INTERNATIONAL STANDARD

ISO 9518

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Forestry machinery — Portable chain-saws — Kickback test

Matériel forestier — Scies à chaîne portatives — Essai de rebond

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9518 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry,* Subcommittee SC 17, *Manually portable forest machinery*.

This second edition cancels and replaces the first edition (ISO 9518:1992), which has been technically revised, mainly to extend it to include chain-saws with an engine capacity of 80 cm^3.

Annex A forms an integral part of this International Standard. Annex B is for information only.

Introduction

The movement of a chain-saw during kickback can be simulated by a mathematical model. Through application of engineering principles, vertical, horizontal and rotational components of the chain-saw's movement are predicted. The model is presented in this International Standard in the form of a computer program which predicts the peak position of the chain-saw, upward and backward towards the user. This is called the "computed kickback angle" and is illustrated in figure 1.

The computer program uses standard engineering force-motion equations to predict the path of the saw based on kickback energy, physical characteristics of the chain-saw and simulated operator reaction forces. User reaction forces were determined through analysis of high-speed motion pictures of actual hand-held kickbacks.[1)]

Input data for the computer program is obtained from physical measurements and from kickback energy tests performed on a completely assembled chain-saw including powerhead, guide bar and saw chain.

Kickback energy of a chain-saw is measured on a apparatus (called the kickback machine) developed specifically for this purpose. Kickbacks are generated by delivering the flat surface of a fibreboard test specimen into contact with the bar tip under controlled conditions. This apparatus and standardized specimen have been found to yield a realistic measurement of kickback energy of any specific saw/bar/chain combination.

The test procedure requires testing over a range of conditions to ensure that peak kickback energy for the particular saw/bar/chain combination on test is determined.

When the rotating parts of a chain-saw are stopped by a chain brake, a moment is generated that tends to reduce the kickback angle. The procedure accounts for this effect.

Annex A is a flow diagram of the computer program used to determine the computed kickback angle. Annex B contains a BASIC language program (complete with examples) to make these computations

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[1)] For additional details see *Overview of the KICKBACK Computer Program — Contents and Development*, available from the Portable Power Equipment Manufacturer´s Association, 4720 Montgomery Lane, Suite 514, Bethesda, MD 20814, USA.

Forestry machinery — Portable chain-saws — Kickback test

1 Scope

This International Standard specifies the methodology for determining the kickback potential of a gasoline-powered chain-saw, complete with guide bar and saw chain.

This International Standard has been demonstrated to be an accurate method of measurement for evaluating computed kickback angles and energy associated with chain-saw kickback for chain-saws with engine capacity up to 80 cm^3. It is not intended to evaluate chain-saws with an engine capacity of above 80 cm^3. Furthermore, because of physical size limitations of the kickback machine, testing of units with guide bar cutting length in excess of 63 cm is not recommended.

NOTE — Although this International Standard is applicable to gasoline-powered chain-saws, the kickback machine and test procedure ought to be also suitable for testing of electric powered chain-saws. To aid in application of this test method to electric powered units, some instructions are included in this document that relate specifically to electric chain-saws.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6535:1991, *Portable chain-saws — Chain brake performance*.

BOM-0100, *Kickback machine — Bill of materials.*[2)]

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
bar tip guard
shield that prevents contact with the chain at the tip of the guide bar and which may be removable and replaceable

3.2
chain brake lever
device, usually the front hand guard, used to activate the chain brake

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[2)] The bill of materials and engineering drawings describing the kickback machine are available from the Portable Power Equipment Manufacturer´s Association, 4340 East-West Highway, Suite 912, MD 20814, USA.

3.3
computed kickback angle
angle used as a measure of the reaction of a hand-held chain-saw, backward and upward toward the user, when subjected to a rotational kickback under simulated conditions

See figure 1.

3.4
contact angle
angle between the surface of the test specimen and a perpendicular to the guide bar centreline

3.5
data set
group of data points, all taken at the same test conditions

3.6
horizontal system
portion of the kickback machine used to measure the horizontal energy of the kickback reaction

3.7
impact
test sequence involving releasing the specimen into contact with the moving saw chain at the guide bar tip to create a simulated kickback reaction

3.8
kickback
rotational kickback
rapid upward and backward motion of the saw which can occur when the moving saw chain near the upper portion of the tip of the guide bar contacts an object such as a log or branch

3.9
kickback machine
apparatus used to measure the energy generated by a chain-saw kickback under controlled conditions

3.10
power head
chain-saw without the guide bar and chain

3.11
rotary system
portion of the kickback machine used to measure the rotary energy of the kickback reaction

3.12
specimen
test specimen
block of medium density fibreboard used as an object for the saw chain to engage in a simulate kickback

4 Test method

4.1 Principle

The flat surface of a wood-like specimen is thrust into contact with the moving saw chain at the tip of a chain-saw guide bar, in order to produce a simulated kickback reaction. This takes place under controlled conditions in apparatus designed to measure the magnitude of rotary and horizontal energies generated during the resulting kickback reaction. A step-by-step search, covering a range of critical test conditions, determines the peak energy values to be used in computing kickback angle. This peak value is intended to simulate the most severe conditions reasonably expected to be encountered by typical users. Since there may be some variability, several impacts are made under each set of conditions and the results averaged.

NOTE — Test parameters such as approach speed, engine speed, shape and type of test materials have been established to permit consistent evaluation of a wide range of cutting attachment and type of power head and to simulate kickback situations found in actual practice. Other test parameters will lead to different computed kickback angles.

4.2 Materials

Test samples, consisting of medium-density fibreboard (density range 732 kg/m^3 ± 32 kg/m^3). Samples shall be oriented with the rough side (end grain) facing the bar tip. Standard test samples are 38 mm × 38 mm × 250 mm. At the discretion of the test laboratory, specimens with depth (measured perpendicular to the test face) up to 76 mm may be used.

NOTE — Because kickback energy measurements are sensitive to the consistency of the fibreboard, careful control of these specimens is essential. In order for test results to be reproducible over time and for comparisons with results from other laboratories, the test specimens need to be calibrated against “known” specimens. Calibration requires kickback testing with samples from batch lots using a “standard” saw/chain/bar combination for which the kickback energies have been established. A calibration factor can then be applied to the energy values before they are used in the computer model.

4.3 Apparatus

4.3.1 Chain-saw kickback machine BOM-0100 for energy level measurements. (See clause 2.)

4.3.2 Engine speed indicator with a rotational frequency reading accuracy of ± 1,5 % of the measured value.

4.3.3 Carriage velocity timing device, including probes with an accuracy of ± 1 ms and a holding circuit to prevent unwanted re-triggering.

4.3.4 Chain brake timing device, including probes having an accuracy of ± 3 ms.

4.3.5 Chain brake testing apparatus in accordance with ISO 6535.

4.3.6 Computer and kickback program to compute the kickback angle.

4.4 Preparation

NOTE — Record all measurements on the kickback test record (see figures 9 and 10).

4.4.1 Physical measurements

4.4.1.1 The following physical measurements are to be made with the guide bar and saw chain attached in proper working position and with oil and fuel tanks full. The saw chain shall be prepared in accordance with 4.4.2 prior to taking measurements.

4.4.1.2 Chain-saw mass in kilograms. An accuracy of ± 50 g is acceptable for this measurement.

4.4.1.3 Location of axis of rotation, through the centre of gravity, perpendicular to the plane of the guide bar. It is to be marked on the saw body. An accuracy of ± 6 mm is acceptable for this measurement.

4.4.1.4 Chain-saw moment of inertia about an axis through the centre of gravity and perpendicular to the plane of the guide bar, in kilograms metre squared.

4.4.1.5 Chain-saw tab tip, front handle and rear handle locations relative to the centre of gravity expressed as x, y coordinates, in millimetres. An accuracy of ± 3 mm is acceptable for these measurements (see figure 2).

4.4.2 Saw chain preparation

4.4.2.1 The saw chain shall be new.

4.4.2.2 Saw chain tension shall be set in accordance with figure 3. The chain should move freely on the bar.

4.4.3 Chain-saw preparation

4.4.3.1 The chain-saw shall be in functionally new condition.

4.4.3.2 The saw shall be run-in according to the manufacturer's recommendations.

4.4.3.3 If the saw is equipped with a removable bar tip guard, remove the bar tip guard for testing.

4.4.3.4 If the saw is equipped with a chain brake, disable the mechanism if necessary to prevent activation.

4.4.3.5 Remove the front handle grip cover in the area where the saw handle clamp will be attached and construct a clamp insert to fit the saw handle. Attach the saw handle clamp to the front handle so that it is as nearly parallel top the guide bar centreline as possible (see figure 4). Tighten securely.

NOTES

1 Under some test conditions, the front handle may become distorted, making testing difficult and subject to error. Substitution of a stronger, fabricated handle is permitted, so long as location of the centre of the mounting clamp is substantially unchanged from the original handle. Weight increase is to be minimized, and in no instance is total added weight to exceed 5 % of the empty saw weight. Chain-saw CG location, balance and mass of carriage matching weight must be adjusted accordingly, but unmodified chain-saw mass and PMI should be used for computer calculations of CKA.

2 For electric chain-saws, the mass, centre of gravity, and polar moment of inertia measurements shall be made with no extension cord plugged into the saw. The length of power cord protruding from the saw shall be positioned over the rear handle and taped or tied in position. For purposes of this test, the maximum length of power cord supplied with the electric saw should be 300 mm.

4.4.3.6 Attach the cradle to the saw clamp assembly. Do not tighten.

4.4.4 Kickback machine preparation

4.4.4.1 If the chain-saw mass (see 4.4.1.2) is less than the standard carriage (4 kg), the standard carriage may be replaced with the lightweight carriage.

4.4.4.2 Insert a fibreboard test specimen in the carriage clamp. The specimen shall be oriented with the rough side (end grain) facing the guide bar tip.

4.4.4.3 If necessary, add weight to the carriage until the carriage mass (including fibreboard specimen) equals the mass of the saw ± 100 g.

