SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

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SAE J335 REV. SEP90

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(R) MULTIPOSITION SMALL ENGINE EXHAUST SYSTEM FIRE IGNITION SUPPRESSION

1. SCOPE:

This SAE Recommended Practice establishes equipment and test procedures for determining the performance of exhaust systems of multiposition engines used in hand-held portable applications. It is not applicable to spark arresters used in vehicles or stationary equipment.

1.1 Purpose:

This document provides a method of testing to evaluate the fire ignition potential of exhaust systems of small multiposition portable engines.

1.2 Performance:

Recommended performance criteria are given in Appendix A which are adequate for the severe fire hazard condition posed by heavy vegetative fuels. However, during periods of extreme fire danger, exhaust systems meeting this standard may not give absolute protection against fires. Additional control of operations may be necessary during such periods.

2. REFERENCES:

2.1 Applicable Documents:

SAE J997, Spark Arrester Test Carbon.

SAE J1349, Engine Power Test Code - Spark Ignition and Diesel.

D. S. Stocksted, "Spontaneous and Piloted Ignition of Pine Needles." Research Note INT 194, USDA Forest Service, Northern Forest Fire Laboratory (1975).

2.1 (Continued):

D. S. Stocksted, "Spontaneous and Piloted Ignition of Cheatgrass." Prepublication Research Note, USDA Forest Service, Northern Forest Fire Laboratory (1976).

G. C. Kaminski, "Ignition Time versus Temperature for Selected Forest Fuels." Project Record, USDA Forest Service, San Dimas Equipment Development Center (1974).

R. T. Harrison, "Danger of Ignition of Ground Cover Fuels by Vehicle Exhaust Systems." ED & T Report 5100-15, USDA Forest Service, San Dimas Equipment Development Center (1970).

Anon, "Standard Test Procedure for General Spark Arresters." USDA Forest Service, San Dimas Equipment Development Center (1982).

2.2 Definitions:

2.2.1 MULTIPOSITION SMALL ENGINE (MSE): A hand-held power unit having an internal combustion engine operable in more than one position. MSE configurations include chain saws, weed trimmers, brushcutters, blowers, hedge trimmers, and cutoff saws.

2.2.2 POWER UNIT: An MSE unit exclusive of removable extensions such as chain saw bar and chain, brushcutter and trimmer shaft assemblies, hedge trimmer blade, cutoff saw blade extension, blower ducts, etc.

2.2.3 SPARK ARRESTER: An exhaust system having the ability to control the amount and size of particulate carbon or metal particles emitted into the atmosphere.

2.2.4 CONTACT PLANE: An imaginary flat surface defined by at least three points of contact on the surface of MSE power unit extremities.

2.2.5 EXPOSED SURFACES TEMPERATURE TEST: A test which measures exhaust system temperatures at the points where the engine exhaust system comes in contact with or intersects the contact plane surfaces established by the extremities of the MSE.

2.2.6 EXHAUST GAS TEMPERATURE TEST: A test which measures exhaust gas temperature at the points where the hottest gasses impinge a contact plane.

2.2.7 SHALL: Indicate a mandatory requirement exclusive of all other methods.

2.2.8 SHOULD: An advisory condition.

2.2.9 MAY: A permissive condition.

2.2.10 BEST POWER: Power at maximum torque achievable by a given test MSE at the maximum continuous corrected net brake power speed. (See SAE J1349.)

3. INSTRUMENTATION:

The following instrumentation is required:

3.1 Calibrated Loading Device:

An apparatus designed to test MSE's at given loads and speeds which display torque or power and is compatible with a multipoint recorder or data logger.

3.2 Tachometer:

A device for determining the rotational speed of an MSE. It may be separate or integrated with the calibrated loading device or multipoint recorder or data logging device.

3.3 Thermocouple: Standard J or K type thermocouple wire with welded tip and grounded and shielded probe.

3.4 Graduated Cylinders:

Calibrated containers for measuring amounts of fuel and lubricant for the fuel mix with an accuracy of ±2% of the amount actually contained.

3.5 Photographic Equipment:

Cameras and adequate lighting, appropriate to record the test setup.

3.6 Wire Plug Gage:

A round wire gage, with a diameter of 0.001 in greater than the Carbon Particle Retention Limit (see Appendix A) with precision ground squared ends. Examine ends with a 40X optical magnifier for any rounding of the corners. Replace if any rounding is noted.

