Electrical Charging Systems for Construction and Industrial Machinery — SAE J180b

SAE Recommended Practice
Last Revised March 1979

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ELECTRICAL CHARGING SYSTEMS FOR CONSTRUCTION AND INDUSTRIAL MACHINERY—SAE J180b

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved June 1970 and last revised by Off-Road Machinery Technical Committee March 1979. Rationale statement available.

1. Scope—This recommended practice covers charging systems for construction and industrial machinery.

2. Purpose—To provide information on which to base vehicle and component design which will result in the most satisfactory operation of charging systems in the severe environment of construction machinery.

3. General—The size of alternator to provide adequate low-speed performance and necessary total output, embodied in a structure to withstand wet and dirty environment, is difficult to reconcile with the space usually provided for charging equipment. Future designs can benefit from a clear agreement on output needs and required envelope size (with some standardized dimensions). Installation practices greatly affect durability; so good practice should be defined.

4. Design Considerations

4.1 Performance

4.1.1 OUTPUT AND ENVELOPE—Desired performance curves for both 12 and 24 V systems are shown in Fig. 1. (Refer to SAE J544 for the method of establishing the curves.) These curves can be provided by machines built within the envelope sizes shown in Figs. 2 and 3. Fig. 2 portrays double-lug mounted and spool mounted machines of ventilated construction. Fig. 3 is a larger envelope providing room for a built-in regulator and the complete enclosure of sensitive parts without exceeding the temperature limitations (based on 200°F (93.5°C) maximum expected ambient). Fig. 4 shows the proper pulley hub dimensions for the machines in both envelopes.

Machines with different top output rating, to comply otherwise to this recommended practice, shall develop the same percentages of top output in the lower speed ranges as those indicated in Fig. 1.

4.1.2 REGULATION—When, as in the case of construction and industrial machinery, engines may run for hours on end without shutdown, the charging systems require special regulation considerations to prevent extensive battery damage from overcharge. Unless there can be direct correlation of battery and regulator temperature, the regulator shall have a fixed setting, with provisions for limited adjustment by operator for seasonal or observed conditions. Temperature compensation may be used under controlled conditions. Possible regulation systems are:

(a) Flat compensated with external voltage adjustment. Nominal voltage setting ranges of 13.5–14.0, with ±0.6 V range of adjustment; nominal range, 27–28 V, with ±1.2 V adjustment.

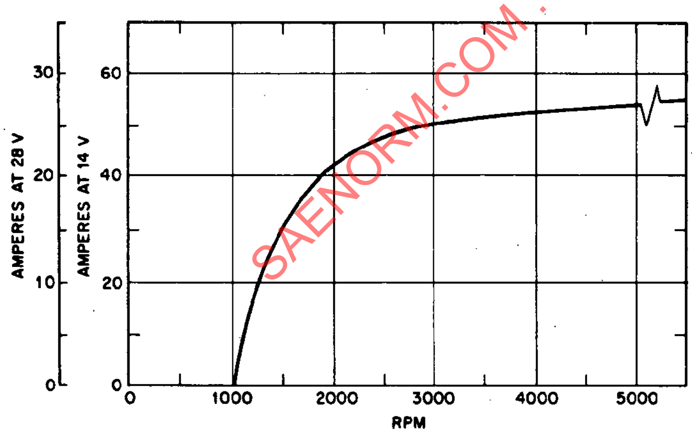


FIG. 1—MINIMUM PERFORMANCE CURVES

(b) Regulator compensated by sensing unit in battery. Voltage range, 13.0–15.5; 26.0–31.0. (See Fig. 5.)

(c) Temperature compensated regulator when regulator and battery are in same ambient. Voltage range, 13.0–15.5; 26.0–31.0. (See Fig. 5.)

The vehicle designer shall consider the probability of open-circuit operation and accidentally induced high transient voltage. When this is a design factor, he shall spell out the conditions (maximum speed, maximum load change, repetition rate) to the alternator manufacturer and specify the maximum voltage (peak and duration) tolerable to the load components of the electrical system.