4.4.5 Chain-saw installation and alignment

4.4.5.1 Install the saw/clamp/cradle assembly in the kickback machine in accordance with figure 4, and align the guide bar with the centreline of the fibreboard specimen.

4.4.5.2 Adjust the chain-saw, clamp and cradle in the kickback machine so that the centre of gravity of the saw is aligned to within ± 3 mm of the rotary axis. Make this adjustment by rotating the saw/clamp/assembly where it attaches to the cradle and by sliding the cradle in the support blocks.

NOTE — Do not rotate the clamp where it attaches to the saw handle, this was adjusted in 4.4.3.5.

4.4.5.3 Attach a brace assembly between the chain-saw rear handle and either leg of the cradle as nearly as possible to the rotary axis, and with mass of brace centred as nearly as possible about the rotary axis. A second brace may be installed if needed to maintain saw position during testing.

NOTES

1 The mass and position of brace assembly can affect test results. The mass of the brace assembly should not exceed 0,4 kg.

2 For electric saws, the cord shall be secured and routed from the front handle so as to closely follow the axis of rotation in such a manner that the cord shall not impede the free rotation of the chain-saw.

4.4.6 Saw/clamp/cradle assembly balance

4.4.6.1 Fuel and oil tanks shall be filled.

NOTE — External fuel and oil supplies to maintain full tanks are acceptable.

4.4.6.2 The system shall be balanced using the minimum amount of mass located as close to the rotary axis as possible (see figure 4).

4.4.6.3 Acceptable initial balance is achieved when the saw/clamp/cradle assembly will not rotate at the “horizontal” or “vertical” positions or when a 60 g mass hung from the rotary pulley will counter any observed rotation. If the centre of gravity of the saw shifts due to soft isolators, a compromise between the horizontal and vertical positions is permissible.

4.4.7 Friction measurements

4.4.7.1 Horizontal friction shall be measured prior to and after kickback energy tests. Measurements shall be made with the ratchet pawl in its activated position: they shall be made over a distance of at least 300 mm. If the horizontal friction the direction of travel away from the power head exceeds 2,2 N the source(s) of friction shall be located and corrected.

4.4.7.2 Rotary friction shall be measured prior to and after kickback energy tests. Measurements shall be made with the ratchet pawl in its activated position: they shall be made through and angle from 0° to 180°. If the rotary friction exceeds a force of 2,2 N applied to the rotary pulley, the source(s) of friction shall be located and reduced.

NOTE — In saws with soft isolator systems, the centre of gravity shifts as the saw and cradle rotate. If shifting of the centre of gravity of the saw prevents accurate friction measurements, a substitute saw of about the same mass may be used for friction measurements.

4.4.8 Restraining systems alignment

4.4.8.1 The specimen contact angle shall be set to 30°. Position the carriage so that the specimen contact so that the specimen contacts the saw chain. Adjust the position of the rack/horizontal restraining assembly so that the cable from the carriage to the pulley is vertical (see figure 5).

4.4.8.2 With the guide bar centreline horizontal, install the cable attachment pin on the rotary pulley and adjust the turnbuckle to bring the 0,9 kg weight on the rotary restraining system to the zero position (see figure 6).

4.4.9 Impact velocity adjustment

Adjust the carriage release point to achieve a velocity (just prior to contact of the specimen with the bar tip) of 0,76 m/s.

4.5 Test requirements and procedures

NOTE — Record data on the kickback test record, figure 9.

4.5.1 Test requirements

4.5.1.1 Adjust the specimen contact angle to the value shown for data set 1A in table 1. For subsequent data sets, readjust the angle as specified.

4.5.1.2 After each impact the chain-saw should be inspected for unusual conditions and reset for the next impact. Do not operate a damaged saw.

4.5.1.3 For saws equipped with a centrifugal clutch, the clutch shall be burned at the start of the test and after each 12 impacts.

To burn the clutch, clamp the saw chain to the guide bar and run the saw for 5 s with full throttle. Measure and record the slip speed in reciprocal seconds (s^{-1}).

If the slip speed varies by more than 8 s^{-1} during the test, replace the clutch.

4.5.1.4 Saw chain tension shall be set initially and adjusted during the test in accordance with 4.4.2.2.

4.5.1.5 On occasion, the balance of the saw/clamp/cradle may change. Check and reset balance if imbalance exceeds 60 g as specified in 4.4.6.3. If imbalance of more than 60 g occurs, data from the previous impact is invalid.

4.5.1.6 The specimen is to be clamped in the carriage with a rough face (end grain) presented to the saw chain.

4.5.1.7 Make only two impacts on each specimen (one on each rough face).

4.5.1.8 The specimen should be examined and changed after each impact.

The orientation of the specimen shall be adjusted so that the kerf from the chain will not intersect the upper edge of the specimen face. All saw chain cuts shall start within the middle 25 mm on the face of the specimen. If any kerf runs off the specimen or if the specimen splits, do not use the energy readings in the computations. Repeat the impact on another specimen

Tendency for specimen splitting can be reduced by adding side supports, for example a C-clamp. If such a device is so used the clamping forces must be minimum and the carriage mass shall be compensated.

4.5.1.9 Upon completion of the test, horizontal and rotary friction levels are to be measured as described in 4.4.7. The greater measured level is to be used for energy computations. If friction at the end of the test program exceeds the specifications of 4.4.7, the test shall be repeated.

4.5.2 Kickback testing

Using the following procedure, perform impacts at the test conditions specified in the test sequence of table 1. If it is more convenient, the test sequence in table 2 may be used instead.

NOTE — For electric powered saws, the supply voltage shall be adjusted to the rated voltage of the chain-saw. The contact angle sequence shall be followed with the unit operating at the resulting output speed.

4.5.2.1 With the barrier bar in position, start the chain-saw. Adjust the engine speed to the value specified for data set 1A in the test sequence.

4.5.2.2 Raise the barrier bar and stand clear of the kickback machine.

4.5.2.3 Release the carriage, observing the engine speed just as the specimen contacts the moving chain at the bar tip.

4.5.2.4 Turn off the chain-saw.

4.5.2.5 Record the vertical displacement, in millimetres, of the horizontal restraining weight and the horizontal displacement, in millimetres, of the carriage (see figure 5).

4.5.2.6 Record the vertical displacement, in millimetres, of the upper and lower rotary restraining weights (see figure 6).

NOTE — The horizontal and rotary restraining systems may have separate calibrations to permit direct readings.

4.5.2.7 Complete data set 1A by repeating the steps in 4.5.2.1 to 4.5.2.6. Each repetition is considered one “impact”. Each data set consists of either three or six impacts depending on the outcome of calculations specified in 4.5.3.

4.5.2.8 Repeat the steps in 4.5.2.1 to 4.5.2.7 for the remaining data sets as specified in the test sequence of table 1 or 2.

4.5.2.9 The test sequence may be discontinued if, at both engine speeds, there is

a) a 50 % reduction in the average rotary energy between measurements at two consecutive contact angles, or

b) a decrease in the average rotary energy for two consecutive contact angles.

Table 1 — Test sequence

Data set	**Contact angle** degrees	**Impact velocity** m/s	**Engine speed**[1)] s^{-1} $\pm 3\ s^{-1}$
1A	0		183
1B	0		150
2A	5		183
2B	5		150
3A	10		183
3B	10		150
4A	15	0,76	183
4B	15		150
5A	20		183
5B	20		150
6A	25		183
6B	25		150
7A	30		183
7B	30		150

1) If a speed of 183 s^{-1} cannot be reached, the A-series tests shall be carried out at the highest possible speed and the B-series tests at the highest possible speed less 33 s^{-1}

Table 2 — Optional test sequence

Data set	**Contact angle** degrees	**Impact velocity** m/s	**Engine speed**[1)] s^{-1} $\pm 3\ s^{-1}$
1A	0		183
2A	5		183
3A	10		183
4A	15		183
5A	20		183
6A	25		183
7A	30	0,76	183
1B	0		150
2B	5		150
3B	10		150
4B	15		150
5B	20		150
6B	25		150
7B	30		150

1) If a speed of 183 s^{-1} cannot be reached, the A-series tests shall be carried out at the highest possible speed and the B-series tests at the highest possible speed less 33 $^{-1}$.

4.5.3 Kickback energy determination

4.5.3.1 Compute the horizontal energy, W_h, for each impact:

$$W_h = (9{,}8\ G_h\ S_h + F_h\ S_c)\ 10^{-3}$$

where

W_h is the horizontal energy, in joules;

G_h is the mass of the horizontal restraining weight, in kilograms;

F_h is the horizontal axis friction, in newtons;

S_h is the displacement of the horizontal restraining weight, in millimetres;

S_c is the displacement of the carriage, in millimetres.

4.5.3.2 Compute the rotary energy, W_r, for each impact:

$$W_r = (9{,}8\ G_u + F_r\ S_u + 9{,}8\ G_l\ S_l)\ 10^{-3}$$

where

W_r is the rotary energy, in joules;

G_u is the mass of the upper rotary weight, in kilograms;

G_l is the mass of the lower rotary weight, in kilograms;

S_u is the displacement of the upper rotary weight, in millimetres;

S_l is the displacement of the lower rotary weight, in millimetres;

F_r is the rotary friction force, in newtons.

4.5.3.3 After performing three impacts at the conditions specified for a data set, compute the average of the three rotary energy values and the average of the three horizontal energy values.

4.5.3.4 If the rotary energy values are each within 10 % of the average rotary value, use the average of the three values.

4.5.3.5 If any of the rotary energy values is not within 10 % of the average, perform three additional impacts and use the average of all six rotary energy values. Similarly, use the average of the six horizontal energy values.

4.5.3.6 The peak rotary energy without a chain brake, W_r, is taken as the highest of the average rotary energies found in the test sequence.

4.5.4 Chain brake energy determination

NOTE — At the discretion of the manufacturer, 4.5.4.1 to 4.5.4.3 may be omitted. For units that generate very low kickback energies, testing with the chain brake may not be possible. It is recommended that testing be discontinued at this point for saws with a computed kickback angle equal to 20° or less at the peak rotary energy condition identified in paragraph 4.5.3.6.

