be lubricated.

(ii) *Vices.*—Vices should be wiped over frequently, using an oily rag for the purpose. The moving jaw should be withdrawn to the limit of its movement in order that the screw bearings and the thread may be lubricated. The jaw-insert screws and the bolts securing the vice to the bench should be tightened occasionally. Vice handles should be kept free from rust in order that they may slide freely in use.

(iii) *Engine stands.*—Engine stands should be cleaned frequently and kept free from corrosion. Bolts should be checked for tightness and, when not in use, any loose packing blocks, etc., should be attached to the stand until required for use.

(iv) *Lifting tackle.*—Lifting tackle should be cleaned, lubricated and maintained as laid down in Vol. II leaflets of this Air Publication.

(v) *Marking out table.*—The marking out table should be kept perfectly level with the supporting stands taking the weight evenly. Any raised portions, the result of surface abrasions, should be removed without delay by means of a flat scraper. The table should be tested for warping when installed and then periodically, using a 6 ft. steel straightedge; if warped, the table should be returned to stores as repairable and replaced. The table should be kept clean and free from corrosion, and a wooden cover should be provided to protect the surface when not in use.

(vi) *Metal workers' equipment.*—The hand-operated metal working machines should be lubricated, kept in adjustment and free from corrosion. Blow-lamps should be kept clean and filled with fuel to the correct level as described in para. 21 of this chapter. The blacksmiths' hearth should be kept free from clinker and fine ash and cleaned periodically. The fan bearings should be lubricated prior to each occasion the hearth is used.

(vii) *Portable oxy-acetylene equipment.*—The oxy-acetylene equipment should be maintained in good condition as described in the Welding Manual (Air Publication 880) and as laid down in Vol. II leaflets of this Air Publication. Gas cylinders should be marked plainly, "full" or "empty" as the case may be, using tie-on labels for this purpose.

(viii) *Lathe.*—The lathe should be kept clean and all bearings and working surfaces lubricated. After use, all metal cuttings and cutting lubricant should be removed from the lathe bed and the saddle; the saddle should be traversed by hand the full length of the bed until it is seen that the oil applied to lubricate the lathe bed is free from particles of metal, etc. Cutting tools should not be allowed to remain in the tool post after use. Other lathe equipment such as face plates, chucks, centres and tool holders should be kept clean and stored in a rack.

(ix) *Drilling machine.*—The drilling machine should be cleaned and lubricated periodically. A piece of planed hardwood should be kept on the table to protect the machined face whilst drilling sheet metal, etc. Table clamping-screws should be slackened several turns occasionally, to enable the threads and thrust faces to be lubricated.

(x) *Buffing machine.*—The buffing machine should be cleaned and lubricated frequently. The wheels and mops in use should be kept dry and free from oil or grease.

(xi) *Grinding machine.*—The grinding machine should be kept clean and as free from abrasive as possible. The bearings should be lubricated frequently but care should be taken to avoid oil or grease coming into contact with the emery wheels. The water provided for cooling purposes should be changed frequently. The tool-rests should be kept in adjustment at a position as near as possible to the emery-wheels. The wheels should be trued up, as required, by means of an emery-wheel dresser and the tool-rests reset; the resulting abrasive should be carefully brushed off the machine after the operation is completed.

(xii) *Drives, electric motors.*—Electric motors used for driving machine tools and portable apparatus should be kept clean and free from dust both internally and externally. Bearings should be lubricated but care should be taken to avoid over-lubrication as the surplus will be carried to the armature and to the commutator. Immediate attention should be given to motors showing signs of overheating or excessive sparking. Only authorised personnel are permitted to attend to defects which may arise in connection with electric motors, switches, cables or fuses.

(xiii) *Workshop tool kits.*—Fitters' tool kits and engine service kits should be kept clean and in a serviceable condition; any tools that are provided with separate divisions in trays should be replaced in the tray after use.

(xiv) *Measuring instruments and appliances.*—Measuring instruments and appliances are dealt with in detail in A.P.1464B, Vol. I, Part 2, Sect. 3. This equipment should be stored in the workshop lock-up and placed in the charge of a senior N.C.O. It is necessary to check all instruments periodically in order to ensure that they are accurate in use.

(xv) *Drills and reamers.*—Drills, reamers, etc., should be maintained in good condition and frequently checked for accuracy. Defective tools should not be used but returned as unserviceable. Twist drills should be accurately ground to a gauge and, when not in use, kept in a graded drill stand. Reamers should be kept in partitioned boxes or laid in grooved trays cut to receive each size of reamer. The cutting edges of reamers should be ground only in a tool grinding machine. Expanding reamers should be set to a standard size and any variation from this size should be made only by a senior N.C.O.

(xvi) *Jigs, gauges and special tools.*—Jigs, gauges, etc., should be protected against damage and corrosion and should be kept in labelled wooden boxes when practicable; the labels should indicate the special purposes only for which the tools may be used.

LIGHTING AND HEATING OF WORKSHOPS

General

16. The installation and maintenance of workshop lighting and heating systems are under the supervision of the Directorate of Works (see Air Publication 855); many duties however are the direct responsibility of the workshop personnel and it may be necessary in cases of emergency for operating personnel to give immediate attention to either of these installations. The layout of both should be thoroughly understood and the precautions laid down to prevent fire, damage and injury strictly observed; the following points should be noted:—

(i) *Lighting.*—Workshop lighting is supplied by means of roof lamps for general lighting and by means of adjustable workshop lamps and inspection hand lamps for local lighting as required. The main electrical switchboard is situated in such a position that access to it is obtained from outside the workshop doors after they have been locked. Lamp wattages are fixed according to a schedule and lamp replacements should be made by lamps of the same power as those removed. Sub-fuses and distribution boards are usually placed in each workshop, a separate board being provided for the power connections. Tapping points for portable equipment are provided in each workshop, of the plug-in-switch type. Further information on general lighting is given in paras. 33 and 34 of this chapter.

(ii) *Heating.*—Workshop heating is usually effected by means of hot water radiators of the single column type. These are spaced around the walls with flow and return pipes coupling them to the heating plant which may be within the building or some distance away. The temperature should be kept as near constant as possible and for this purpose modern systems include thermostatic control. The temperature desired will be dependent on the type of work being done and normally should be in the region of 58°–62° Fahrenheit; any wide divergence from this range should be notified to the Section Officer of the Directorate of Works, who is responsible for the maintenance of the heating system. Leaks in the radiators and pipe-lines should also be reported. Care should be taken to obtain economical and efficient heating service by conserving the radiated heat within the workshop, as far as possible consistent with proper ventilation. Precautions must be taken to prevent leaks or other damage to radiators, etc., which may be caused by contact with heavy objects. Inflammable, volatile or rubber materials should be kept away from the pipe-lines in order to prevent loss and deterioration due to heat, and to reduce the risk of fire.

SAFETY PRECAUTIONS TO BE TAKEN IN THE WORKSHOPS

General

17. The safety precautions adopted should prevent as far as possible any injury to personnel or damage to property. There are a number of risks to be considered such as those caused by fire, acids, machining, electricity and explosive gases. Orders are laid down to cover various risks and these must be adhered to, as for example those in the Royal Air Force Fire Manual, Air Publication 957. A list of general safety precautions should be summarised and posted on the workshop notice board, and attention drawn to special risks by means of suitable notices placed near the danger points. Although some precautions may appear to be elementary it should be remembered that many accidents are the result of over-confidence. In all cases of personal injury first aid treatment should be given immediately, and proper medical attention obtained as soon as possible. The box or cabinet containing first aid appliances and an instruction chart should be placed in a prominent position in the office. The nature of the contents should be clearly indicated and, whenever any of the items are used, replacements should be made without delay. Suitable equipment is available as indicated in Air Publication 132. In workshops where acids are handled, additions to the outfit should be made in the form of approved neutralising agents such as those which should be available for use where accumulators are charged (see the A.P. "1095" series).

Fire precautions

18. Adequate precautions should be taken against fire as laid down in the Fire Manual, Air Publication 957. The following remarks are not intended to over-rule existing regulations, but to draw attention to possible fire risks appertaining particularly to workshops.

(i) *Waste.*—Receptacles containing waste paper and oily rags, or rags impregnated with spirit, dope, varnish and paint are prolific sources of fire and it is desirable that metal containers only are used; these substances should be separated from other rubbish. Smoking is prohibited in workshops. Attention is drawn to the possibility of spontaneous combustion, caused by the tight packing of oil rags, etc., in the containers. All waste oil and combustible rubbish should be removed from the workshops on cessation of work for the day, when it should be burned in a safe place or otherwise carefully disposed of.