4. SCREEN TEST:

The following screen test shall be made on all MSE screen-type spark arresters:

4.1 With the Screen Installed:

With the screen installed, probe its periphery for any gaps in the mounting structure. Any penetration using the wire plug test gage fails the test. When gaging, do not exceed 2 oz (1730 dynes) of force.

4.2 Test with System Removed:

Remove the exhaust system and randomly probe the screen at least 20 times. Especially pay attention to any bends, molding, or edges. Any penetration using the 0.024 in gage fails the test. Record results as GO for penetrations and NO GO for nonpenetration attempts.

4.3 Maximum Diameter Test:

Using various gage sizes, find the largest diameter gage to penetrate the screen. Record results as "Max. gage size." To the "Max. gage size," add 0.001 in and record the results as "No-go wire gage size for screen openings."

5. CONTACT PLANE DETERMINATION:

The contact planes are determined by the following method:

5.1 General:

5.1.1 Determine the configuration of the MSE to be tested in accordance with 5.2 through 5.7.

5.1.2 Slowly roll the test plate around the MSE exhaust system, or roll the MSE around the exhaust system on a flat surface, paying close attention to the area around the exhaust outlet. For each plane checked, mark at least three contact points to form a straight consistent line. (Refer to Figures 1 and 2.) When locating contact points, pay close attention to areas where the test plane touches the muffler assembly. Mark the contact points.

5.1.4 Use 1/8 to 1/4 in pin stripe drafting tape or use a stiff, straight, 1/8 in (3.175 mm) thick hard wire or welding rod to construct the planes. These types of plane indicators may be fixed to the test unit for more accurate thermocouple probe alignment during the test.

5.2 Chain Saws:

5.2.1 Assemble per manufacturer's specification, less bar and chain, fuel, and oil.

5.2.1.1 If spikes or bumper bars are supplied and required by the manufacturer, test the saw with spikes in place. Locate the test planes from the roots of the bumper spikes.

5.2.2 Fit a spacer, the same thickness as the bar, between the clutch cover and body and reinstall the bolts. The spacer shall not protrude beyond the body of the saw.

5.2.3 Place the chain brake in the "OFF" or disengaged position and deflect the hand guard by the weight of the saw into its most rearward position. Use tape to secure the chain brake and hand guard in this position.

5.2.4 Determine the planes per 5.1.

5.3 String Trimmers and Brushcutters:

Use the power head and lower end shaft to determine the planes per 5.1.

5.4 Blowers:

Use 5.1. Exception: Where the exhaust port is vented within the blower duct, thermocouples should be attached to the outlet surface of the exhaust outlet duct. Thermocouples should be attached to the outlet surface of the exhaust outlet.

5.5 Hedge Trimmers:

Excluding the cutter bar, use bar mount to determine planes per 5.1.

5.6 Cutoff Saws:

Remove blade and rotate blade housing. Establish plane as the closest possible plane to the muffler and exhaust outlet.

5.7 Other MSE Configurations:

Determine planes for other configurations (that is, power drills, impact devices, and compactors) without attachments or detachable accessories.

6. TEMPERATURE TEST:

Perform the following temperature tests on all MSE's:

6.1 Exposed Surfaces Temperature Test:

Measure exhaust system temperatures at the points where the engine exhaust system comes in contact with the plane surfaces established per 5.1.

6.1.1 Test Apparatus: Use thermocouples welded or brazed to the exhaust system to determine temperatures. For chain saws, a calibrated loading device is required (see Section 7).

NOTE: During all tests, a thermocouple should be mounted to the cylinder head or spark plug gasket to monitor the head temperature.

6.2 Exhaust Gas Temperature Test:

Measure exhaust gas temperature at the points where the hottest gasses impinge a plane established per 5.1.

6.2.1 Test Apparatus: Use shielded and grounded thermocouples. For chain saws, a calibrated loading device is required.

NOTE: During all tests, a thermocouple should be mounted to cylinder head or spark plug gasket to monitor head temperature.