4.5.4.1 At the conclusion of the test sequence specified in 4.5.2, remove the means used to prevent the chain brake from actuating and perform three additional impact a peak rotary energy conditions. If the rotary energy values are not within 10 % of the average, perform three additional impacts and compute the average of all six impacts.

4.5.4.2 If the chain brake actuates each time, the energy value that is put into the computer model as rotary energy with the chain brake operating, W_c, is taken as the average of the rotary energy values. If the chain brake does not actuate each time, proceed to 4.5.4.3.

NOTE — When the chain brake does not operate each time, and it can be demonstrated through a means such as described in ISO 13772:1997, *Forestry machinery — Portable chain-saws — Non-manually actuated chain brake performance*, that the brake will release in actual operation, an additional mass (not to exceed 200 g) may be added to the centre of the front hand guard. Balance of the saw cradle unit should be compensated accordingly, if required to maintain balance requirements of 4.4.6.3. Other parameters may not be changed.

4.5.4.3 Mount the brake actuator on the left side of the mainframe column of the kickback machine.

4.5.4.4 Set the spring-loaded lever so that the lever and the hand guard contact each other at or immediately past the point where the saw exits from the test specimen (see figures 7 and 8).

4.5.4.5 Set the spring-loaded lever of the chain brake actuator in the set position so that its centreline intersects the chain-saw centre of gravity as shown in figure 7.

4.5.4.6 Adjust the position of the spring-loaded lever (in its set position) so that the contact point of the chain brake lever (hand guard) with the spring-loaded lever is 90 mm from the pivot of the spring-loaded lever (see figure 7).

4.5.4.7 Recheck steps 4.5.4.4, 4.5.4.5 and 4.5.4.6. Readjust if necessary.

4.5.4.8 Measure the chain brake release force in newtons, with the engine not running. The brake release force shall be measured with a spring scale accurate to ± 1 N. The force shall be applied at a uniform rate at the centre of the top part of the brake lever. The force shall be measured in a direction which is normal to the centreline of the spring-loaded lever when the saw is in the position shown in figure 7 and the spring-loaded lever is set as shown in figure 7.

4.5.4.9 Adjust the release force of the spring-loaded lever to a value equal to the chain brake release force plus 10 N. Measure the release force of the spring-loaded lever by placing a spring scale at a point 90 mm from the pivot point of the spring-loaded lever and pulling normal to the centreline of the lever.

4.5.4.10 Position the chain-saw so that the guide bar is horizontal, and set the contact angle and engine speed at the settings determined to give the highest average rotary energy in 4.5.3.

4.5.4.11 All tests performed in accordance with 4.5.4.12 and 4.5.4.13 shall be conducted at the contact angle and engine speed determined to give the highest average rotary energy.

4.5.4.12 Conduct the chain brake actuation test to determine the rotary energy with both the chain brake and the chain brake actuator operating, W_{ca}. Using the procedures detailed in 4.5.2, conduct the kickback test with both the actuator and chain brake operating. Repeat for a total of three impacts. If the rotary energy values are not within 10 % of the average, perform three additional impacts and use the average of the six values. If the chain brake activates on each impact, W_{ca} is taken as the average of the rotary values. If the brake does not activate on each impact, compute the kickback angle using values calculated in accordance with 4.5.3.

NOTE — If the brake activates but does not trip the spring-loaded lever, record that the lever did not trip and continue calculations and test as through the lever did trip.

4.5.4.13 Conduct the kickback test to determine the rotary energy with the chain brake actuator operating, W_a, but without the chain brake operating.

By a suitable means, such as taping or wiring the chain brake handle to the saw handle, disable the chain brake so that it will not activate. Using the procedures detailed in 4.5.2, conduct the kickback test with the chain brake actuator operating and the chain brake disabled.

Repeat for a total of three impacts. If the rotary energy values are not within 10 % of the average, perform three additional impacts and use the average of the six values. W_a is taken as the average of the rotary energy values.

4.5.4.14 Calculate W_c, the rotary energy, with the chain brake operating. This is the energy value which is input to the computer model:

$$W_c = W_r - W_a + W_{ca}$$

where

W_r is the peak rotary energy without a chain brake as determined in 4.5.3, in joules;

W_a is the rotary energy with the chain brake actuator operating, but without the chain brake operating, as determined in 4.5.4.13, in joules;

W_{ca} is the rotary energy with both the chain brake and the chain brake actuator operating, as determined in 4.5.4.12, in joules.

4.5.5 Chain brake actuation angle measurement

4.5.5.1 Measure the angles where the guide bar tip exits from the fibreboard specimens at peak rotary energy conditions as determined in 4.5.3 and compute the average. This is the specimen exit angle (see figure 8).

4.5.5.2 If the rotary energy, W_c, was determined in accordance with 4.5.4.2, then the actuation angle $A2$ is one-half of the specimen exit angle.

4.5.5.3 If the rotary energy, W_c, was determined in accordance with 4.5.4.14, the chain brake actuation angle $A2$ is taken as the specimen exit angle.

4.5.6 Chain brake stopping time measurement

4.5.6.1 The chain brake stopping time test shall be conducted at the engine speed setting of the peak rotary energy condition determined in 4.5.3. Use the pendulum test technique specified in ISO 6535.

4.5.6.2 The chain-saw shall be adjusted for best cutting performance in accordance with the chain-saw manufacturer's recommendations.

4.5.6.3 The chain-saw shall be solidly mounted during the test.

4.5.6.4 No adjustment of the brakes is permitted during the test.

4.5.6.5 Initially, the brake shall be in a dry and unlubricated condition.

4.5.6.6 The chain brake shall be activated 10 times without recording data. Then activate the brake three times and record the average stopping time. Refer to ISO 6535 for test apparatus details and test technique.

4.6 Kickback angle computation

The computed kickback angle, defined as shown in figure 1, is used as a measure of the reaction of a hand-held chain-saw when subjected to a rotational kickback under simulated conditions. Annex A is a flow diagram of the computer program used to determine the computed kickback angle.[3)]

[3)] A list of suppliers of computer programs to make these computations is available from the ISO Central Secretariat.

4.6.1 Input data

4.6.1.1 Chain-saw mass, in kilograms, in accordance with 4.4.1.1.

4.6.1.2 Chain-saw moment of inertia, in kilograms metre squared, in accordance with 4.4.1.3.

4.6.1.3 Bar tip and handle location, in millimetres, in accordance with 4.4.1.4.

4.6.1.4 Energy levels established at the peak rotary conditions in accordance with 4.5.3:

a) horizontal energy, W_h, in joules;

b) rotary energy, W_r, in joules.

NOTE — If the average rotary energies measured at other sets of conditions are within 10 % of the peak rotary value, calculate the computed kickback angle for each of the these sets of conditions and use the highest computed kickback angle.

4.6.1.5 Chain brake rotary energy, W_c, in joules, in accordance with 4.5.4.

4.6.1.6 Chain brake actuation angle, $A2$, in degrees, in accordance with 4.5.5.

4.6.1.7 Saw chain stopping time, in milliseconds, in accordance with 4.5.6.6.

NOTE — Before input to the computer program, energy values should be adjusted to account for any fibreboard specimen lot variations.

4.6.2 BASIC computer program

NOTE — The BASIC computer program was developed to run on a Tektronix 4052 microcomputer. If a different computer is used, some of the commands may have to be modified.

For the purposes of this International Standard, a simulation time increment, $T9$, of 0,001 s (1 ms) shall be used.

CAUTION: If the time increment at line 210 is changed, incorrect values of chain stop angle may result.

4.6.3 Results

4.6.3.1 Record the results on the test record (figure 9):

a) computed kickback angle (with or without brake):

b) chain stop angle (if appropriate).

NOTE — The analytical model is unproved above about 70° and computed kickback angles above this should be treated as speculative.

4.6.3.2 Because of differences in guide bars, the following guidelines may be used to determine kickback energy without the need for extensive testing.

a) Sprocket nose guide bars with the same cutting length, the same number of sprocket nose teeth, and the same pitch may be considered to have equivalent kickback energy.

b) A hard-nose guide bar having the same cutting length, and the same or smaller nose radius as a sprocket nose bar, may be considered to have equivalent or less kickback energy than the sprocket nose bar.

c) Kickback energy of all guide bar types may be considered to be less for smaller nose radius sizes.

4.7 Test report

The test report shall include the test record (figure 9) and the computer printout (see annex B).