(ii) *Cleaning.*—The use of petrol in the workshop is permitted only for such special purposes as cleaning magneto parts during overhaul and then only in quantities up to half a pint. Petrol should not be used in engine cleaning tanks or mixed with the paraffin. On no account should petrol or any other inflammable liquid be poured down a drain, as this may cause a serious explosion. Paraffin cleaning tanks should be placed in such a position that an outbreak of fire at this point could be isolated; a metal cover should be provided to fit over the bath for use in case of fire, and also to reduce the possibility of accident when the bath is not in use. Processes involving the use of heat or naked flames should be undertaken only at a safe distance from all inflammable material or vapour.

(iii) *Magnesium alloys, etc.*—The working of magnesium alloys, electron, etc., requires special care in order to reduce the risk of fire because under certain conditions these materials are readily combustible. When machining these metals fine cuts should be avoided, the tool used should be sharp, with generous clearance, and low cutting speeds employed. When grinding, special wheels should be kept for use on these metals; they should be clearly marked for identification purposes. Metal particles should not be allowed to accumulate or remain on the clothing and as a precaution, a rubber apron is recommended for the use of operators. Prior to dressing the wheels they should be free from metal dust. During hand finishing processes glass-paper should be used in preference to emery cloth. To extinguish a fire involving magnesium alloys, dry sand or earth should be applied to smother the flames, alternatively, dry cast iron cuttings may be used if available in sufficient quantities; water should not be used for this purpose as hydrogen gas is generated when water comes into contact with these metals when burning, and combustion is thereby accelerated.

(iv) *Fuel tanks.*—In order to avoid the risk of fire in the vicinity of petrol fumes, only special types of hand inspection lamps may be used, i.e. those designed for this purpose and listed in Air Publication 1086. For petrol tank inspection a suitable lamp is also available and no other type should be used for this purpose. Reference should also be made to A.P.1464D, Vol. I, Part 2, Sect. 5, regarding tank repairs and the precautions to be observed.

(v) *Acids.*—Acid should not be retained in any building other than the authorised store, or where its use is necessary for some process. The floor should be sprinkled with sand; sawdust should not be used for this purpose. If the acid is kept in containers these must be tightly closed, and should a leak be detected, the container should be removed outside the building and its contents transferred to a sound container. A good supply of sand and a shovel should always be available for use in emergency.

(vi) *Doping.*—Fabric-covered aircraft components that have been recently doped should not be dusted or brushed until the metal parts have been earthed and precautions taken as described in para. 30. Care should be used when employing electric water heaters or any electrical equipment in the vicinity of dope shops in order to minimise the risk of fire.

(vii) *Alumino-thermic soldering irons.*—Alumino-thermic soldering irons should not be lighted inside a building or taken inside whilst the tablet is burning, nor within a distance of 15 yards from aircraft or inflammable material. These irons are issued to the service for use in emergencies only and should not be employed in other circumstances.

(viii) *Sodium-filled exhaust valves.*—There is a risk of fire and injury to personnel in the handling of sodium-filled exhaust valves during breaking down processes; this operation is only to be effected by authorised Units, according to the procedure laid down in Vol. II leaflets of this Air Publication.

Electrical precautions

19. Precautions should be taken to guard against the possibility of accidents where electric light and power systems are installed, particularly when the supply current is at a pressure exceeding 125 volts alternating current or 250 volts direct current. In instances where the pressure is 650 volts or over, notices should be displayed, clearly marked "High Voltage"; this applies especially to positions where any contact with live conductors is possible. Personnel operating electrical apparatus should be instructed in the use of such apparatus including the methods to be employed in case of emergency. Main switches should be clearly marked so that they are readily located in an emergency. The following list of precautions is given to indicate possible sources of danger and to reduce risks to a minimum:—

(i) *Electrical fires.*—On any outbreak of fire in connection with electrical supplies or equipment, the current should if possible be cut off at the main switch. The method of dealing with electrical fires as laid down in the Fire Manual, Air Publication 957, must be strictly observed.

(ii) *Damp conditions.*—Damp conditions and steam are liable to cause leakage of current from electrical apparatus; approved apparatus only should be used in these circumstances and all earthing wires must be checked frequently. It is advisable for the operator who is using electrical apparatus in damp conditions to stand on a dry wooden platform.

(iii) *Earthing.*—It should be ascertained that all electrical equipment, portable or otherwise connected to workshop supplies is earthed efficiently.

(iv) *Defects.*—All electrical equipment, particularly flexible wires, extension cables, switch plug connections, etc. should be examined frequently for defects. Loose connections should be tightened by authorised personnel and any defective parts replaced without delay. Flexible cables for hand lamps and portable apparatus should be examined to ensure that the cables are supported at each end in such a manner that no tension is applied to the terminal connections.

(v) *Oil on rubber insulation.*—Rubber components should be kept free from oil, otherwise the insulating properties will become impaired. In the case of unavoidable contact, the oil should be wiped off immediately and french chalk applied to the portion of the cable affected.

(vi) *Carbon dust.*—The brush gear of rotary equipment should be examined periodically and any carbon dust that has accumulated carefully removed, otherwise sparking and current leakage may occur.

(vii) *Fuses.*—Sub-fuses may be repaired by competent personnel but main fuses must be repaired by the Directorate of Works personnel. When a fuse has "blown", the current supply should be cut off before any attempt is made to repair the defect, and it should be ascertained that the replacement is of the correct amperage. During the repair of any fuse it is inadvisable to touch any bare metal within the fuse box. Fuse box covers should be replaced when repairs are completed satisfactorily

(viii) *Equipment voltage.*—Before any new electrical equipment is connected to a supply circuit it should be ascertained that the voltage required for such equipment is the same, within approved limits, as that of the supply current

(ix) *Heating apparatus.*—Electrical heating apparatus such as glue kettles, soldering irons and immersion water heaters, should be switched off immediately after use. Water heating appliances should not be allowed to boil dry, and suitable notices should be placed over the switches connected to such heating appliances to remind personnel of the necessity for switching off.

(x) *Screw-cap lamps.*—To prevent danger to personnel from shock due to contact with the lamp screw of 150 to 500-watt lamps fitted with Edison screw caps, precautions should be taken to ensure that the supply of current is disconnected before any attempt is made to replace or remove a lamp from the holder or to insert a new lamp. In instances where a switch plug connection is fitted this must be removed.

(xi) *Overheating.*—Electrical equipment showing signs of overheating should receive immediate attention; the equipment may be overloaded, and unless this condition is relieved there is risk of fire. Air-cooled motors should have a free flow of air, which must not be obstructed by covering the air ducts or enclosing the motor for guarding or other purposes. Overheated wiring may be the result of using wire of too small a section to carry the load applied.

Accident precautions

20. Precautions should be taken to prevent accidental injury to personnel or damage to property, and should include efficient supervision with the provision of necessary guards and fences at danger points. The workshop should be kept free from tools and material not in actual use; ropes and inspection lamp leads in use should be so placed that there is no possibility of anyone falling over them. When it is necessary to leave any equipment projecting into a gangway, it should be made plainly visible by means of some noticeable material such as white rag or paper. Similar precautions should be taken when a tie-rod or any other object is projecting at eye level. Inefficient workshop lighting may contribute towards accidents, therefore the recommendations contained in para. 33 should be noted. The following sub-paragraphs contain information regarding specific risks relevant to service workshops:—

(i) *Working at a height.*—When working at a height any ladders or platforms employed should be firmly fixed and tools placed in such a manner that there is no possibility of their dropping and causing injury or damage. Tools in actual use should be held by means of strong cord when this is practicable; the cord should be tied at one end to a fixed object, or to the wrist of the operator, and should be of sufficient length only to allow free movement. Safety belts are available for the use of personnel who are working on the planes or structure of seaplanes or amphibians, whether afloat or ashore.

(ii) *Pressure risks.*—When operating hydraulic presses, hand-operated arbor presses and air compressors, special attention is required to prevent the building up of excessive pressures and to avoid mechanical failures which would cause damage and injury. Pressure release valves on hydraulic or pneumatic appliances should be tested frequently to ensure that they are functioning correctly. If there is any possibility of the collapse of work or supports when using presses, suitable guards should be placed in position to prevent any damage by parts that may otherwise be projected across the workshop.