7. DETAILED TEMPERATURE TEST METHODS:

Use the following temperature test methods to test MSE exhaust systems:

7.1 Chain Saws:

7.1.1 Preparation:

7.1.1.1 Mount the test unit to the calibrated loading device with the bar clamp.

7.1.1.2 Weld or braze surface probes to all points found by the methods described in 5.1 and 5.2 where the test plane touches any part of the muffler surface. Use spark plug or cylinder head thermocouples for all tests.

7.1.1.3 Prepare a fresh fuel and oil mixture per the manufacturer's recommendations ±2%.

7.1.1.4 Establish contact planes by setting the narrow line of tape or 1/8 in welding rod sections between marked points.

7.1.1.5 Run engine until it reaches operating temperature. Set loading device for the best power speed stated by manufacturer. Adjust the high-speed mixture jet adjustment screw setting to maximum torque at best power, then back it out slightly to allow for proper lubrication. Adjust load to maintain head temperatures within 30°F (14.1°C) below manufacturer's maximum head temperature limit.

7.1.1.6 By carefully using a portable, hand-held, shielded probe, crisscross the plane surfaces to find the hottest spots. Mount shielded probes to monitor exhaust gas temperatures during the test at these locations.

7.1.2 Test:

7.1.2.1 Run test engine at best power speed for at least 3 min, simultaneously recording time, temperatures, engine speed, torque and head temperature.

NOTE: If engine head temperature continues to rise after 3 min, recheck high-speed mixture setting and repeat.

7.1.2.2 Increase speed slowly by 1000 rpm above best power and run for at least 3 min, simultaneously recording time, temperatures, engine speed, torque and head temperature.

7.1.2.3 Decrease speed slowly to 1000 rpm below best power in steps of 500 rpm. Record torque for each step. When the 2000 rpm speed reduction has been reached, run for 3 min simultaneously recording time, temperatures, engine speed, torque and head temperature.

EXAMPLE: If best power is 8000, then Test 7.1.2.2 would be conducted at 9000 rpm and Test 7.1.2.3 at 7000 rpm.

7.1.2.4 Complete documentation per Section 8.

7.2 String Trimmers and Brushcutters:

7.2.1 Preparation:

7.2.1.1 Instrument test unit to measure speed and temperatures per Section 6.

7.2.1.2 Run test unit with cutting head attachment until the head reaches operating temperature.

7.2.1.3 Establish operating engine speed by extending the line to the line limiter and adjusting the high-speed mixture jet for best power speed, or use the best power speed specified by the manufacturer. To achieve required speed, lengthen or shorten the cutting line. Record the speed and line length and diameter to document loading.

7.2.1.4 Adjust the high-speed mixture adjustment screw setting to maximum best power speed, then back out slightly to allow for proper lubrication at maximum power.

7.2.1.5 Do not exceed manufacturer supplied maximum engine head temperature during test.

7.2.2.2 Test:

7.2.2.1 Run engine at best power for at least 3 min. Record time, temperatures, engine speed, head temperature, and line length and diameter.

NOTE: If engine head temperature continues to rise after 3 min, recheck the high-speed mixture setting.

7.2.2.2 Increase speed to 1000 rpm above best power by cutting the length of the line. Run the unit for at least 3 min. Record time, temperature, speed, and head temperature, and line length.

7.2.2.3 Decrease speed to 1000 rpm below best power by lengthening the line. Run the unit for at least 3 min. Record time, temperatures, engine speed, head temperature and line length.

EXAMPLE: If the best power speed is 7000, Test 7.2.2.2 would be conducted at 8000 rpm and Test 7.2.2.3 at 6000 rpm.

7.2.2.3 Complete documentation per Section 8.

7.3 Blowers:

7.3.1 Preparation:

7.3.1.1 Instrument test unit to measure speed and temperatures per Section 6.

7.3.1.2 Run test unit until the engine is at operating temperature.

7.3.1.3 To check the operational speed, set the unit up without tubes or nozzles. (Blowers are constructed to run at full throttle with very little load on the engine.) Blowers usually run at a much higher speed than the best power speed.

7.3.1.4 Run unit for 3 min, adjust high-speed mixture adjustment screw for the best operational power speed, then back out slightly to allow for proper lubrication. If engine head temperature continues to rise, recheck the high-speed mixture setting and repeat after 3 min.

7.3.2 Test:

7.3.2.1 Run test unit at wide open throttle at least 3 min without tubes or nozzles. Record time, temperatures, speed, and head temperature.