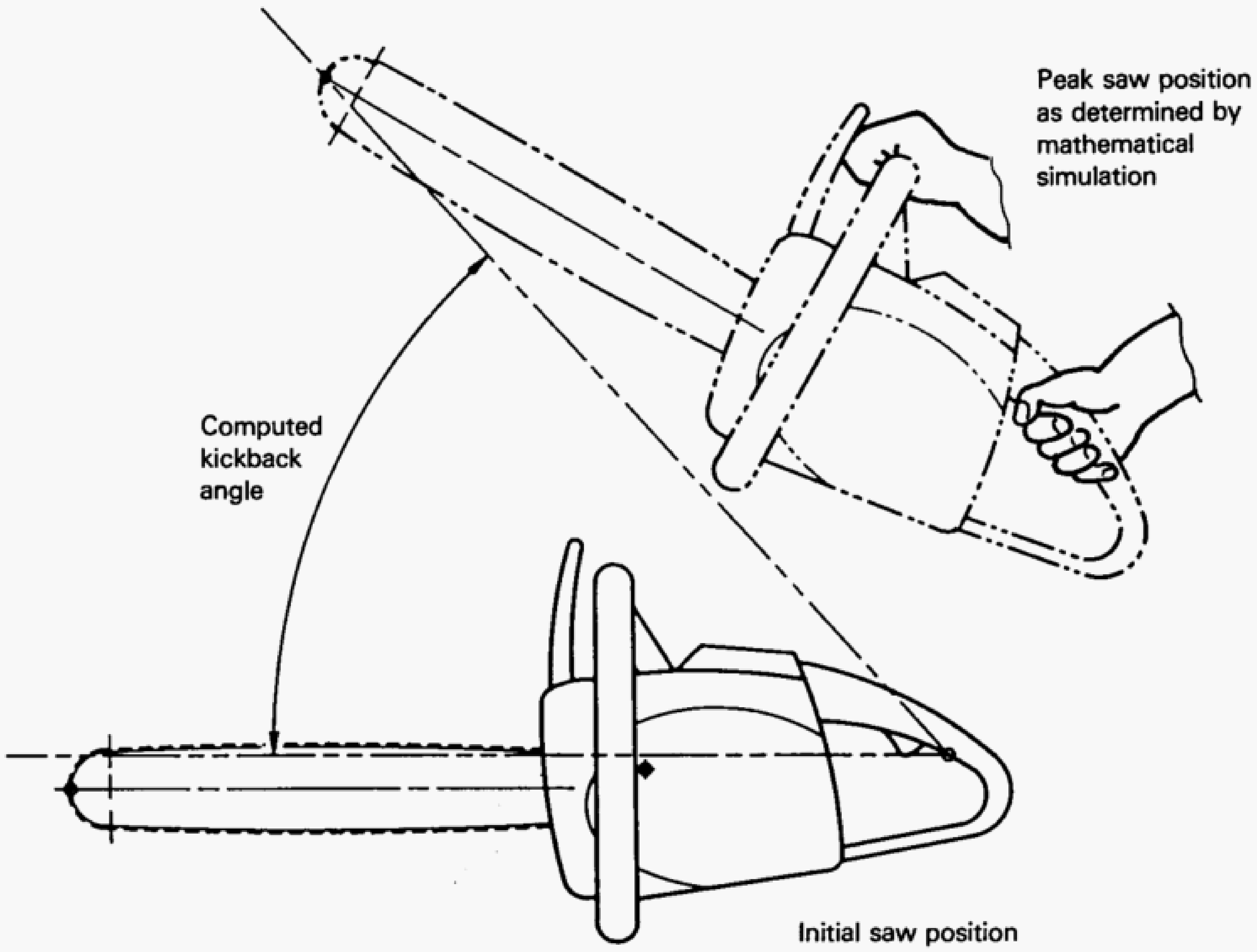


Figure 1 — Computed kickback angle

Dimensions in millimetres

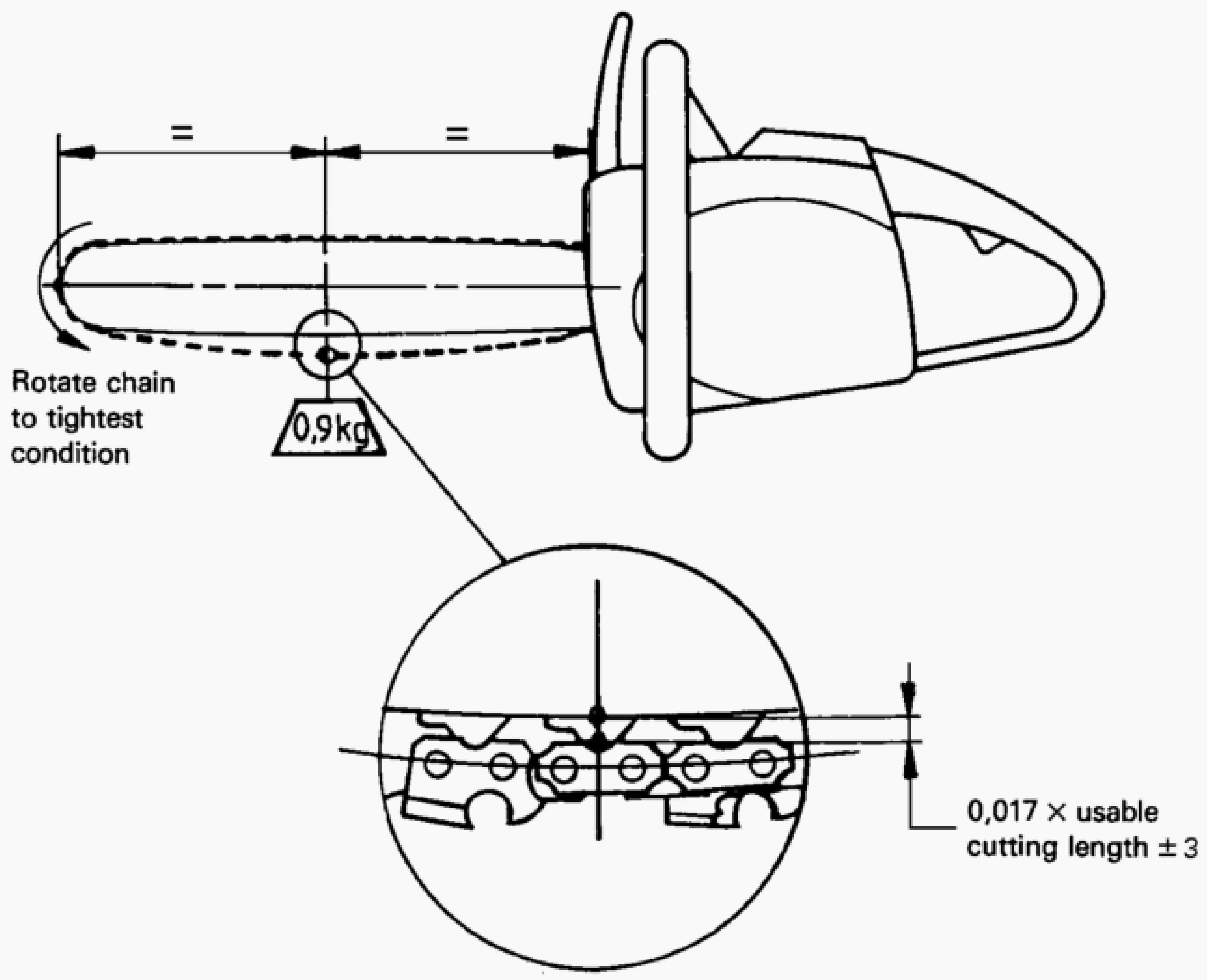


Figure 3 — Saw chain tension adjustment

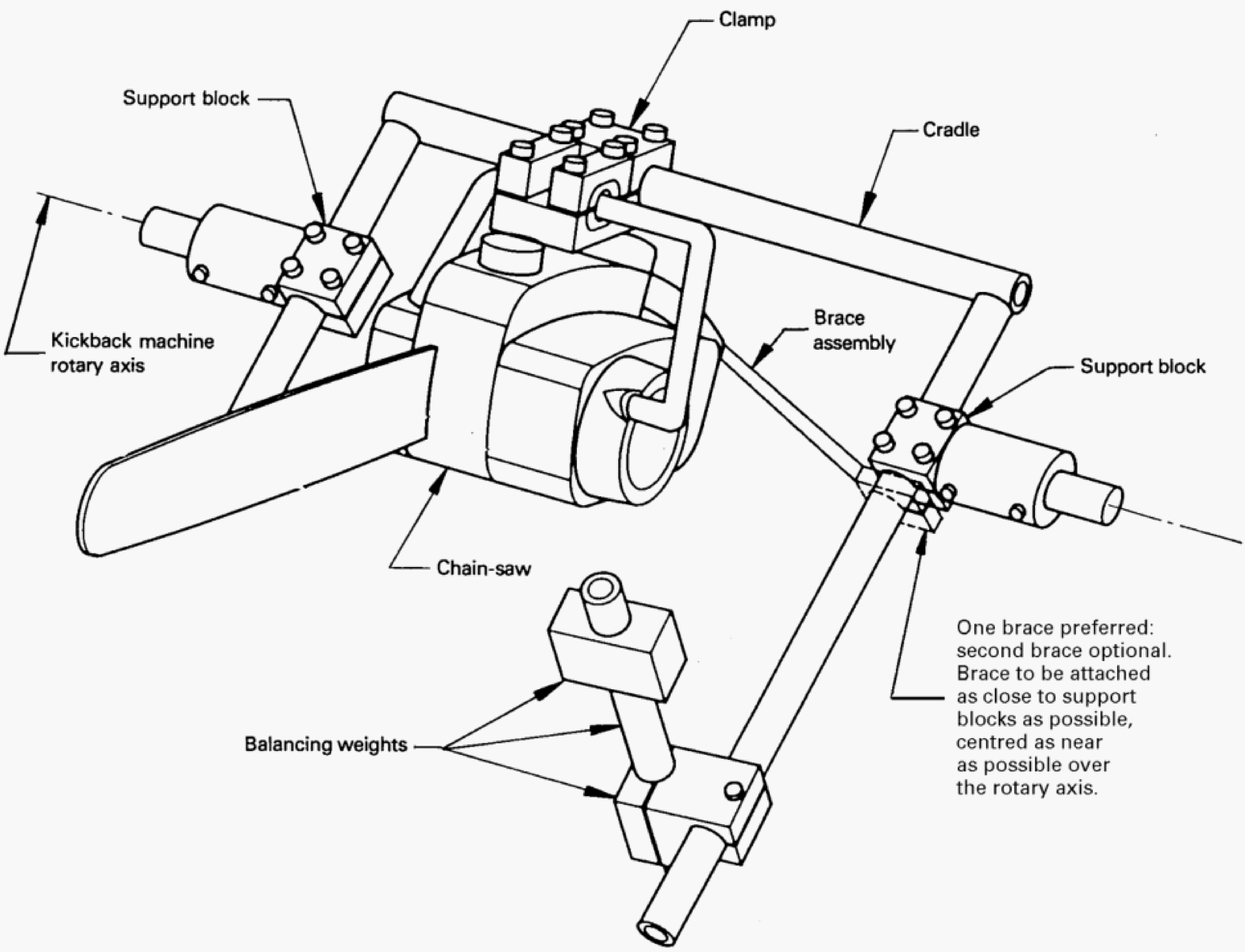