4.2 Mounting Recommendations

4.2.1 VIBRATION—The tolerance of alternators to vibration shall be given by the component manufacturer in a form similar to Fig. 6, for determining the suitability when used with a particular mounting on a particular engine. (The vehicle manufacturer shall mount the pick-up devices exactly as specified by the component manufacturer because the measurement is only relative. These curves cannot in any way be used to compare alternators of different manufacture.)

The vehicle or engine manufacturer shall build up and test a proposed installation to make sure of staying within the limitations. An alternative would be to follow closely the component manufacturer's recommendation for hardware design.

Mounting bolt strength and mounting surface hardness are important in retaining initial tightness and vibration resistant performance. Mountings of types shown in Figs. 7 and 8 have been effective in adjusting differences between the alternator lug and the mounting bracket dimensions, thus providing the necessary clamping without excessive strain on the alternator lug or a requirement for close tolerances on either part.

4.2.1.1 *Double Lug Mounting*—Fig. 7 shows a hardened split bushing spring-fitted in the mounting lug opposite the drive end. The mounting bolt clamps the mounting bracket to this bushing. Tightening of the mounting bolts urges the bushing to an accommodating position, easing strain on bracket and lugs.

4.2.1.2 *Spool Mounting*—Fig. 8 also uses a hardened, spring-fitted bushing, but it must be in the mounting bracket.

4.2.2 BELT LOADING—Pulley overhang from the drive-end bearing is generally the most severe cause of excessive bearing loads. To prevent bearing wear or failure from this cause, the vehicle designer must keep within the limits of a chart provided by the alternator manufacturer. The chart would be like Fig. 9, showing maximum loadings versus overhang at different expected speeds. For the machines shown in Figs. 2 and 3, which normally use a medium-duty 25 mm bearing with the $\frac{7}{8}$ in. (22.2 mm) diameter shaft extension, the curves present information based on 10,000 h B-10 life. In other combinations of shaft and bearing size, the limitation may be set by shaft fretting or shaft fatigue.

To help determine the belt specifications and to help calculate the belt loading, the alternator manufacturer shall furnish curves showing the full-load horsepower and torque required to drive the alternator, as in Fig. 10. For calculating loads on the drive components due to accelerations, the moment of inertia of the rotor is also required.

For avoiding one cause of shaft wear and bearing failure, the pulley hub dimensions shall conform to Fig. 4 shown with the envelope drawings. The hub must have a free fit over the shaft so that all of the nut torque will be available for providing clamping force against bearing inner race.

4.3 Terminals—The alternators shall be capable of single-wire operation with the alternator being of the self-exciting type. Only a positive insulated output terminal shall be provided. Optional auxiliary or field terminals shall be made available for those users who wish to operate auxiliary items from the alternator phase windings, or who wish to control the field supply from an external controller. On all alternators provision shall be made for a negative ground connection, either by a terminal post or a threaded hole, to ensure a solid electrical ground path from the alternator to the vehicle system ground.

To ensure correct electrical connection between the alternator and the mating wiring harness, and to standardize on terminals between the various alternator manufacturers, the following terminal sizes are recommended:

Positive output stud: Not larger than $\frac{7}{16}$ in. but larger than the negative stud.

Negative ground stud or threaded hole: No smaller than $\frac{1}{4}$ in.

Auxiliary stud: Not larger than No. 10.

Field terminal: Must be keyed against cross-connection with other terminals.

On any alternator, the various terminals must be different sizes or keyed against cross-connection.

Blade type terminations shall not be used on alternators that are covered by this recommended practice.