(iii) *Bench work.*—Heavy coil springs should not be compressed in a bench vice but by means of a special rig. Hardened steel-headed hammers should never be struck together or used to strike any hardened steel, such as drills, files, etc., as there is a danger of injury from steel splinters. Care should be taken when filing to ensure that the handle of the file is a tight fit on the tang, so preventing the possibility of the handle becoming detached with consequent risk of injury to the operator.

(iv) *Goggles and respirators.*—Goggles should be worn by personnel engaged in grinding or chipping operations to prevent abrasives or pieces of metal injuring the eyes. During welding processes tinted goggles of the approved type must be used. Dope and paint spraying respirators are available for use during the application of dope, etc. (see para. 30 (vii). Respirators should be worn if the time taken for the process be more than a few minutes when materials such as bonded asbestos brake linings are being ground; as a temporary measure a damp cloth tied round the mouth and nose of the operator will serve for this purpose. Respirators must be worn during sand-blasting operations (see Vol. II leaflet, A.P.1464/D.112).

(v) *Exhaust fumes.*—The inadvertent inhaling of injurious fumes should be guarded against by efficient ventilation; exhauster fans and cowls should be used, if necessary, especially where large acid containers are exposed as in the case of electro-deposition processes. Exhaust fumes from M.T. vehicles or any internal-combustion engine should not be discharged into a workshop; these exhaust fumes are injurious to health and if inhaled in enclosed spaces may have fatal results. M.T. vehicles should not be allowed to remain in the workshop, or at the entrance with the engine running, during loading or unloading operations.

(vi) *Use of heat.*—The application of heat in workshop processes in many instances requires care, especially when the reaction of the particular material to be heated is not fully understood. Allowance should be made for the effects of expansion and contraction, also for possible changes in the structure or composition of the materials. Before heat is applied to any tubular work which is sealed at each end, as in the case of some brazed work, examination should be made to ensure that there is a suitable vent to permit the escape of air or steam. During any operation involving the use of molten metal, the greatest care should be taken to prevent contact of such metal with oil, water or moisture, especially when pouring the metal, otherwise gases will be formed which may cause an explosion resulting in injury to the operator.

(vii) *Heat screening.*—Fire-bricks, metal screens, sheet asbestos cord may be used to screen objects from the heat of a flame. Stone, ordinary bricks or concrete should not be subjected to heat as there is a danger of these materials splitting with considerable force. Portable heating apparatus having a pressure fed flame, such as an oxy-acetylene blowpipe, should be suitably guarded or used in such a manner that the flame is not pointing towards a glass window or in the direction of any person or any inflammable material in close proximity to the flame.

(viii) *Poisonous fumes.*—The fumes given off from zinc when this metal is volatilised by heat are injurious to health and should not be breathed during operations that entail the heating of alloys with a zinc content, as in brazing, or when heating galvanised iron. Similarly, inhaling the fumes of burning lead base paints should be avoided. All processes during which harmful gases are evolved should be done in such a position that the fumes cannot affect personnel employed in other working stations.

(ix) *Cleanliness.*—Precautions should be taken with regard to the cleanliness of personnel handling lead, lead oxides or paints, mineral oils, dope and cellulose enamel, acids, sodium-cyanide and other harmful materials. The hands should be washed in running water as soon as possible after contact with any of the above. Food should not be eaten or placed near any of these materials.

Paraffin brazing lamp precautions

21. In order to minimise the risk of accidents which are attendant upon the improper use and neglect of paraffin brazing lamps, the following instructions should be observed:—

(i) *Filling.*—It should first be ascertained that the lamp is filled to the correct level with clean paraffin. The lamp should not be filled beyond three-quarters of the container capacity and it is essential that only paraffin be used; in no circumstances must petrol or

other spirit be used in the container. The chief trouble experienced in the use of blow lamps is due to foreign matter choking the nipples or jet orifices. It is essential therefore that a funnel fitted with a fine gauze strainer be used during filling operations. The filler cap should be tightened only by hand.

(ii) *Lighting.*—Before lighting the lamp the nipple should be cleaned by inserting a cleaning needle of the correct type in the nipple orifice; no other wire or instrument should be used for this purpose. The lighting cup should now be almost filled with methylated spirit and ignited, care being taken that the air release valve is open and the flame regulator valve closed. Petrol may be used in the lighting cup when methylated spirit is not available. When the vaporiser is thoroughly heated, the release valve should be closed and the regulator valve opened to a position varying from one to two turns. On operating the plunger pump a clean blue flame should be produced at the burner and an auxiliary light should be to hand in case the flame in the lighting cup be burnt out prematurely. If the lamp burns with a yellow flame or emits jets of flame when first lighted it indicates that the vaporiser is insufficiently heated, in which case the regulator valve should be closed immediately and the air release valve opened, until the vaporiser has been heated further. Lighting operations will be facilitated by shielding the burner from cold air currents, for which purpose a metal screen should be used, large enough to prevent the possibility of long jets of flame damaging surrounding objects when air pressure is first applied. The vaporiser must not be heated by means of another blow lamp or by application of heat other than that described above.

(iii) *Flame regulation.*—The flame is regulated by the air pressure that exists in the lamp fuel container and by the regulator valve. The pressure is decreased by releasing the air valve and increased by means of a plunger pump. In no circumstances must the pressure in the fuel container exceed 45 lb. per sq. in. Working pressures of from 20 lb. to 30 lb. per sq. in. are sufficient to produce the maximum heat of which the lamp is capable. To extinguish the lamp the regulator valve should be closed and the air release valve opened fully.

(iv) *Using lamps.*—Care must be taken when more than one lamp is in operation to prevent the flame of one lamp playing even momentarily on any part of the other lamp. Precautions should be taken to avoid damaging the vaporiser whilst the lamp is in use, and the flame hood should not be removed when the lamp is at working temperature. After use the lamps should be allowed to cool off, when they may be cleaned before storing. The successful use of these lamps depends to a great extent on paying strict attention to their maintenance. Considerable difficulty will therefore be avoided if the nipples are kept clean and the various parts renewed as necessary.

(v) *Testing.*—The pressure gauge should be tested at frequent intervals to ensure that it is in working order.

(vi) *Inspection.*—As an additional precaution the senior technical officer of the unit concerned is to ensure, by periodical inspection, that all blow lamps are maintained in a serviceable condition.

(vii) *Brazing lamps, Type B.*—A number of type B brazing lamps have been issued fitted with a pump which is so arranged that the valve at the bottom of the barrel can be screwed down when the lamp has been started, to prevent leakage into the pump barrel. This valve should be retained in the closed position, except when the pump is being operated. Care is to be taken to ensure that the pump handle is unscrewed to the limit before pumping, as failure to do this will cause damage to the non-return valve, with a subsequent risk of fire, should fuel collect in the pump barrel. It should be also ensured that the cap nut at the top of the pump barrel is secure and that the grub screw securing this nut is screwed home, otherwise damage may occur to the threads.

Salt bath safety precautions

22. Personnel should be careful whilst using salt baths to avoid contact with the molten salts as its appearance gives no indication of the high temperature; splashing of the salts should be avoided. The heat should be gradually applied, as the solidified salts do not make contact with the container as a result of the contraction that takes place when cooling after use. The hard top surface should be broken as the salts become heated in order to release air lock that may exist below the crust. Any object placed in the bath must be perfectly clean and dry. The heater flame should be under constant observation and the regulator valve turned off if the flame is extinguished. In the event of fire the workshop should be vacated immediately and the fire dealt with from outside the building. Any burns received by contact with the salts must be given immediate medical attention.

Blacksmiths' shop precautions

23. Accidents in the blacksmiths' shop are usually caused by heated metal, splinters from

hardened steel, faulty hammers, work held insecurely in tongs, or from such causes as those indicated in the following sub-paragraphs:—

(i) The coke breeze used in the hearth should be free from foreign matter such as slate or stone that may explode when heated.

(ii) Care should be taken in lighting the fire to avoid heavy accumulations of inflammable vapour in the cowl such as that given off by heated paraffin, and in instances where paraffin is used it must not be poured on to the breeze; a small piece of oily rag is usually sufficient to start the fire in normal circumstances, aided by gentle application of the air blower.

(iii) Work that has been heated and thrown on to the floor to cool should be marked plainly with white chalk to indicate that the item is "black hot". Tongs and other tools that are in frequent use should be cooled in the water trough immediately after use.

(iv) During case-hardening operations, where sodium cyanide is being used, care should be taken to avoid inhaling the poisonous fumes evolved during the process.

(v) Setts and other tempered steel tools used should only be hardened by competent personnel and steel should not be hammered cold unless it has been ascertained that the temper has been drawn.