Figure 4 — Installation of saw/clamp/cradle assembly

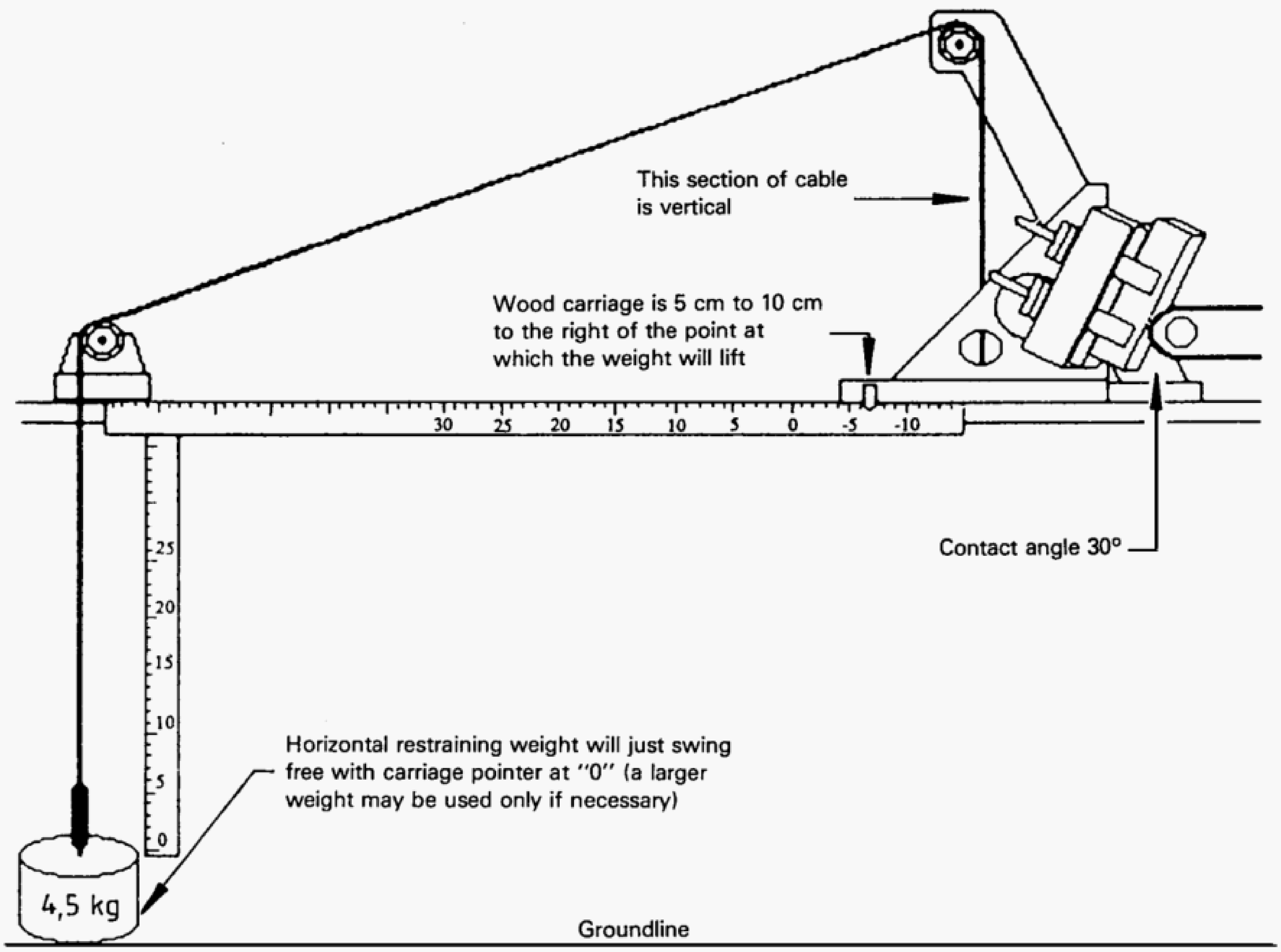
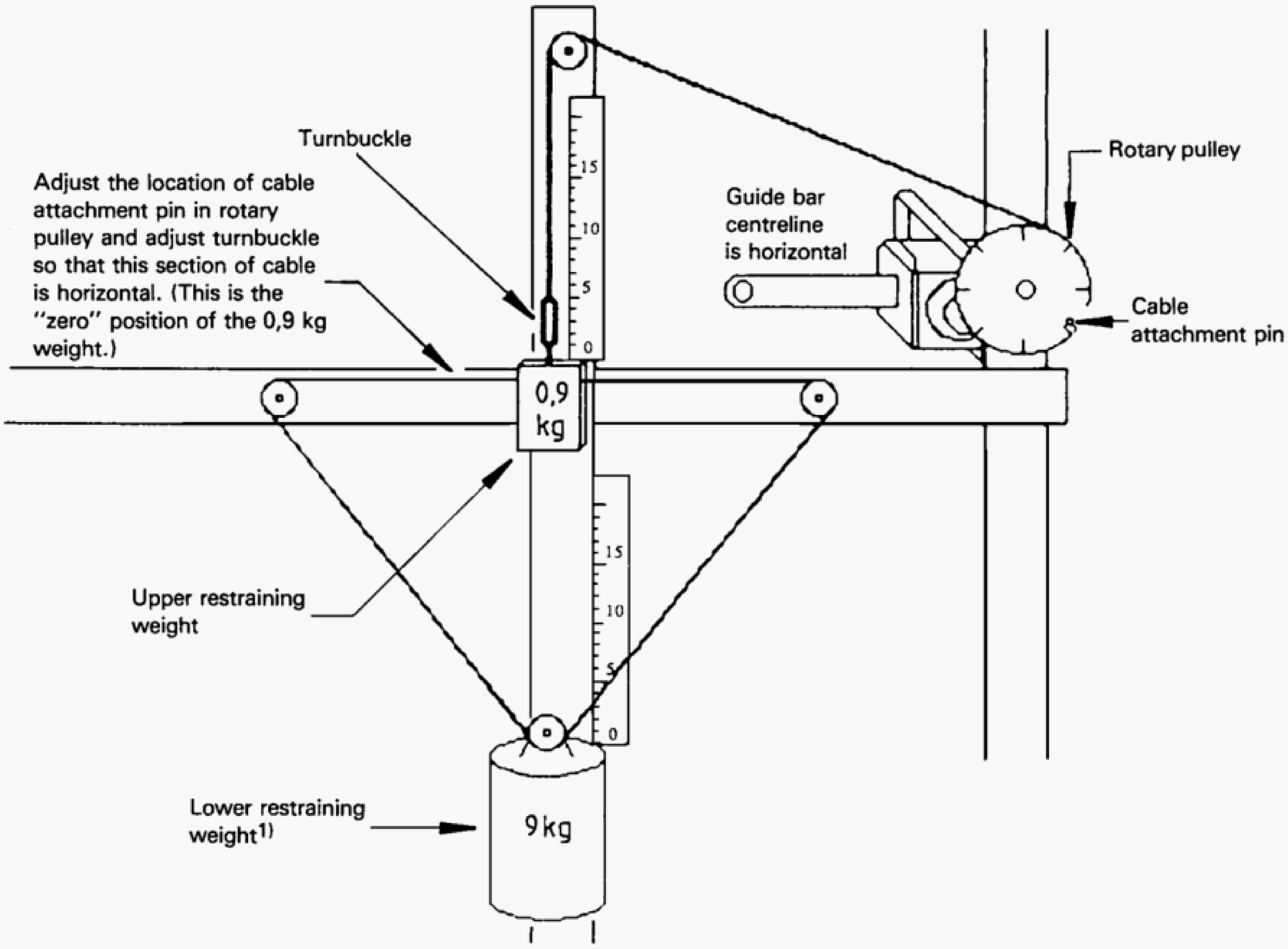


Figure 5 — Adjustment of rack/horizontal restraining system



1) A larger weight may be used only if necessary.