7.3.2.2 Increase speed by 1000 rpm above the speed found in 7.3.2.1, by partially covering the blower intake or discharge ports. Run at least 3 min. Record time, temperatures, speed, head temperature and approximate percentage of the port area blocked.

EXAMPLE: If the wide open throttle speed is 7000 for step 7.3.2.1, then run Test 7.3.2.2 at 8000 rpm.

7.3.2.3 Complete documentation per Section 8.

7.4 Hedge Trimmers and Cutoff Saws:

7.4.1 Preparation:

7.4.1.1 Instrument test unit to measure speed and temperatures per Section 6.

7.4.1.2 Run the engine and let it warm up for 3 min.

7.4.2 Test: Run the test with the throttle wide open. (Hedge trimmers and cutoff saws are constructed to run at full throttle with very little load on the engine. Hedge trimmers usually run at a much higher speed than the peak torque speed.)

7.4.3 Complete documentation per Section 8.

7.5 Other MSE Configurations:

Test methods for configurations other than those listed above may be developed by agreement between the testing agency and the manufacturer with respect to the limits dictated by Appendix A of this document.

8. DOCUMENTATION PROCEDURE:

Prepare at least the following documentation for all temperature tests, in addition to data required in Section 7:

8.1 Establish planes and photograph the procedure.

8.2 Photograph to show:

a. General test setup
b. Thermocouple and probe locations with respect to the body of the test MSE unit
c. Thermocouple and probe locations with respect to the planes and exhaust system

8.3 Draw a sketch to record the position of exhaust probes and thermocouples.

8.4 Record the hottest temperatures for each engine speed and torque. Record running time.

9. SPARK ARRESTER EFFECTIVENESS TEST:

9.1 Introduction:

This test method determines the proportion of carbon particles of two sizes retained by the spark arrester portion of the exhaust system. By definition, an arrester is 100% effective for the retention of carbon particles larger than the largest actual opening of its screens or baffles through which all gases pass. **No test is required for carbon particle retention of the sizes larger than the actual openings, thus no retention test is required for screen type arresters which are found to have a "go" size of 0.023 in or smaller per 4.3.**

9.2 Test Position of Spark Arrester:

Test the spark arrester in the position where it is the least effective. This position is determined by attaching the spark arrester to a short length of hose from the air source. The hose I.D. should be equal to or larger than the spark arrester inlet.

Establish conditions described in 9.5.2 and 9.5.3 and then move spark arrester to different positions while watching for the emission of test carbon particles. The position at which the largest number of particles escape is the position of least effectiveness.

9.3 Test Apparatus:

The test apparatus consists of a suitable blower with air directed through the testing apparatus, a flowmeter, a flow controlling valve or orifice, a back pressure manometer, a screened exhaust vent, a carbon injector, and a trap for collecting the particles. Figure 3 shows one acceptable arrangement with some optional features.

9.3.1 Flowmeter: Use a flowmeter of an established design, such as a calibrated orifice. The indicated flow shall be within ±5% of actual.

9.3.2 Injecting Mechanism: Inject the test carbon with a feeder mechanism that does not crush or grind the material or affect the normal flow of air through the apparatus, located approximately as shown in Figure 3. Inject test carbon into the airstream at uniform rate over a period of 15 min ± 5.

9.4 Test Carbon:

Make separate test runs using SAE J997.

9.4.1 Use 5 g ± 0.1 of carbon used for each test run.

9.4.2 Test carbon may be reused if the guidelines given in SAE J997 are followed.

9.5 Back Pressure and Flow:

9.5.1 Make provision for measuring back pressure (differential pressure from intake to discharge of the arrester) and flow rate through the arrester.

9.5.2 Unless 9.5.3 applies, test the spark arrester at its assigned maximum flow capacity and at its assigned flow capacity with both coarse and fine test carbon:

9.5.2.1 Establishment of Assigned Flow Capacity and Assigned Maximum Flow Capacity: The assigned maximum flow capacity is the constant airflow rate resulting when a spark arrester is subjected to a pressure differential from intake to discharge of 1 lbf/in^2 gage (6.9 kPa) without test carbon being injected. The assigned flow capacity is the constant airflow rate resulting when a spark arrester is subjected to a pressure differential of 0.5 lbf/in^2 gage (3.45 kPa).