4.4 Electromagnetic Interference—The charging system, when installed on the vehicle, shall not cause the vehicle to fail to pass the requirements of

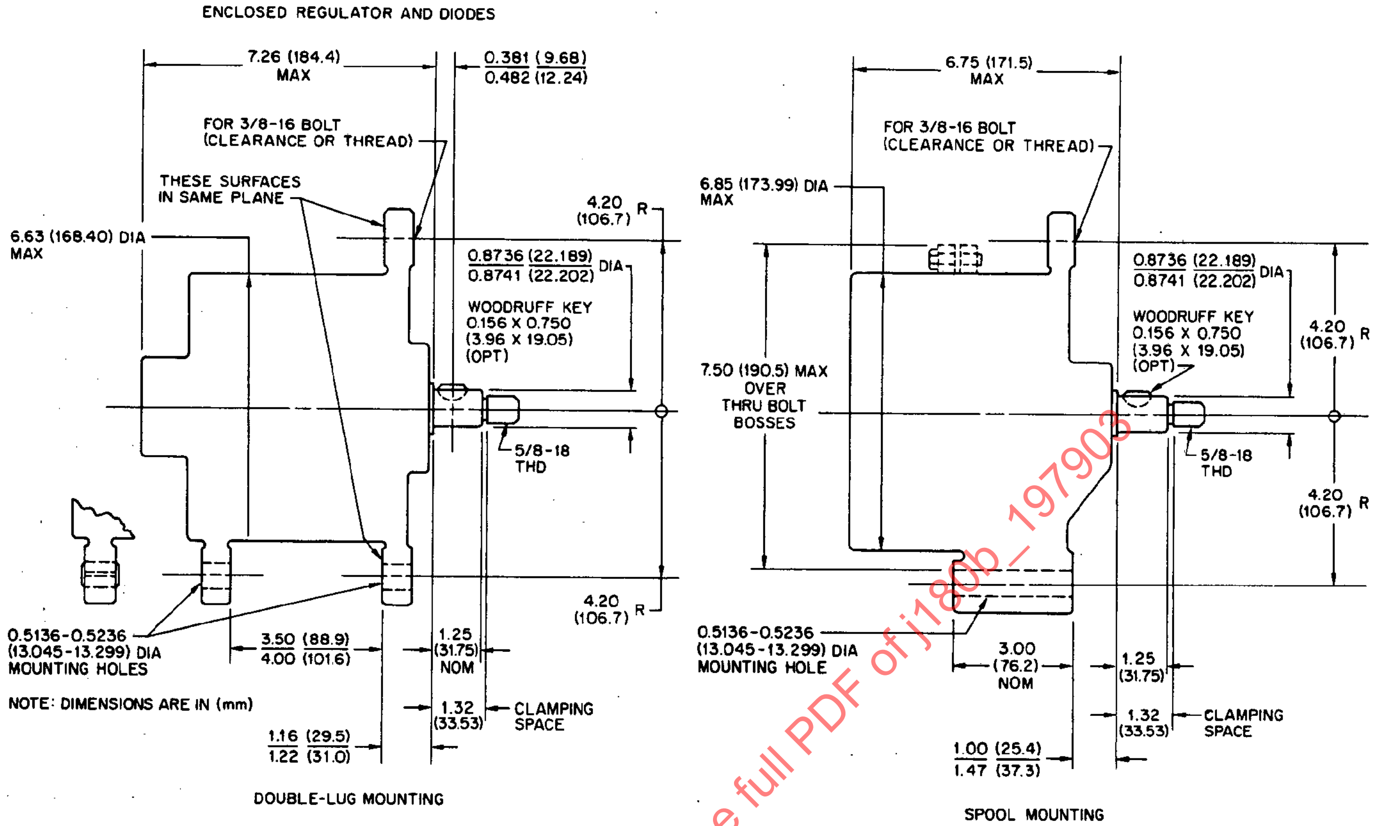


FIG. 2—ALTERNATOR ENVELOPES FOR VENTILATED CONSTRUCTION

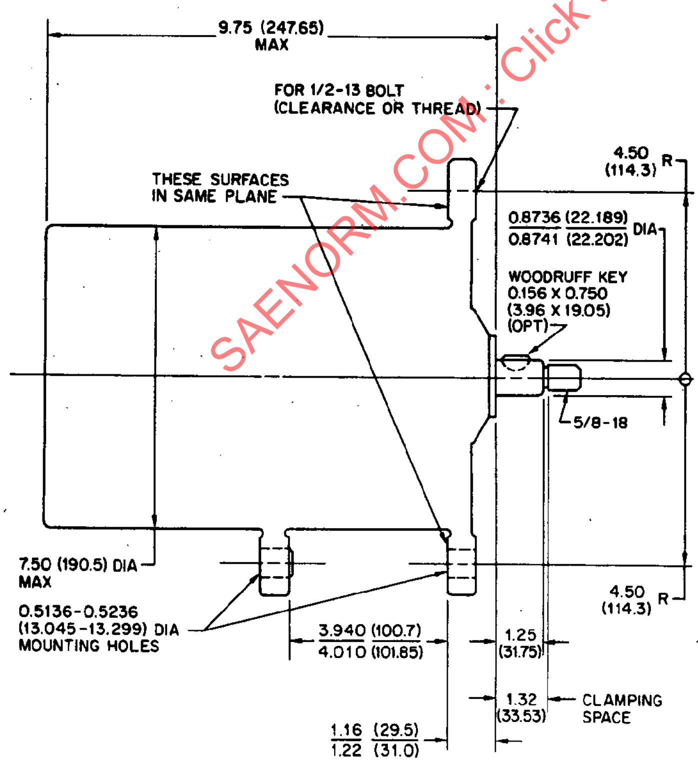


FIG. 3—ENVELOPE FOR MACHINE WITH ENCLOSED REGULATOR AND DIODES