(vi) Sledge hammer heads should be examined frequently to ensure that they are secure on the shafts, and that the shafts are free from damage; defective hammers should not be used until the faults are rectified.

Oxy-acetylene welding precautions

24. Oxy-acetylene welding and cutting apparatus should be used according to the methods laid down in the Welding Manual, Air Publication 880. The following precautions to be adopted apply to the equipment in use in the service, and should be regarded as a general guide to operators with a view to preventing damage and injury resulting from misuse of such equipment:—

(i) The generator house for low-pressure acetylene supplies, and where any gas cylinders are stored, should be well ventilated and a notice board, as laid down in the standard rules for oxy-acetylene welders, exhibited.

(ii) Leakages of oxygen or acetylene should be located and remedied immediately; tests for leakage should be made with soapy water. Oil should not be used for this or any other purpose in connection with oxy-acetylene equipment, nor should any jointing material of any description be used for making joints.

(iii) The identification colour for oxygen cylinders is black and cylinders painted black must not be filled with air, or used for any other purpose than that for which they are intended.

(iv) Connections for cylinders which do not fit easily should not be forced and all connections should be free from dirt or oil.

(v) Rubber tubing which conveys either oxygen or acetylene should be secured by means of approved clips, and wire must not be used for this purpose. The tubing should be kept free from oil or grease.

(vi) The blowpipes should not be used unless the operator is wearing goggles of the approved type, the lenses of which should be returned as unserviceable when they become badly pitted.

(vii) Blowpipes must either be put in the case or hung up on a suitable holder, and flux tins when not in use should be closed. Cylinder valves should be closed and the pressure in the regulators released when left unused for any length of time.

(viii) Fire buckets and appliances must be easily accessible and in case of fire the operator should, if possible, close the cylinder valves.

(ix) Oxygen valves must be opened very slowly, otherwise the pressure reducing valve may fracture and inflict serious injury on the operator.

(x) Hydraulic valves used with low-pressure acetylene supplies should be free from obstructions. They should be tested before commencing work, also after a back-fire. Purifiers in use with these supplies should, if possible, be placed within the workshop as too low a temperature impedes the correct working of this component.

(xi) When lighting back occurs from the jet there is a possibility of a leakage occurring along the acetylene feed tube at a joint or a weak place, the tube should therefore be inspected to ensure that such a point is not alight after a back-fire. The rubber tubing used for the oxygen and the acetylene feeds should not be patched. Defective tube ends should be cut off immediately any signs of deterioration are evident at these positions.

Machine shops safety precautions

25. Safety precautions applicable to the machine shop apply to all types of workshops equipped with line shafting, machine tools, appliances with independent drive, or any power driven machinery.

Personnel employed in such workshops must be instructed in the method of stopping the machinery in an emergency. The workshop floor should be kept free from oil, grease or any objects, such as pieces of round section metal, on which operators may slip. The following regulations apply to all Royal Air Force machine shops and must be strictly observed:—

(i) Suitable fences or expanded metal screens are to be fitted to electric motors or other power units when these are installed in such a manner that any part thereof is at a height of less than 6 ft. 6 in. above the floor level, or when they are otherwise accessible.

(ii) Guards must be used in instances where main drive or countershaft belting approaches within 7 ft. of the ground level in a fairway or open gangway, or in positions used by operators when making adjustments, etc., also where there is a space not permanently screened off to prevent unauthorised access of personnel.

(iii) Any shafting or countershafting that is erected at a height of less than 7 ft. from the floor level is to be enclosed or screened by fencing.

(iv) Final belt drives from countershafts to machine tools situated in such positions as described in sub-para. (ii) are to be guarded where any belting approaches within 5 ft. 6 in. of the floor level; this distance is measured from the floor to the belt in a vertical plane at the extreme point of the machine immediately under the belt.

(v) Flywheels and any exposed gearing or transmission shafting incorporated in a machine at a height of less than 6 ft. 6 in. from the ground level to any part of such component, when situated in conditions as stated for shafting in sub-para. (ii), must be suitably fenced or guarded.

(vi) Gear trains of machine tools are to be fenced by guards or screens fixed to the machine or to the floor in such a manner as to be readily detachable for the purpose of gear changing, but secure against accidental movement.

(vii) Guards and fences must be in position at all times when the machine shafting or belt is in motion and only removed for the purpose of authorised inspection and adjustment of machinery.

(viii) Machine tools employing a traversing table or tool carriage, e.g. planing and shaping machines, are to be installed in such a position that the table or ram at each end of the maximum travel positions are not less than 18 in. from any fixture that is not a part of the machine.

(ix) Machines, line shafting and countershafting must not be lubricated or cleaned whilst in motion, and cleaning operations are not to be commenced on a machine the line shaft of which is running until the final drive belt to the machine has been removed.

(x) Belt striking gear operated by hand controls must be so adjusted that any tendency of the gear to move will be towards the off position. Line shaft belts must not be removed or replaced whilst the machinery is running and, when changing the belt positions on a speed cone drive, the machine must be stopped and the change made by hand.

(xi) Lathe face plates, driving plates, chucks, etc., are to be mounted or removed with the mandrel at rest. These fittings must not be braked by hand in order to bring the mandrel to rest after switching off.

(xii) Clothing worn by personnel working in the machine shop should be close fitting at such positions as the sleeves, and loosely tied scarves or articles of clothing that are liable to be caught in a machine or shafting should not be worn.

(xiii) The floor immediately around all horizontal milling machines should be maintained in good condition and kept free from loose material. Suitable measures must be taken to prevent the floor from becoming slippery.

(xiv) The lighting at the machines should be good, and where artificial lighting is provided the lighting points should be so placed or shaded that direct rays of light will not impinge on the eyes of the operator whilst he is operating the machine.

(xv) The cutter or cutters of horizontal milling machines must be fenced by a strong guard, properly adjusted to the work, which shall enclose the whole cutting surface excepting such parts necessarily exposed for the milling operations. This regulation does not apply to

milling cutters used on a spindle which exceeds 2½ in. dia., or on an arbor which exceeds 2 in. dia. at the place where the cutter is mounted. Exception is also made in the following cases:—

(*a*) Making tools, jigs, or gauges for use in the workshop.

(*b*) Accurate operations where the traverse is being worked by the operator.

(*c*) Internal and thread milling.

(*d*) End milling other than face milling.

(*e*) Automatic hobbing, profiling, and gear cutting.

(xvi) The guards should be provided with adequate side flanges or should extend on each side of the cutter or cutters to the end of the arbor or arbor support, or to a distance not less than half the diameter of the cutter. This type of guard must be used as stated for all cutters except those used for face milling.

(xvii) Each horizontal milling machine must be provided with an efficient starting and stopping appliance, and the control of this appliance must be in such a position that it is readily and conveniently operated by the operator.

(xviii) When cutting lubricants are used on a horizontal milling machine, suitable safety arrangements should be made to enable the operator to apply the lubricant or to adjust the supply pipe, and suitable means for removing the cuttings should be provided.

(xix) The guards or other appliances required by these regulations must be maintained in an efficient state and must be constantly retained in position while the milling cutter is in motion, except when the tool setter is setting up the machine.

(xx) Personnel employed on a horizontal milling machine must use, and maintain in proper adjustment, the guards or appliances provided in accordance with these regulations.

Woodworking machinery safety precautions

26. Particular care is necessary in the use of woodworking machinery, in order to avoid accidents to personnel. Personnel of the woodworking trades only, above the classification of aircraftsman, 2nd class, are to be allowed to use woodworking machinery. Permission for an airman to work on a specific machine must only be granted by the appropriate specialist officer after he has satisfied himself by personal investigation that the airman is competent to operate the machine. It is essential that the machines are maintained in good condition, that cutters are secure and correctly sharpened, and that the guards and fences supplied with each machine are used and properly fixed. Especial care is necessary in securing the blades of planing machines to the rotating spindle and absolute cleanliness is essential before inserting the blades; the clamping screws must be tightened carefully without over-tightening and they must be checked frequently for tightness. The following list of causes of accidents is given as a guide for the prevention of injury to operators:—

(i) Over-confidence of the operator, lack of general experience, or insufficient knowledge of the particular type of machine.

(ii) Guards and fences removed or carelessly set in position.

(iii) Operators using their hands too close to cutters instead of feeding the work into the machine by means of another piece of wood.

(iv) Using the machine for an operation for which it is not designed, and overloading the machine.

(v) Attempting to work with defective or improperly adjusted cutters.

(vi) Machining timber which has not been previously examined and prepared.

(vii) Using a machine on small items that should be worked by hand.