9.5.3 Some spark arresters may clog before the entire 5 g of test carbon is injected into the arrester. In these instances, use the following procedure:

9.5.3.1 Condition 1: Initially establish an airflow to cause a back pressure of 1 lbf/in^2 gage (6.89 kPa). Then allow the back pressure to build up to 1.3 lbf/in^2 gage (8.96 kPa). Once the 1.3 lbf/in^2 gage (8.96 kPa) is reached, maintain this pressure for the balance of the test.

9.5.3.2 Condition 2: Initially establish an airflow to cause a back pressure of 0.5 lbf/in^2 gage (3.45 kPa). Then allow the back pressure to build up to 0.8 lbf/in^2 gage (5.52 kPa). Once the 0.8 lbf/in^2 gage (5.52 kPa) is reached, maintain this pressure for the balance of the test.

9.6 Carbon Particle Collection:

Carefully brush all carbon inside the test apparatus which has escaped through the spark arrester during each run into the trap and then hand-sieve lightly on a U.S. Standard No. 30 [0.023 in (0.584 mm) opening] screen. Weigh the carbon particles retained.

9.6.1 Determination of Arresting Effectiveness: Use the following formula to determine arresting effectiveness for both SAE fine and SAE coarse carbon:

$$\%\ \text{effectiveness fine or coarse} = \frac{\text{Weight used} - \text{Weight of Carbon Retained on No. 30 U.S. screen}}{\text{weight used}} \times 100 \qquad \text{(Eq.1)}$$

Use the following formula to determine the arrester's combined effectiveness:

$$\%\ \text{Combined effectiveness} = \frac{\%\ \text{effectiveness with fine} + \%\ \text{effectiveness with coarse}}{2} \qquad \text{(Eq.2)}$$