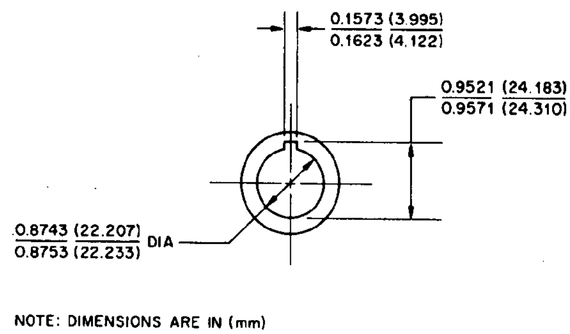


FIG. 4—PULLEY HUB DIMENSIONS

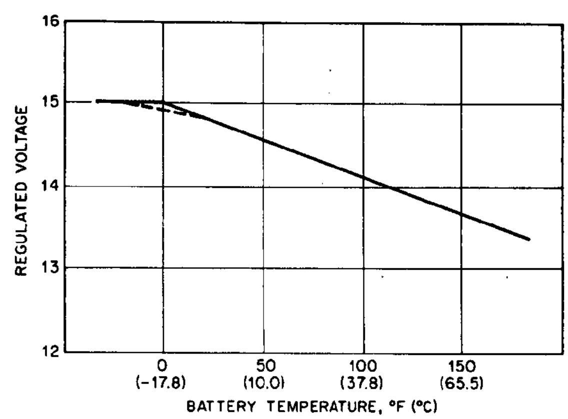


FIG. 5—NOMINAL REGULATOR COMPENSATION CURVE

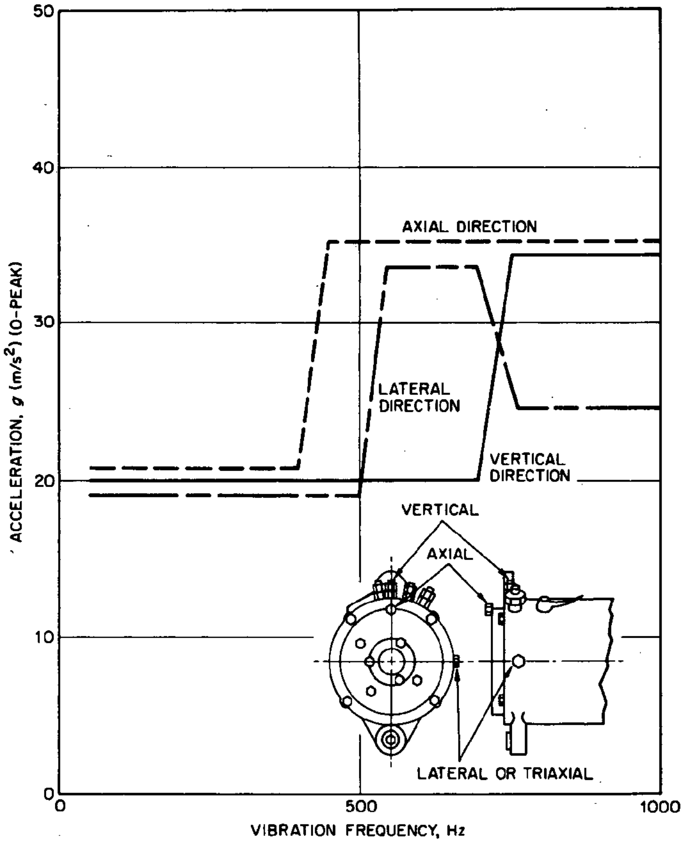


FIG. 6—VIBRATION TOLERANCE CURVE

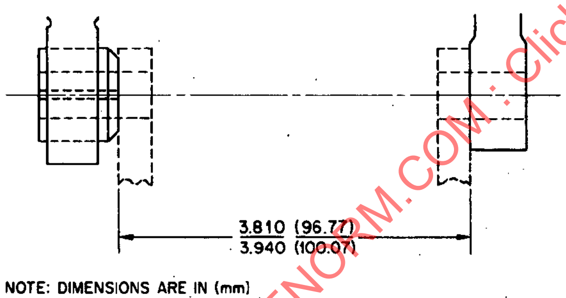


FIG. 7—TYPICAL INSTALLATION OF SPLIT BUSHING IN HINGE MOUNTING LUG