(viii) Insecure foothold whilst leaning over a machine, caused by pieces of wood, shavings, etc., on the floor.

Lifting appliances precautions

27. In order to safeguard against the possibility of accidents due to failure or misuse of lifting appliances, the correct use and periodical inspection of such appliances are essential. In addition to the information given herewith, further information on the use and care of lifting tackle, types of special engine slings, and safe working loads will be found in Volume II leaflets of this Air Publication. All lifting tackle should be returned as unserviceable immediately any signs of deterioration are noticed, e.g. frayed strands or defective splices in ropes or wear and damaged links in chains. Over-

loading should be avoided at all times. Suspended objects should not be left unattended and personnel should never pass directly underneath. The following points should be noted:—

(i) *Chains.*—Chains should not be subjected to shock loads or hammered. When used for slinging purposes protection should be given to links against sharp edges, by means of wood or sacking. Chain slings should not be shortened by tying the chain into a knot, as this method is unsafe and may result in permanent injury to the chain. A chain should not be considered serviceable when the diameter of the link material is reduced by wear to an amount exceeding 10 per cent. Chains should not be dragged on the floor or thrown down from a height; in the latter case the chain would be liable to failure caused by the resulting crystallisation of the link material. Chains should not be exposed to extremes of temperature for long periods; the strength of a chain diminishes rapidly at temperatures exceeding 600° Fahrenheit, whilst low temperatures tend to make the chain brittle especially at weak places, when notched or damaged in use.

(ii) *Safe working loads for chains.*—The following table gives the safe working loads for ordinary short link steel chains of various link material diameters. The maximum safe working load for a long link chain should be two-thirds of that for a short link chain with link material diameter of the same size. A reduction in the safe load must be allowed for, as shown in fig. 2, according to the sling angle used when lifting.

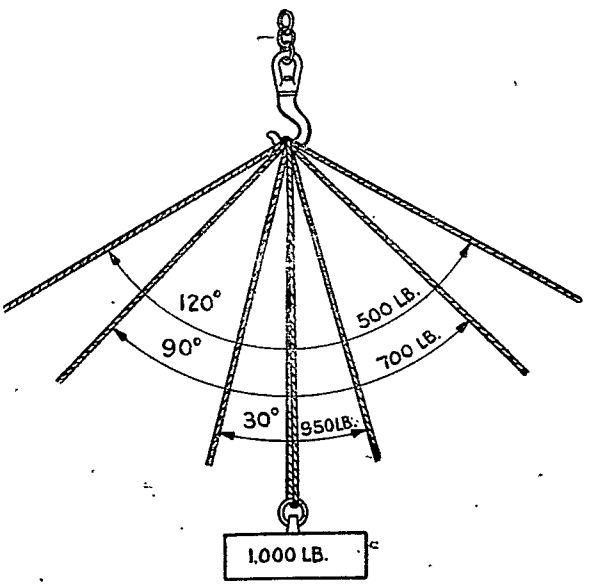

Fig. 2.—Diagram of proportional loads and sling angles

Diameter in inches of link material	Maximum working load in lb.	Diameter in inches of link material	Maximum working load in lb.
$\frac{1}{4}$	650	$\frac{9}{16}$	3,360
$\frac{5}{16}$	1,100	$\frac{5}{8}$	4,200
$\frac{3}{8}$	1,500	$\frac{11}{16}$	5,040
$\frac{7}{16}$	1,900	$\frac{3}{4}$	6,720
$\frac{1}{2}$	2,550	1	7,840

(iii) *Wire ropes.*—Wire ropes should be examined frequently for defects such as frayed strands and ends. They should be kept free from corrosion, and care should be taken to avoid kinks and knots. Protection should be given against sharp edges and rubbing or fretting should not be permitted when a wire rope is in use. When used as a sling the angle of spread

should be taken into account as indicated in fig. 2. The following table indicates the average safe working load for galvanised steel wire ropes of various sizes as listed in Air Publication 1086:—

Safe loads for single galvanised steel wire ropes
Factor of safety allowed = 6

Circum. in inches	Breaking strain lb.	Safe load lb.
½	2,016	336
¾	4,256	710
1	6,720	1,120
1¼	10,752	1,790
1½	15,904	2,650
2	29,568	4,928
2½	45,024	7,504
3	66,752	11,125

(iv) *Hemp and manilla ropes.*—Ropes made of these materials should be inspected frequently for frayed ends, frayed strands, and weak splicing. Ropes should not be allowed to come into contact with acids, nor should they be subjected to heat. Protection should be given against the cutting action of sharp edges. The allowances indicated in fig. 2 for various sling angles should be observed. The following table gives the average maximum safe working loads that may be lifted whilst using tarred hemp ropes of various sizes; for a cotton rope the safe load will be half of that indicated for a hemp rope of the same circumference:—

Safe loads for single hemp and manilla ropes
Factor of safety allowed = 6

Circum. in inches	Hemp (tarred) lb.	Manilla and hemp (untarred) lb.
1	112	150
1½	224	250
2	350	400
2½	650	750
3	950	1,090
3½	1,120	1,280
4	1,400	1,650

Air compressor precautions

28. Air compressors are a source of accidents when not properly serviced. During their servicing it is important to ensure that any water and vapour which is present in the system be drained frequently, otherwise the combination of oil-mist and water-vapour that is formed during the operation of the compressor unit may be ignited by the heat which is generated, thereby resulting in an explosion. The risk of an explosion will be reduced by using a lubricating oil of a high flash point in the compressor crank case and by removing frequently the carbon deposits from the valve heads and piston top, etc. Fixed pipe lines should be so arranged that there is a gradual rise from the air container to the extreme tapping points. Water must be prevented from collecting in any part of the system. All connectors to flexible extensions should be firmly secured to prevent the possibility of adaptors being blown out whilst in use. The safety valve should be tested frequently at the recommended pressure to which it has been adjusted, and the pressure gauge also checked periodically to ensure correct functioning.

Caustic soda precautions

29. Caustic soda should be carefully handled and contact with this substance avoided, especially when it is moistened or when decomposition has taken place and there is a collection of liquid caused by absorption of moisture from the air. The following precautions should be observed when handling caustic soda:—

(i) The approved protective clothing should invariably be worn.

(ii) A vessel of dilute vinegar and a vessel containing a weak saline solution consisting of one teasponnful of salt to one pint of water should be kept ready to hand.

(iii) Should any part of the skin or clothing come into contact with the substance, the part affected should be washed with vinegar solution without delay.

(iv) If the mouth or eyes are affected they should be washed with a weak vinegar solution or the saline solution.

(v) Should any of the substance be swallowed, a weak solution of vinegar and water should be administered immediately, but on no account should the saline solution or anything which may cause vomiting be given. In every case a medical officer should be sent for at once.

Doping precautions

30. During the process of doping aircraft components an explosive mixture of gases is formed in the spaces enclosed by the fabric and this mixture may retain its explosive character for three or four days. Even when the usual precautions are taken against the risk of fire the possibility of an explosion exists under certain conditions, particularly when aircraft are dusted too soon after doping. The dusting of aircraft, especially in a warm, dry atmosphere, induces an electrostatic charge of high voltage on the fabric and metal parts. This charge may cause a spark which may ignite the explosive mixture in the aircraft if unconnected metal parts of the aircraft approach each other, or when the metal parts are brought close to earth, or close to other conductors of high capacity such as metal parts of another aircraft. In order to obviate this and other dangers the precautions given below, together with those relating to the ill-effects of inhaling the gases given off during doping operations and in Vol. II leaflets should be observed:—

(i) Before doping, all metal parts of the aircraft including the control cable must be connected together with copper wire if they have not been previously bonded.

(ii) Before dusting aircraft that have recently been doped, the metal parts must be connected to earth; the metal framework of the building or a metal water-pipe will serve for this purpose.

(iii) It is important that the connections be made in such a way as to give good electrical contact which cannot break if the aircraft is removed.

(iv) Doping operations must not be commenced on an empty stomach.

(v) Food must not be eaten in the doping rooms, nor may personnel remain there during the time allowed for meals, and dope must be removed from the hands before a meal is eaten.

(vi) Doping must be commenced at that portion of the work which is nearest the exhaust fans and must proceed away from that point; personnel must not stand between the exhaust fans and the work while it is drying; the safest position is near the fresh air inlets.

(vii) Respirators must be worn by personnel when spraying dope as laid down in A.P.1464/D.111.