Figure 6 — Adjustment of rotary restraining system

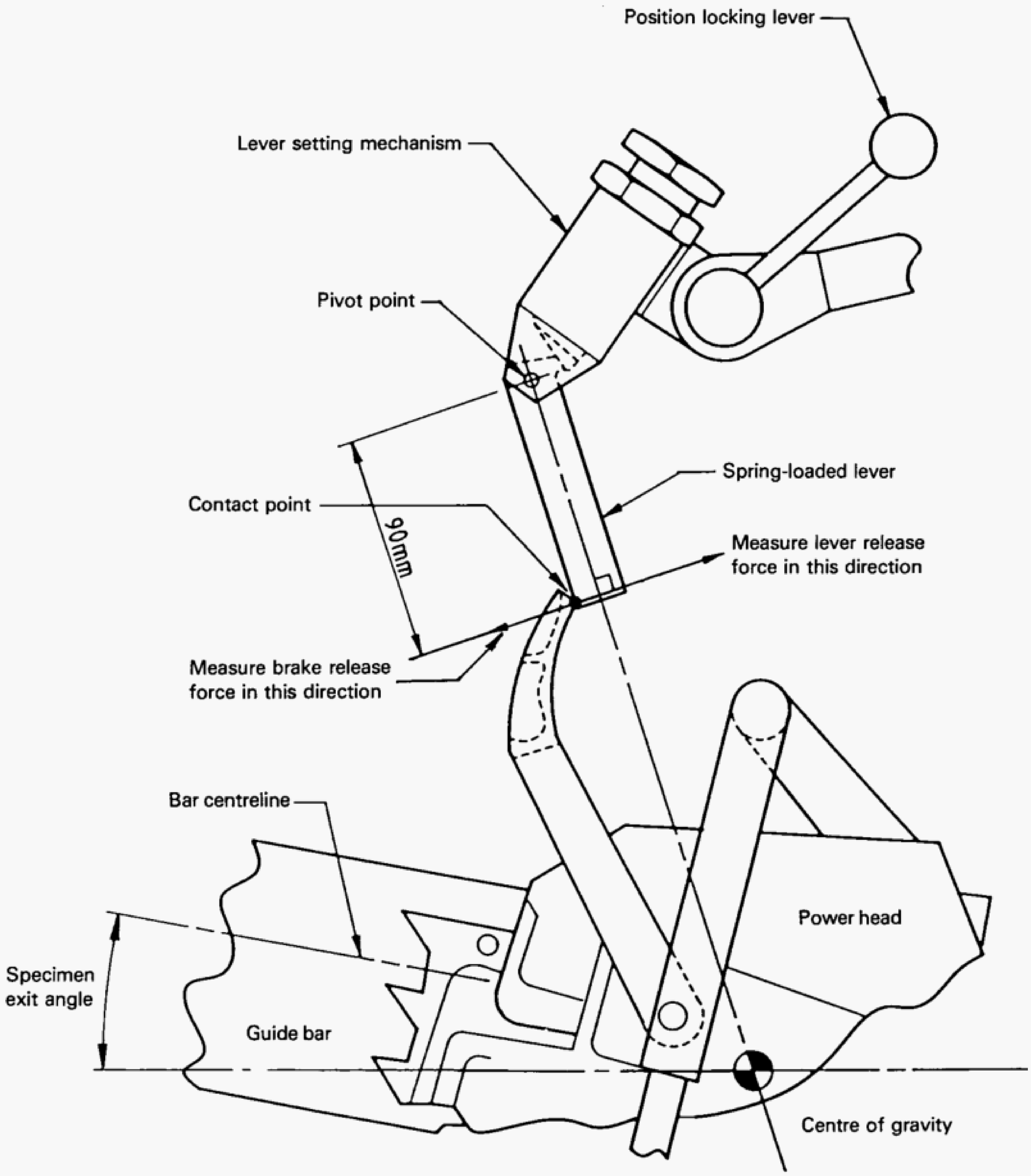


Figure 7 — Adjustment of chain brake actuator

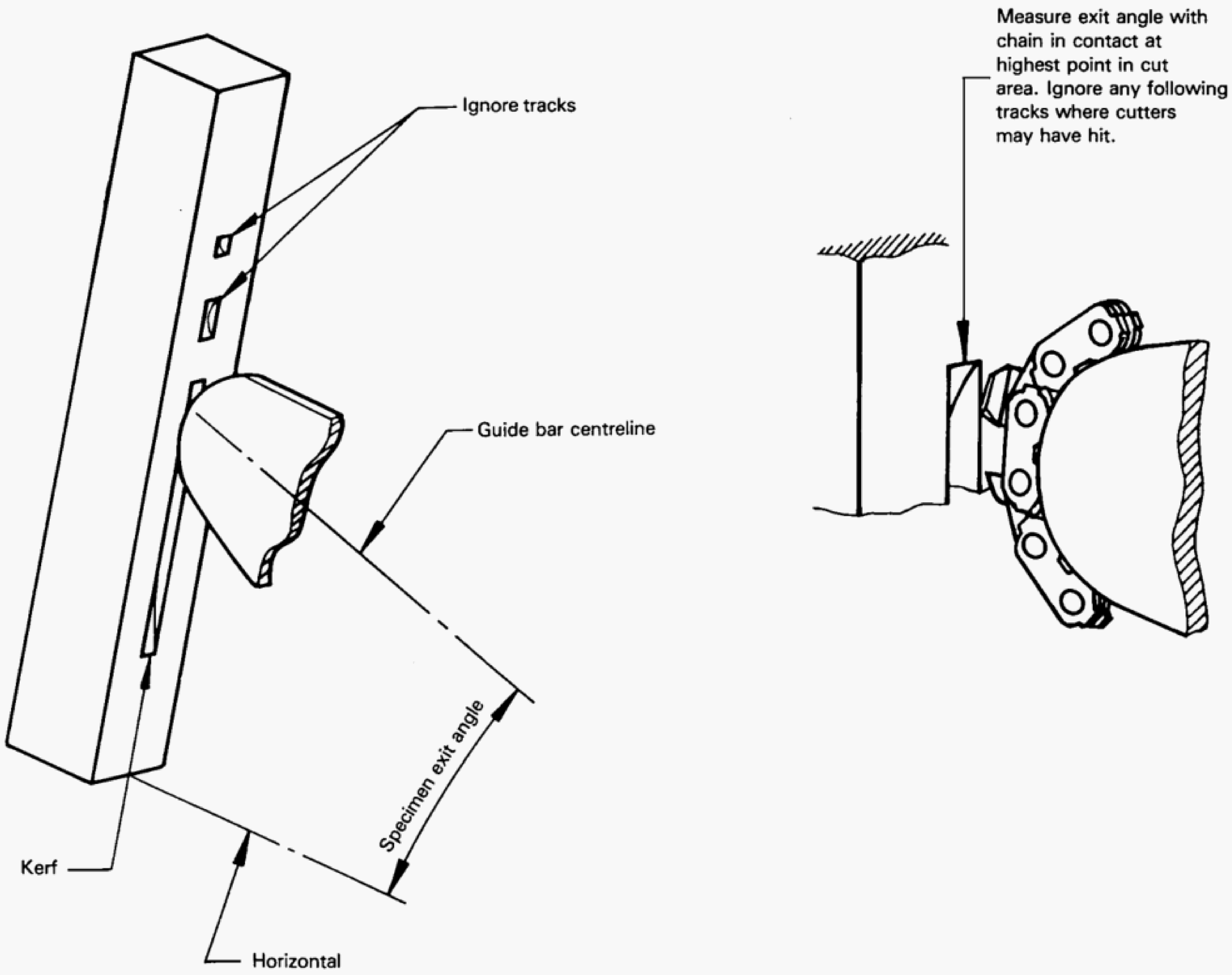


Figure 8 — Specimen exit angle measurement

Kickback test record

Laboratory ____________

Date ____________

Technician ____________

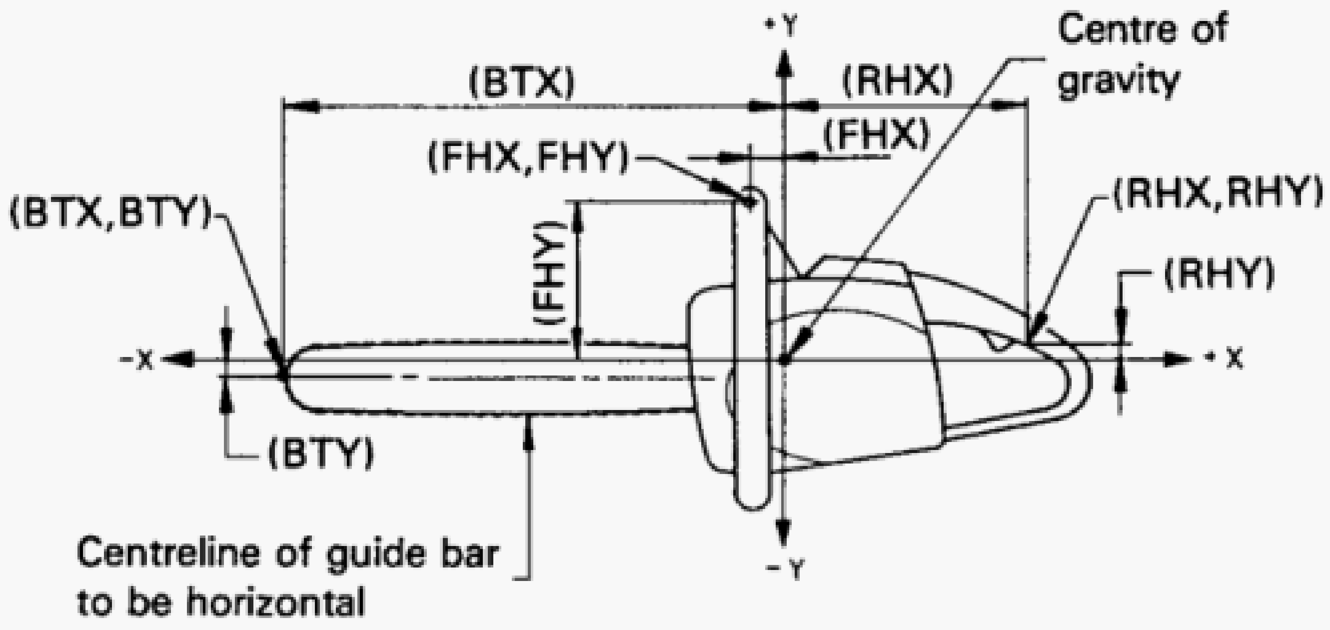
Test number ____________

Test combination

Saw model/manufacturer:	Chain type/manufacturer: D.L. count:
Serial No.:	Cutter type:
Displacement:	Sequence:
Saw mass:	Condition: D.G. setting:
Carriage mass: Matching mass:	Pitch: Gauge:
Inertia:	Guide bar:
Rotary friction:	Tip type: Gauge:
Horizontal friction:	Bar part No./manufacturer:
Clutch slip speed:	Drive sprocket type: Tooth count:

Chain-saw handle and bar tip coordinates. Left side view.