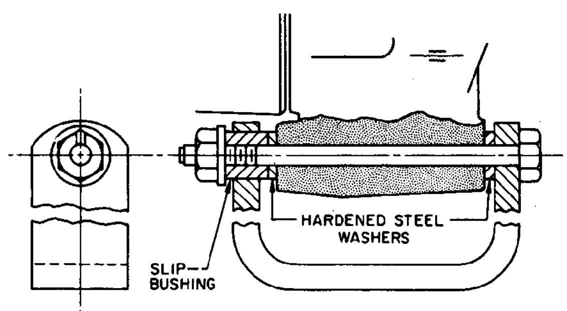


FIG. 8—TYPICAL INSTALLATION OF SPLIT BUSHING IN BRACKET FOR SPOOL MOUNTING

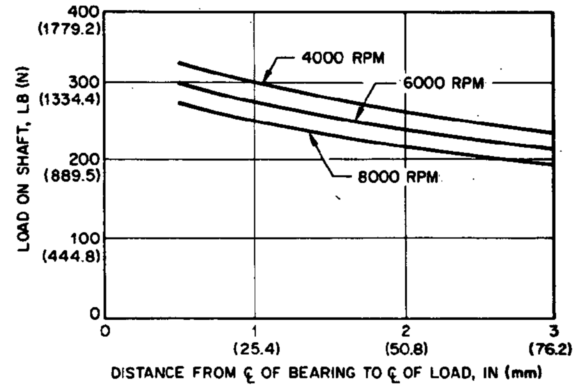


FIG. 9—TYPICAL CHART FOR SHOWING LIMITATIONS FOR SHAFT LOADING

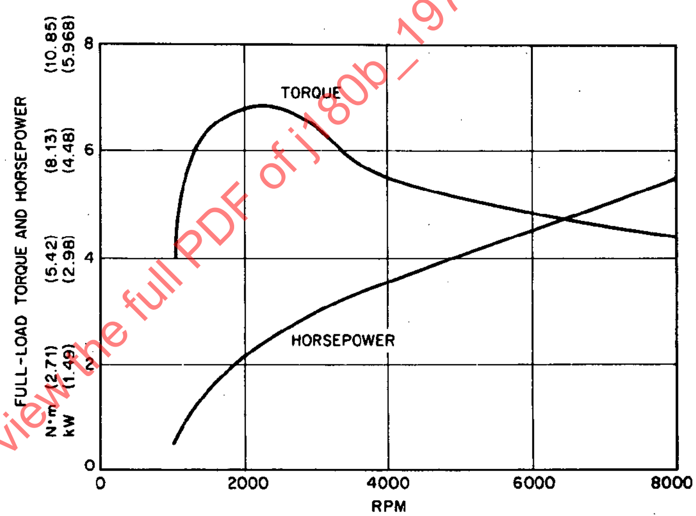


FIG. 10—TYPICAL CURVES OF TORQUE AND HORSEPOWER REQUIREMENTS

SAE J551.