Chromium-plating precautions

31. Where chromium plating is undertaken precautions should be taken to prevent personal contact with the acid. Operators of this process should be provided with rubber gloves, rubber boots and rubber aprons, and supplies of hot running water should be available for washing purposes. An efficient air current should be provided by mechanical means to draw injurious vapour away from the plating vat and clear of all personnel. The floor in this position should be impervious to water and should be swilled down daily. The first-aid box should contain suitable ointment and waterproof plaster in case of injury to operators; medical examination should be given every 14 days.

Anodic process precautions

32. Precautions should be taken where this process is in operation according to the instructions in para. 31 on chromium plating. The electrolyte must not be allowed to come into contact with the skin nor should the fumes be inhaled; any irritation of the skin should be reported to the medical officer immediately. Although the operating voltage required is relatively low, the conductor bars should not be touched whilst the current is switched on, and the current should be switched off before removing jobs from the electrolyte.

Workshop lighting

33. The efficient lighting of the workshop, by daylight and artificial light, is of primary importance. The main objective is to ensure a sufficiency of light at all times, with absence of glare and elimination of shadow, to a degree economically practicable. Considerable saving of artificial light can be effected by carefully positioning the various working stations and frequently cleaning windows, etc. Whitened interiors properly maintained assist in the reflection of all light, artificial or daylight. In instances where sunlight is too brilliant and causes glare, a system of blinds should be utilised to obscure the light, or, as a temporary measure, glass may be whitewashed, this latter material having the advantage of being readily removed. Artificial lighting should be arranged to give a good general effect over the whole area of the workshop, while localised illumination should be employed to assist at the various working stations, as required. In addition, portable illumination, i.e. hand inspection lamps, torches, etc., should be provided for use as occasion demands. The disposition of the various illuminating points together with the use of suitable lamps, reflectors and shades, are primary factors with regard to lighting efficiency and economy; an indication in this direction may be obtained from the following information:—

(i) *Lighting layout.*—It will be seen on examination of the list below that particular workshops are given a recommended intensity of light in foot-candles with the type of reflector that should be used for specified types of work. The higher figures given in the list for the workshops concerned should be adhered to where possible both for general and local lighting. From the number of foot-candles indicated in the list, the graph II of fig. 4 should be utilised to find the area in square feet which can be illuminated to the desired intensity by a lamp of the wattage shown on each curve. Examples are given in dotted lines from 12 foot-candles, which cut through the wattage curves of 100, 150, 200 and 300 watts; horizontal lines taken from these points of juncture to the vertical scale of area values will indicate the area per unit point of illumination, which in the examples are 70, 100, 150 and 220 sq. ft., respectively. The square root of any area so found will give the required spacing of lamps, and by referring to fig. 3, graph I, the recommended height and the type of reflector can be determined from the spacing so obtained.

List of recommended light intensities

Type of work or shop	Recommended foot-candles		Type of reflector	
	General	Local	General	Local
Carpenters'	8–15	—	Dispersive reflector	—
Cellulosing	7–15	25–50	Well glass	Projector well glass
Fine bench work	—	25–50	—	Adjustable workshop
Foundries	5–15	—	Concentrating dust-proof	—
General engineering ...	7–13	15–25	Dispersive or con-centrating	Adjustable workshop
Machine shop	5–15	25–50	Dispersive	Adjustable workshop
Ordinary bench work ...	—	7–20	—	Adjustable workshop
Plating	5–10	—	Well glass	—
Polishing	8–15	—	R.L.M. dustproof	—
Metal workers'	8–25	20–25	Dispersive	Adjustable workshop
Blacksmiths'	3–10	—	Dustproof Dispersive	—
Stores	2–6	—	Distributing	—

(ii) *Correct illumination.*—For the correct disposition of lamps of suitable types giving the requisite intensity of illumination for the whole of the workshop, the following recommendations ensuring the greatest economy and utility will be found useful. The light intensity given is that obtained at the working level, which may be defined as being approximately 3 ft. above the floor level of the average workshop; the actual intensity of light reaching the working plan is from 60 per cent. to 80 per cent. utilisation efficiency. The loss in efficiency is due to light going up and sideways and to differences in reflector efficiencies. The intensity of the illumination can be conveniently based on the unit of a foot-candle (see fig. 4) or on a basis of watts per square foot as given in the tables below.

Table I

Utilisation efficiency	80 per cent.	70 per cent.	60 per cent.	50 per cent.	40 per cent.
Lamp watts	Foot-candles—230-volt lamps At 1 watt per square foot				
40	8·2	7·1	6·1	5·1	4·1
60	9·2	8·0	6·9	5·7	4·6
75	9·7	8·5	7·2	6·0	4·8
100	10·5	9·2	7·9	6·6	5·2
150	10·8	9·4	8·1	6·7	5·4
200	11·2	10·1	8·7	7·2	5·8
300	13·5	11·0	9·4	7·8	6·3
500	16·9	11·8	10·1	8·4	6·7
750	18·1	12·7	10·9	9·0	7·2

Table II

Watts per sq. ft.	0·5	0·75	1·0	1·25	1·5	1·75	2·0	2·5	3·0	3·5
Lamp watts	Foot-candles based on 60 per cent. utilisation efficiency. 230-volt lamps.									
40	3·0	4·6	6·1	7·6	9·2	10·7	12·3	15·3	18·4	21·5
60	3·4	5·1	6·9	8·6	10·3	12·0	13·8	17·2	20·7	25·1
75	3·6	5·4	7·2	9·0	10·9	12·7	14·5	18·2	21·8	25·4
100	3·9	5·9	7·9	9·8	11·8	13·8	15·8	19·8	23·7	27·7
150	4·0	6·0	8·1	10·1	12·1	14·2	16·2	20·3	24·3	28·4
200	4·3	6·5	8·7	10·8	13·0	15·2	17·4	21·7	26·1	30·4
300	4·7	7·0	9·4	11·8	14·1	16·5	18·9	23·6	28·3	33·0
500	5·0	7·6	10·1	12·7	15·2	17·7	20·3	25.4	30·4	35·5
750	5·4	8·1	10·9	13·6	16·3	19·0	21·7	27·2	32·7	38·1

(iii) *Limiting factors.*—There are certain factors which may limit the dimensions of a lighting installation, one instance being the height available above the working plane; in such a case the spacing will be determined by the height shown in fig. 3, (see examples C and D) while the square of the spacing so obtained will give the area illuminated per point. The wattage required (see fig. 4) to give the correct lighting in foot-candles is found by taking a horizontal line from the corresponding area marked on the graph scale to a point immediately over the requisite number of foot-candles; the curve nearest to this point will represent the wattage of the lamp. Other deciding factors are the varying lengths and widths of workshops and the wattage of the lamps available. Lamps of high candle power should be so shaded that no part of the filament may be seen at an angle of less than 20 degrees to the horizontal plane, by any person employed within a distance of 100 ft.; in the case of any person employed within 6 ft. of the light source it is recommended that the angle be not less than 30 degrees. Direct reflection from highly polished surfaces such as aluminium or steel into the eyes of personnel should be avoided by the provision of adequate shading.

Maintenance of lighting systems

34. To retain the efficiency of a lighting system proper maintenance of the fittings, etc., must be regularly observed. The following points should be carefully noted:—

(i) All electric lamps, fittings, reflectors, etc., should be examined periodically and cleaned. Lamps should be removed from their holders and the glass bulbs washed in soapy water and carefully dried with clean rag; reflectors must not be wiped with oily rag as the oil will burn on to the surface, thereby leaving a hard deposit with consequent loss of efficiency in light reflection.

(ii) The average useful life of the filament of an ordinary electric lamp is approximately 1,000 hours, at which point the current consumption increases and the lighting efficiency

decreases. When this point is reached it is more economical to replace the lamp than to leave it until the filament finally burns out. All damaged and burnt-out lamps should be replaced by lamps of the correct voltage and wattage as soon as possible.

(iii) Electrical wiring, fuses, switches, etc., should be examined periodically and any defects rectified immediately by authorised personnel. Suspended lamps on flexible wiring should not be raised to a higher position by tying knots in the wire, but should be carefully suspended by approved methods. The flexible leads of portable equipment should be protected from contact with sharp metal edges and from heat; if laid on the floor during use, adequate protection should be provided to prevent damage to the wire insulation or core, caused by wheeling portable cranes or engines stands, etc., over them. After use the cables should be carefully coiled prior to storage.

(iv) Repeated failure of fuses in the electrical circuit indicates an overload, faulty equipment, defective wiring or the presence of moisture. The defect should be traced without delay and remedied by competent personnel.