BTX		FHX		RHX	
BTY		FHY		RHY	



Chain brake summary

Release force	N	W_r:
Release force + 10 N	N	W_{ca}:
Angle of actuation $A2$	°	W_a:
Chain stopping time $T3$	s	W_c:

Data summary

Data set No.	Contact angle °	Engine speed s^{-1}	Average horizontal energy J	Average rotary energy J	Kickback angle °

Data Set No.	Contact angle °	Engine speed s^{-1}	Average horizontal energy J	Average rotary energy J	Kickback angle °

Peak average rotary energy ____________ J

Average rotary energy at peak CKA ____________ J

Computed kickback angle:

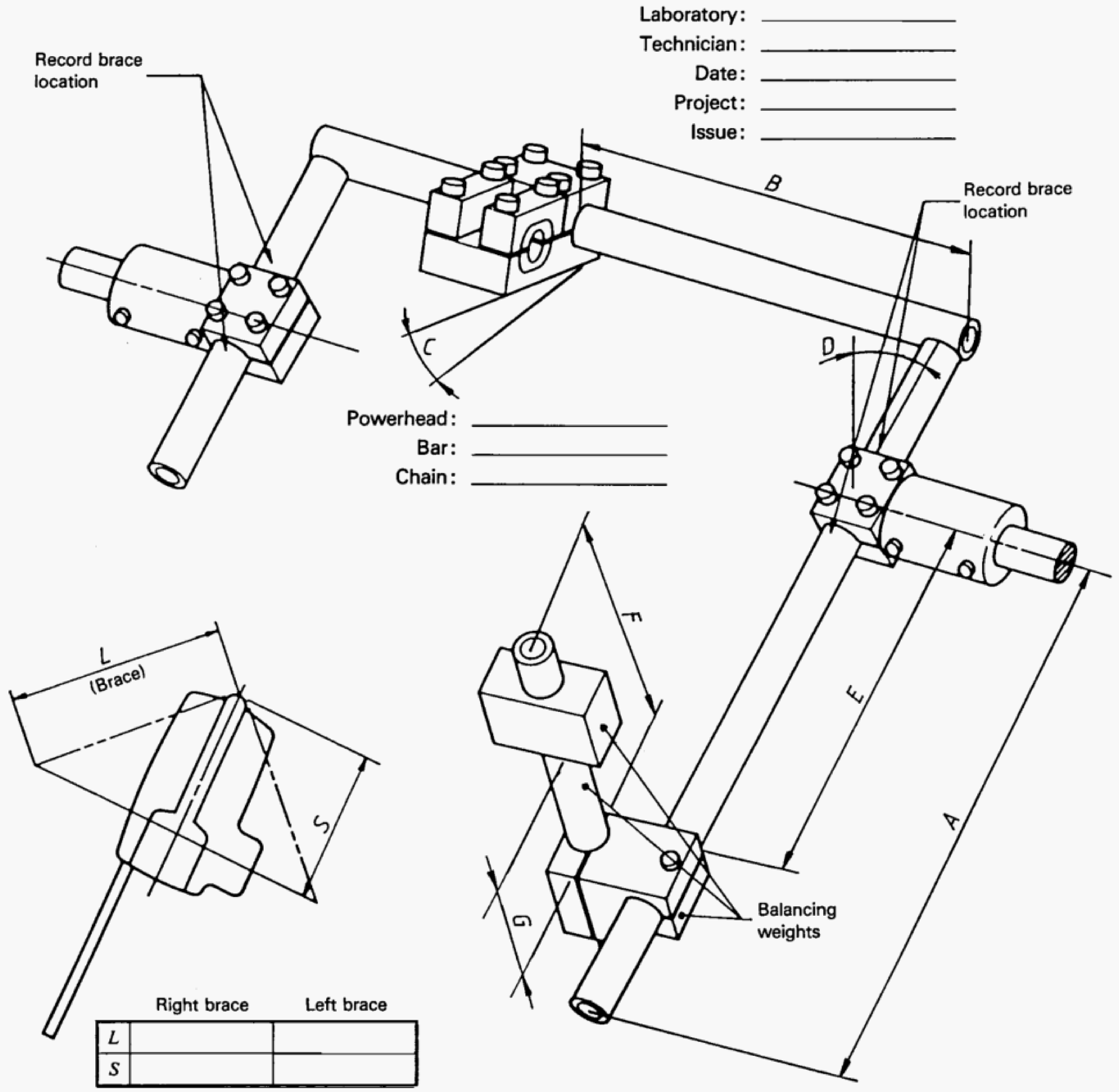
Without brake ________ °

With brake ________ °

Chain stop angle ________ °

Comments ____________

Figure 9 — Kickback test record



	Right brace	Left brace
L		
S		

Cradle measurements

A: ______ mm
B: ______ mm
C: ______ °
D: ______ °

Counterbalance measurements

E: ______ mm
F: ______ mm (if necessary)

Counterbalance measurements

G: ______ mm

Comments: ______________________________

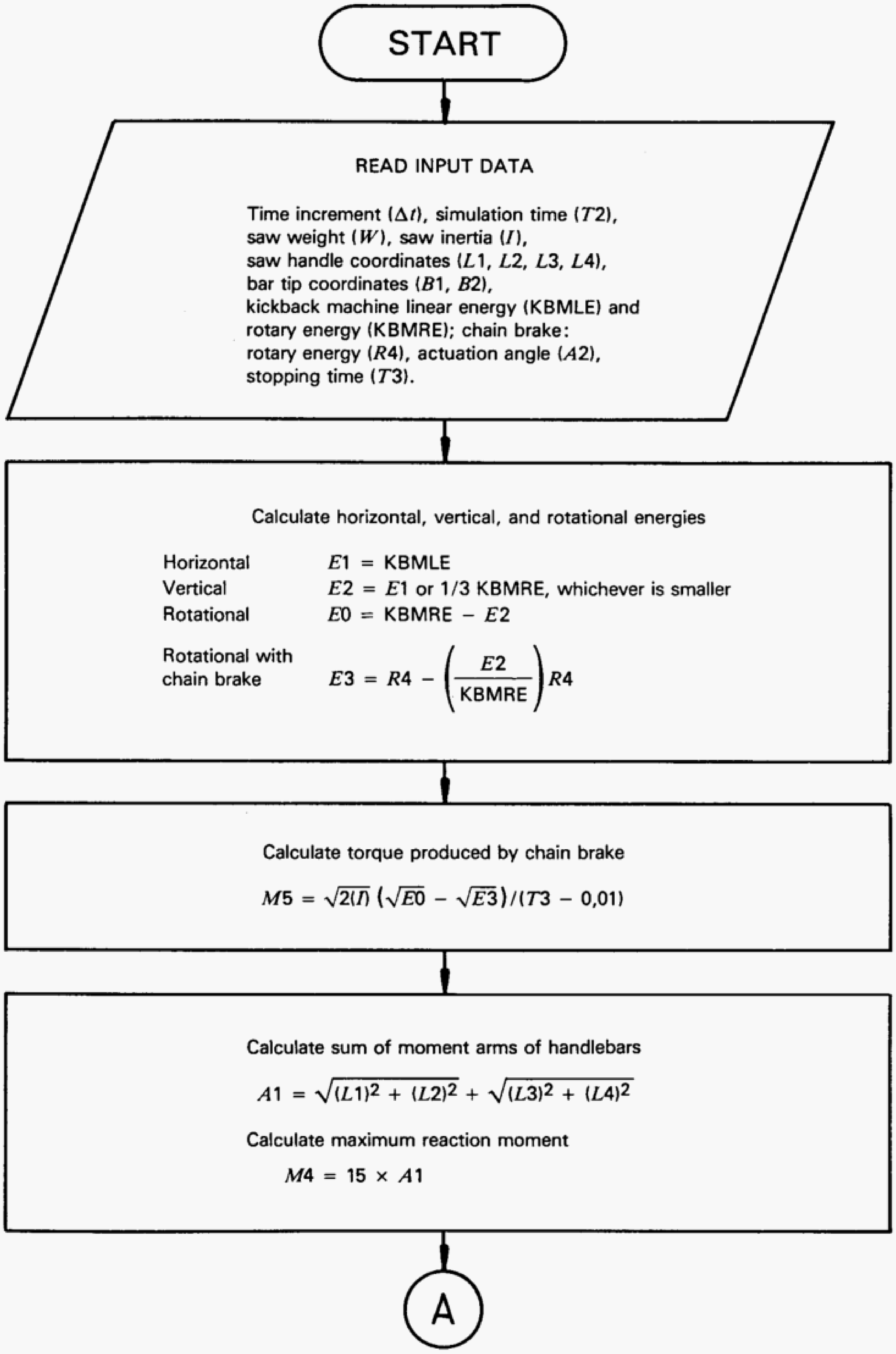
____

____

Figure 10 — Chain-saw installation and balancing test record

Annex A
(normative)

Computer program flowchart



A

Calculate initial velocities

$$\omega = -\sqrt{\frac{2\,(E0)}{I}} \quad \text{Rotational}$$

$$V_x = \sqrt{\frac{2\,(E1)}{W}} \quad \text{Horizontal}$$

$$V_y = \sqrt{\frac{2\,(E2)}{W}} \quad \text{Vertical}$$

$V_{1,1} = \omega$
$V_{2,1} = V_x$
$V_{3,1} = V_y$

Calculate intercepts of hand force equations

Force intercepts:

$$J1 = \frac{1{,}3(E0)^{0{,}25}\left(\sqrt{(L1)^2+(L2)^2} \quad + \quad \sqrt{(L3)^2+(L4)^2}\right)^{1/2}}{\sqrt{(386{,}4)(I)}}$$