4.5 Batteryless Operation—The average steady-state alternator system output terminal voltage, with battery disconnected and a minimum resistive load of 60 W, shall not rise by more than 10% when compared to the allowable voltage with the battery connected.

4.6 Load Dumping Characteristics—The alternator system including all associated rectifying, regulating, and filtering devices, shall withstand the self-induced voltage surge resulting from the sudden disconnection (not longer than 20 ms to complete break) of the output current (including battery) at 6000 rpm and maximum possible output at that speed.

4.7 Corrosion Tests—The charging system shall be placed in salt spray conditions, per ASTM B 117 (except the temperature shall be held to 35° ± 5°C) for 100 h. It shall be electrically energized (battery connected to the output terminals), rotating for the first 50 h and not rotating for the second 50 h. At the end of this test, the unit shall be capable of rated output and show no significant deterioration of the alternator system.

4.8 Dust Test—The charging system shall be capable of operating in severe dust environments with no detrimental effects on performance. This can be tested by operating the complete unit for 1000 h at 5000 rpm in an enclosure where standard dust is available to be circulated at an approximate average density of 10 oz of dust per ft^3 of air (9.9 kg/m^3). This test can be run with no output from the charging system, up to rated output if the temperature in the enclosure is kept below the maximum ambient specified in paragraph 4.1.1.

Some standard dusts:

Per MIL-E-5272C, paragraph 4.11.1.
AC coarso dust, AC Spark Plug Div., General Motors Corp.
Phoenix dust.
Fly ash.

4.9 Reverse Polarity Protection (Optional)—When specified by the user, it is recommended that either an integral reverse polarity protective device for the charging system or a separate device which could protect the entire vehicle system be used. Such a device should protect the charging system against reverse battery. Upon proper reconnection of the protective device and the battery, the charging system must work satisfactorily. The charging systems which use this device must meet the load dump requirements of paragraph 4.6. This system must work over a temperature range as specified in paragraph 4.1.1.

4.10 Fungus Proofing (Optional)—When end use requirement includes operation in areas where fungus attack may be a problem, the end item manufacturer or user will request fungus proofing. The method of fungus proofing shall be the alternator manufacturer's responsibility. The alternator manufacturer shall use methods which will ensure that exposed organic materials are either: non-nutrient to fungi, or designed or treated so that fungi will not be detrimental to the life or operation of the unit.

5. Alternator Output Capacity Selection

5.1 Proper alternator selection must include end item duty cycle, maximum practical connected load, and idle requirements.

5.2 The minimum alternator output current at operating speed is the sum of the load currents that are likely to be used at one time, multiplied by an allowance factor to recharge the battery. (See Table 1.) Heater and air-conditioning loads should not be summed and added to the total load; only the higher of the two should be used. For short duration loads, such as starters, radio transmitters, sirens, etc., add average value of current (load current × % of time used).

5.3 Use of Selection Table—To illustrate the use of the Selection Table, the following example is given:

End item—Bulldozer
Duty cycle—10% low idle
Total connected load—30 A
From selection table—3 A low idle
Alternator output—33 A (min)