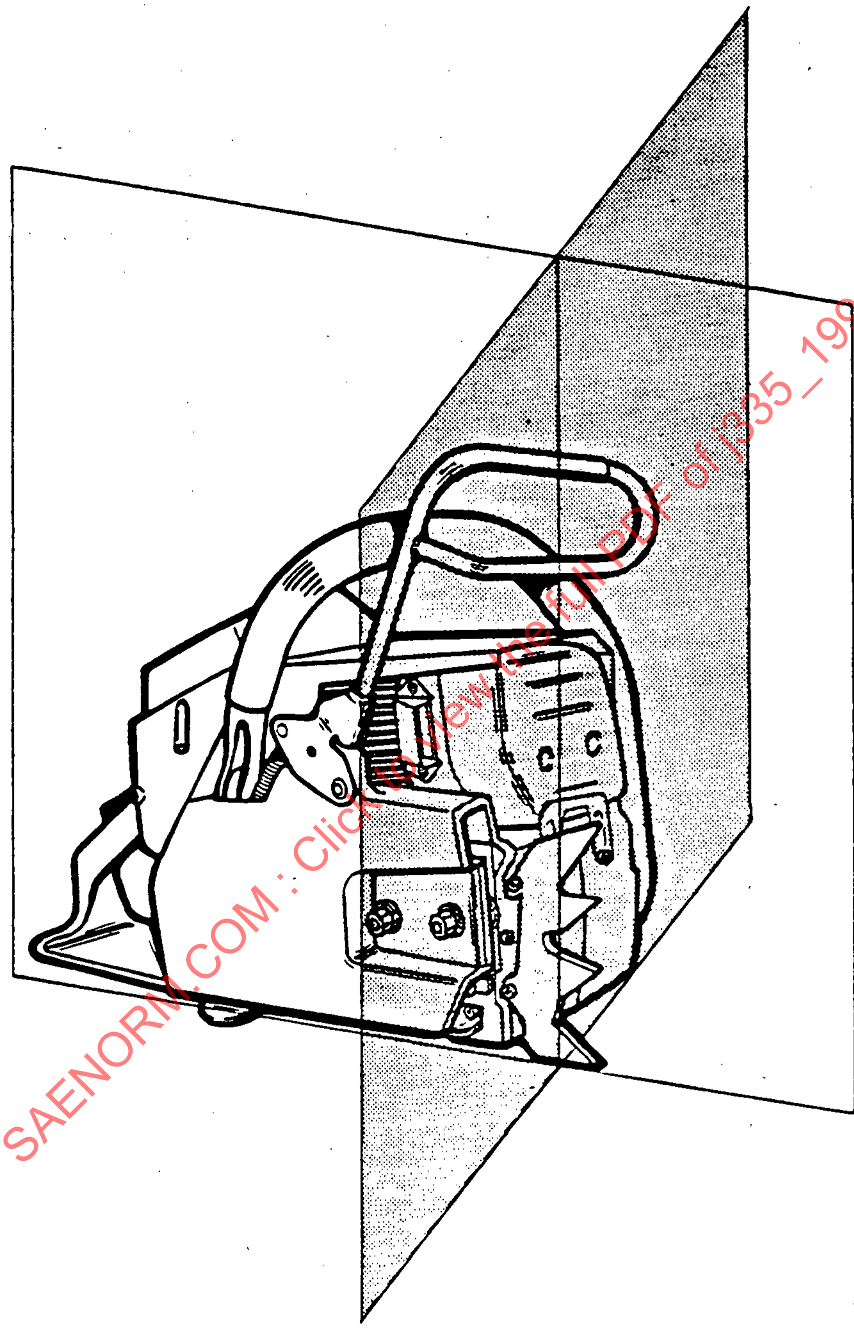

FIGURE 1 - Chain Saw with Planes

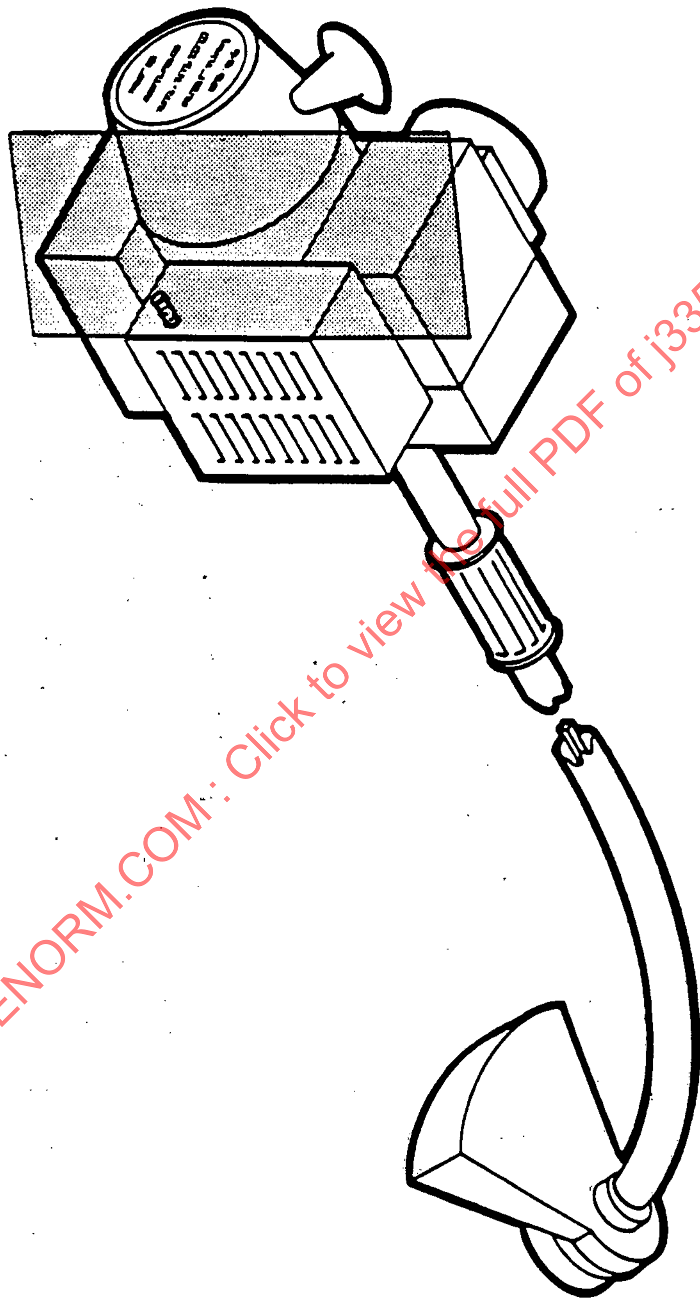

FIGURE 2 - Brushcutter with Planes