(v) The fastenings of heavy lamp fittings should be frequently examined and any defective parts replaced; this especially applies where such fittings are permitted to swing freely, and where they are exposed to corrosive agents, e.g. to sea air at coastal stations.

(vi) Economy in the consumption of current must be practised at all times. Constant supervision should therefore be exercised in order to prevent waste caused by the unnecessary use of lighting and electrical equipment.

(vii) Sub-switches in the various workshops should be switched off before the main supply is switched either on or off, in order to relieve the load on the main switch.

Portable electrical installations

35. Portable electric generating sets are available to the service for the supply of power and light. Early types are of different voltages, but 230-volt alternating current generating sets are now standardised, thus enabling apparatus already employed with normal 230-volt supplies to be retained. The information given in this paragraph is intended as a guide in the various applications of portable sets, and to electric lighting and power plants generally:—

(i) *Application of power.*—Portable generating sets may be utilised for the supply of power and light for workshop use, airfield floodlighting, land beacons, battery charging, etc. Small direct current (D.C.) generating sets are available for the purpose of charging batteries, and these are described fully in the A.P. "1095" series. An alternating current (A.C.) generator cannot be used directly for charging purposes but the A.C. current may be rectified first and then used; metal rectifiers are available and listed in Air Publication 1086. A.C. generators are used mostly for the supply of power for lighting, heating and driving electric motors. The actual power output will be less than the rated output according to the nature of the load; the difference is due to the effects of resistance, capacity and induction as present in induction type motors. A circuit consisting of lighting is practically non-inductive, and the power factor for the true output may be taken as 0·95 of the rating; for power motor supplies the average value will be 0·80 and for motors and lights together 0·85. Power rating is dealt with in the following sub-paragraph.

(ii) *Power rating.*—The power rating of a D.C. generator is usually given in kilowatts (K.W.) and of an A.C. generator in kilo-volt-amperes (K.V.A.). The unit of electric power is the watt and one watt is the work done during one second by a current unit (one ampere) against a resistance unit (one ohm); see para. 39. The electrical horse power is equal to 1·34 times the rating in kilowatts and 746 watts is the equivalent of one mechanical horse power. The standard frequency for alternating current is 50 cycles per second. A.C. generators may be single, two, or three phase according to the design and the circuit; in three phase circuits each supply wire is used as the return for the other two. For the types of generators indicated, the amperage of the output for a known voltage may be obtained from the formulae given below, when the load is non-inductive, such as lighting:—

Direct current ... ... $\dfrac{\text{K.W.} \times 1{,}000}{\text{voltage}}$

Alternating current:—
Single phase ... ... $\dfrac{\text{K.V.A.} \times 1{,}000}{\text{voltage} \times 1}$

Alternating current:—
Two phase ... ... $\dfrac{\text{K.V.A.} \times 1{,}000}{\text{voltage} \times 2}$

Alternating current:—
Three phase ... ... $\dfrac{\text{K.V.A.} \times 1{,}000}{\text{voltage} \times \sqrt{3}}$