TABLE 1—SELECTION TABLE

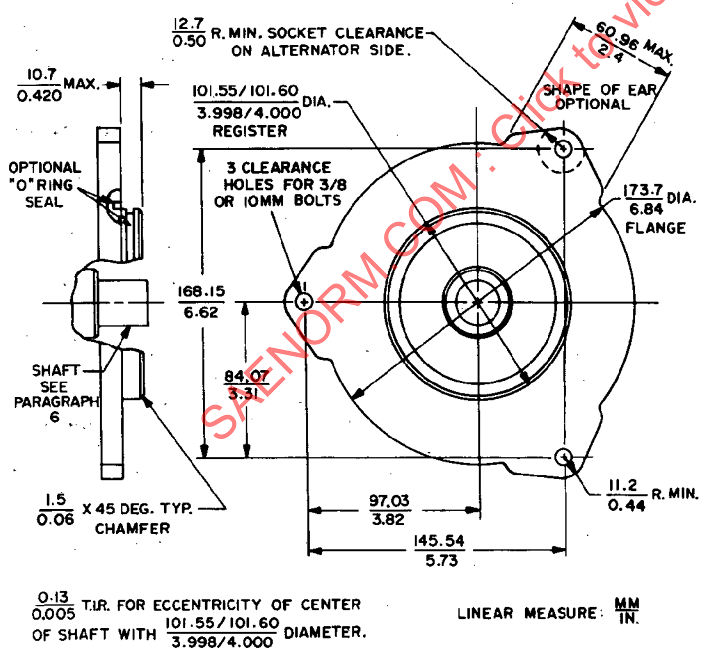
Engine low idle time, %	5–10	10–30[a]
Min output at low engine idle, % of max load	10	30
Min allowance factor to recharge battery	1.1	1.1
Typical examples	Bulldozers Scrapers	Lift trucks Cranes

[a]For engine low idle times in excess of 30% of time used, the alternator output at low idle should be capable of supporting the full normal load and the user should consult the alternator manufacturer for specific recommendations.

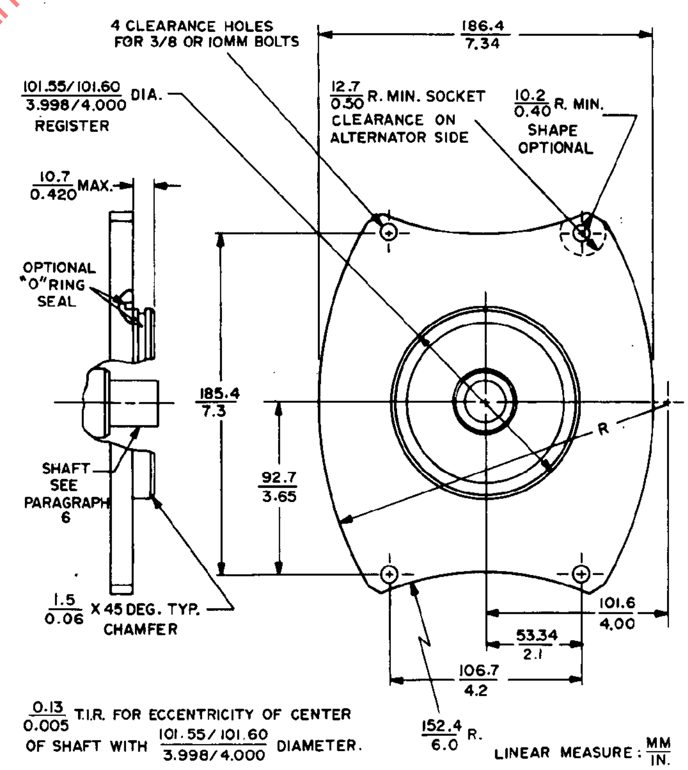
ϕ *6. Direct Driven Alternators (Flange Mounted)*—In order to obtain interchangeability of alternators of different manufacture, the following drawings have been developed (Figs. 11–13).

The parameters shown are those that define major tooling requirements. The alternator shaft dimensions have not been included. Further field testing is required before a recommendation can be made. The alternator shaft can be altered readily without incurring major tooling changes.

ϕ **6.1** Vibration considerations, as given in paragraph 4.2.1, are valid for direct driven alternators, but in addition there are strong torsional vibration considerations not present with belt driven units. It is essential that information be exchanged between engine and alternator manufacturers relative to torsional vibration requirements.



ϕ FIG. 11—ALTERNATOR FLANGE MOUNT. THREE BOLT—AIR COOLED



ϕ FIG. 12—ALTERNATOR FLANGE MOUNT. FOUR BOLT—AIR COOLED