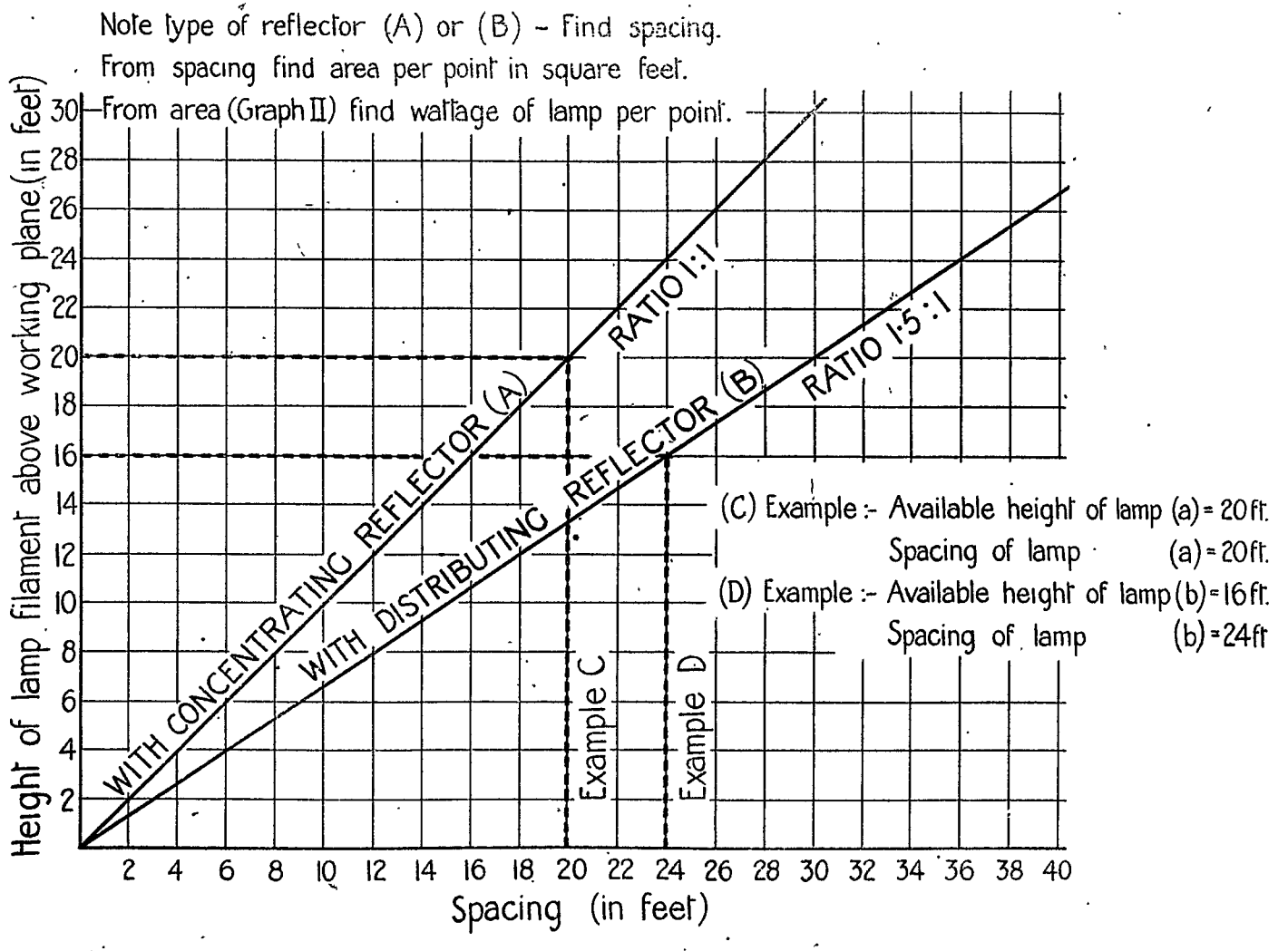

Fig. 3.—Mounting heights of lamps for uniform lighting

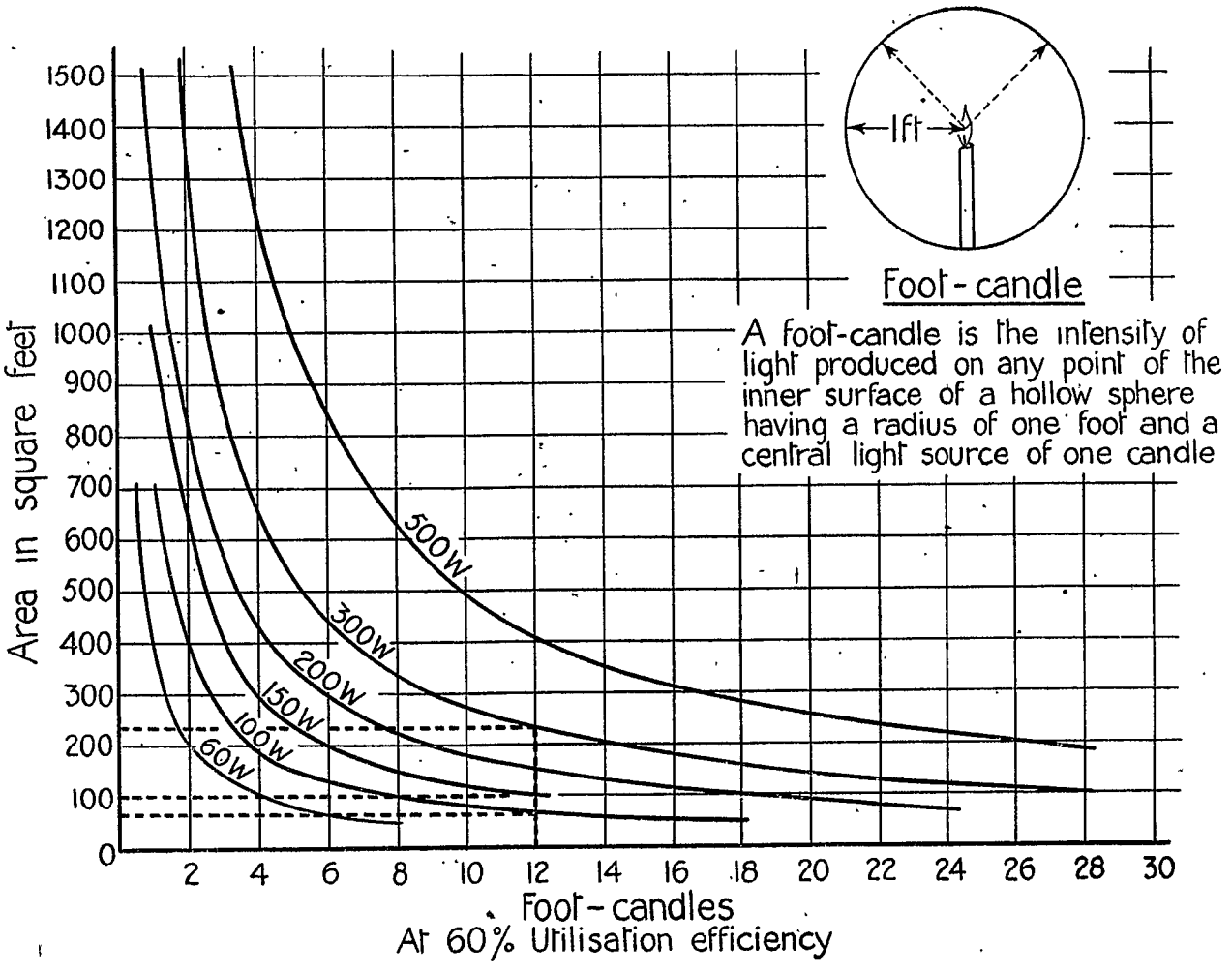

Fig. 4.—Relation between area and illumination

(iii) *Distribution of power.*—In order to ensure the efficient distribution of current it is essential that the cables used are of a sufficiently large cross sectional area to carry the current required at any point. For a given amperage a cable size may be selected from Table III below. The current carrying capacity of cables listed in Air Publication 1086 is also given in that publication together with the core sizes. The lamps or motors that are included in a circuit should be protected by means of fuses of the correct amperage at suitable distributing points, whilst the whole system should be protected by means of main fuses. Fuses should "blow" at double the normal maximum current which is being carried for amounts up to 50 amperes and at one-and-a-half times the normal current for supplies of 50 to 100 amperes, whilst for amounts over 100 amperes one-and-a-quarter times the normal supply should be allowed. Sizes of copper wire for use as emergency fuses are given in Table IV. The voltage of lamps or any apparatus used in an installation should be the same as that of the generator; as a rule the generator voltage may be slightly higher in order to compensate for a drop in the voltage due to resistance in the cables. The number of lamps of different wattages that constitute a full load for given outputs is given in Table V.

Table III

Cable sizes for load in amperes

Current in amps.	Size of cable	Current in amps.	Size of cable
3	1/036	37	7/052
5	1/044	46	7/064
5	3/029	53	19/044
10	3/036	64	19/052
15	7/029	83	19/064
24	7/036	97	19/072
31	7/044	118	19/083

Note.—The No. before the stroke in the cable size represents the number of wires forming the cable. The No. after the stroke indicates the diameter of each wire and should be read 0·036 to 0·083 in.

Table IV

Sizes of copper fuse wires (emergency)

Fusing current in amperes	Dia. in in.	S.W.G.
1	0·0021	47
3	0·0044	41
5	0·0062	38
10	0·0098	33
15	0·0129	30
20	0·0156	28
25	0·0181	26
30	0·0205	25
50	0·0288	22
70	0·0360	20
100	0·0457	18

Table V

Engine B.H.P.	Generator K.W.	Number of lamps			
		25 W	60 W	100 W	150 W
5	3	100	40	25	16
7	4½	150	60	35	24
10	7	230	90	60	35
20	14	450	180	120	70

Power, general requirements

36. The power required for workshops will vary considerably according to the size of the installation and the type and efficiency of the layout. Machine tools which are provided with individual drive electric motors require a reserve of power for which an allowance must be made in power calculations. The information given below is based upon the average requirements of machine tools and lighting as applicable to the service. In practice it has been found that for the purpose of driving a generator an allowance of one brake horse power should be made for each 600 watts output.

37. *Power, station workshop requirements.*—The following particulars are given to indicate the usual requirements of a station workshop. The total consumption of current will be approximately 13 K.W. and a 14 K.W. generating set would therefore supply such a station workshop easily.

Lighting:—

No. of lamps	*Wattage*	*K.W.*
24	25	0·660
12	60	0·720
12	100	1·200
28	150	4·200
		6·780

Power:—

Load	*K.W.*
6¾ in. centre lathe	2·0
Buffing machine	2·0
Grinding machine	0·5
Sensitive drilling machine	0·5
Portable drilling machine	0·5
Electric soldering irons	0·2
Glue kettles	0·3
	6·00

38. *Power, machine tools, individual drive.*—The average power required by machine tools fitted with individual electric motor drive is given below for each type of machine. The power values given are applicable to machines used for normal purposes, but in the case of high speed work, or machining such exceptionally hard material as manganese steel, then the power required will be 50 per cent. higher in each case than the appropriate average value given here:—

Type of machine tool	*Size*	*Electrical H.P.*
Boring:—		
Machine, horizontal	4 in. spindle for bores up to 20 in. dia.	7·5
	6 in. spindle for bores up to 30 in. dia.	10·0
Drilling:—		
Machine, sensitive	to ½ in. dia. drill	0·75
Radial	3 ft. arm	3·0
Radial	4 ft. 6 in. arm	5·0
Vertical	24 in. up to 2 in. drill	5·0
Grinding machines:—		
Tool grinding, stand type	10 in. wheels	2·0
	12 in. wheels	3·0
	18 in. wheels	5·0
Cylindrical grinding	10 in. to 12 in. × 2 in. wheel	5·0
	14 in. × 2 in. wheel	7·5
	18 in. × 2 in. wheel	10·0
Lathes:—		
Engine lathe, general purpose	7 in. centre	3·0
	12 in. centre	7·5
	18 in. centre	15·0
Milling machines:—		
Plain	24 in.	7·5
Plain	36 in.	10·0

Type of machine tool	*Size*	*Electrical H.P.*
Planing machines:—		
Double tool	24 in. × 24 in.	10·0
	36 in. × 36 in.	15·0
	48 in. × 48 in.	25·0
Shaping machines:—		
	12 in. stroke	3·0
	18 in. stroke	5·0
Slotting machines:—		
	6 in. stroke	3·0
	8 in. stroke	5·0
	12 in. stroke	7·5
Gear cutting machines:—		
	36 in. × 9 in.	3·0
	48 in. × 10 in.	5·0

39. *Electrical units and formulae.*—The following information will be found useful in obtaining electrical unit values as required, by the application of Ohm's law when the information given above is insufficient for the work in hand:—

(i) The current in an electrical circuit varies directly as the electro-motive-force (E.M.F.) and inversely as the resistance of the circuit. The unit of current is an ampere (I), the unit of resistance an ohm (R), and the unit of pressure (E.M.F.) is a volt (E); thus

$$I = \frac{E}{R}, \quad R = \frac{E}{I} \text{ and } E = IR.$$

(ii) The power (P) in a circuit is the product of the E.M.F. (E) and the current (I), and the unit of power is the watt. For large power outputs the kilowatt (1,000 watts) is used as a unit of power.

From the above it will be seen that $P = EI$

and as $I = \frac{E}{R}$ then $P = E \times \frac{E}{R}$, or $P = \frac{E^2}{R}$; also $E = IR$, so that $P = IR \times I$, or $P = I^2R$

Note.—This application of Ohm's law is true when applied to direct current supplies only and not to alternating current, as induction, capacity and resistance each affect the power output (see para. 35).

(iii) In order to determine the brake horse power required to drive a generator of a known output, the output in KW × 1·34 will give the electrical horse power, and this divided by the generator efficiency will give the B.H.P. required (see Table III, para. 35).

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