$$J2 = -3{,}614\,[(W)(E1)]^{0{,}25} + 6{,}012$$

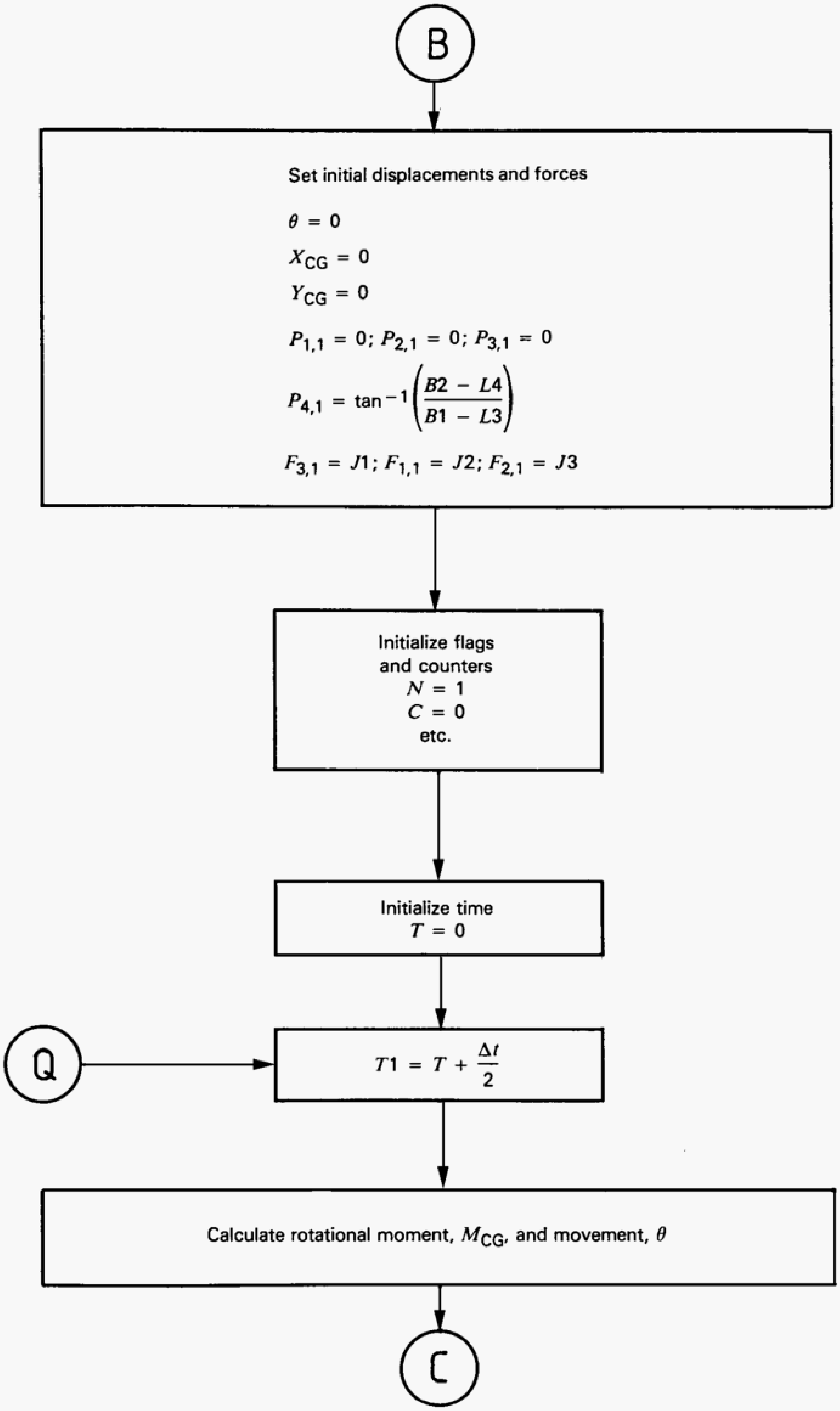
$$J3 = 0{,}0713(J1) + 3{,}047W - 5{,}215\sqrt{E2} + 2{,}989$$

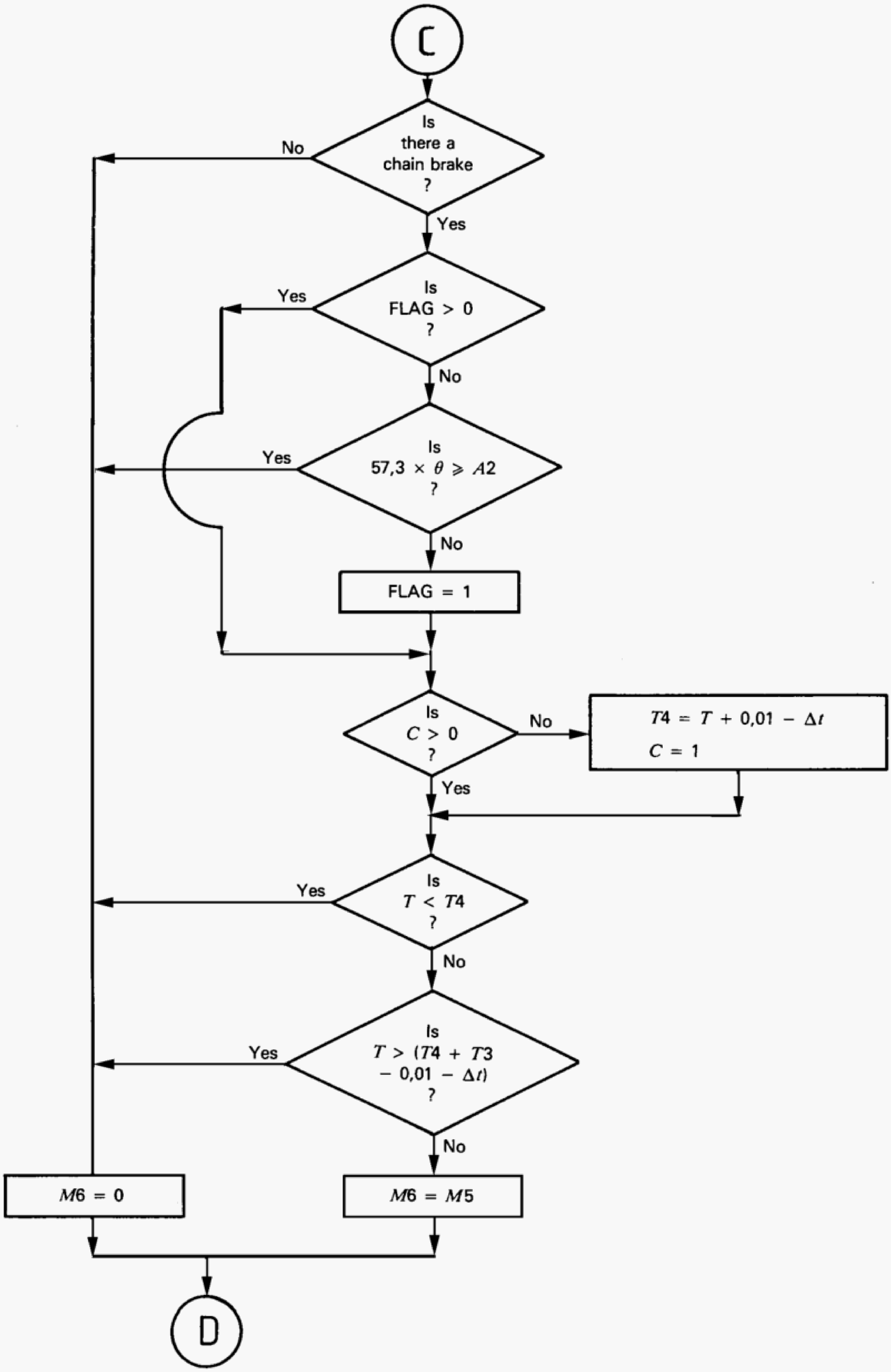
Time intercepts:
$K1 = 0{,}107$
$K3 = 0{,}112\,8$

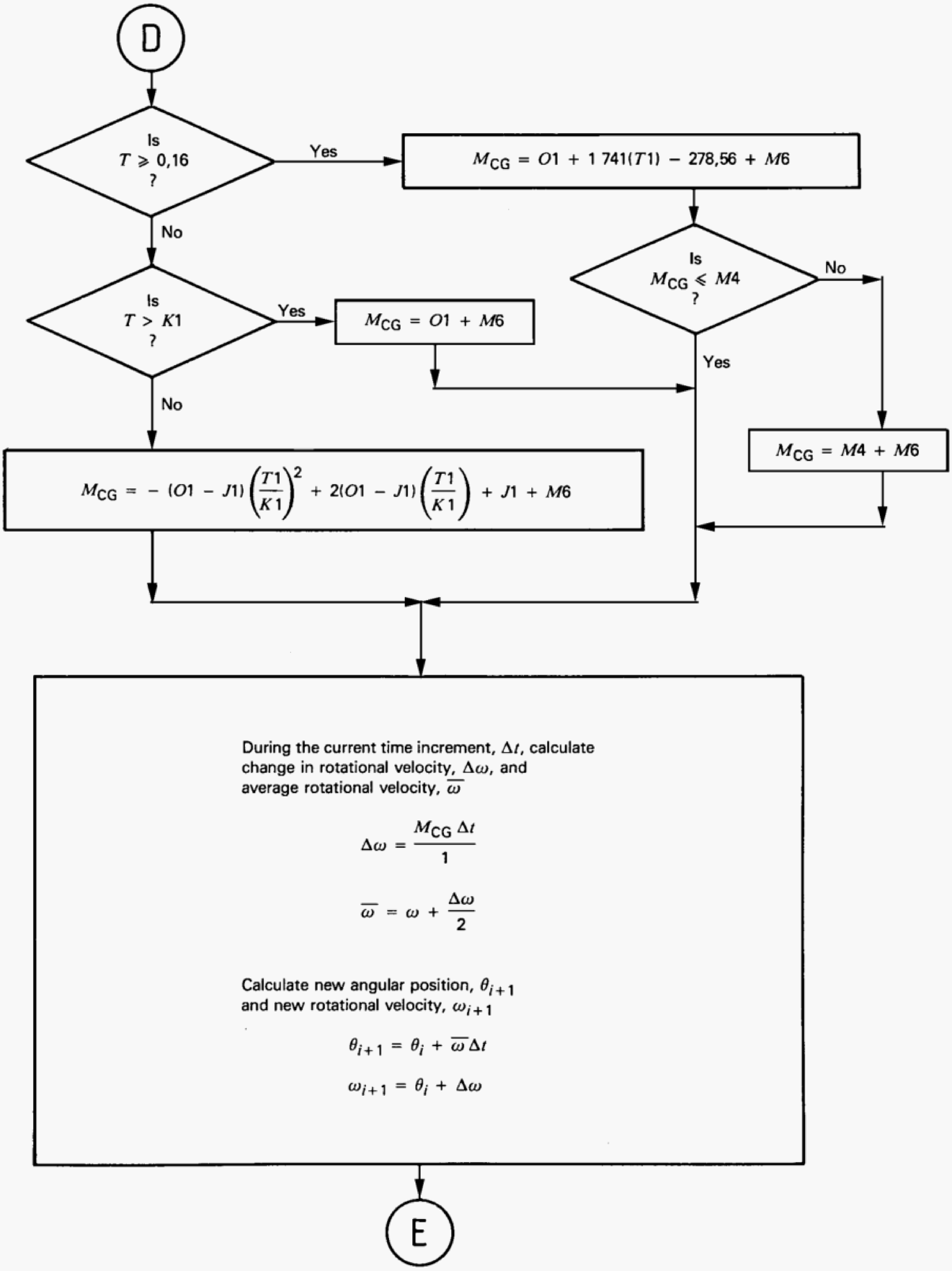
Offset:
$O1 = 0$
$O3 = 0{,}327\,64W + 2{,}063$

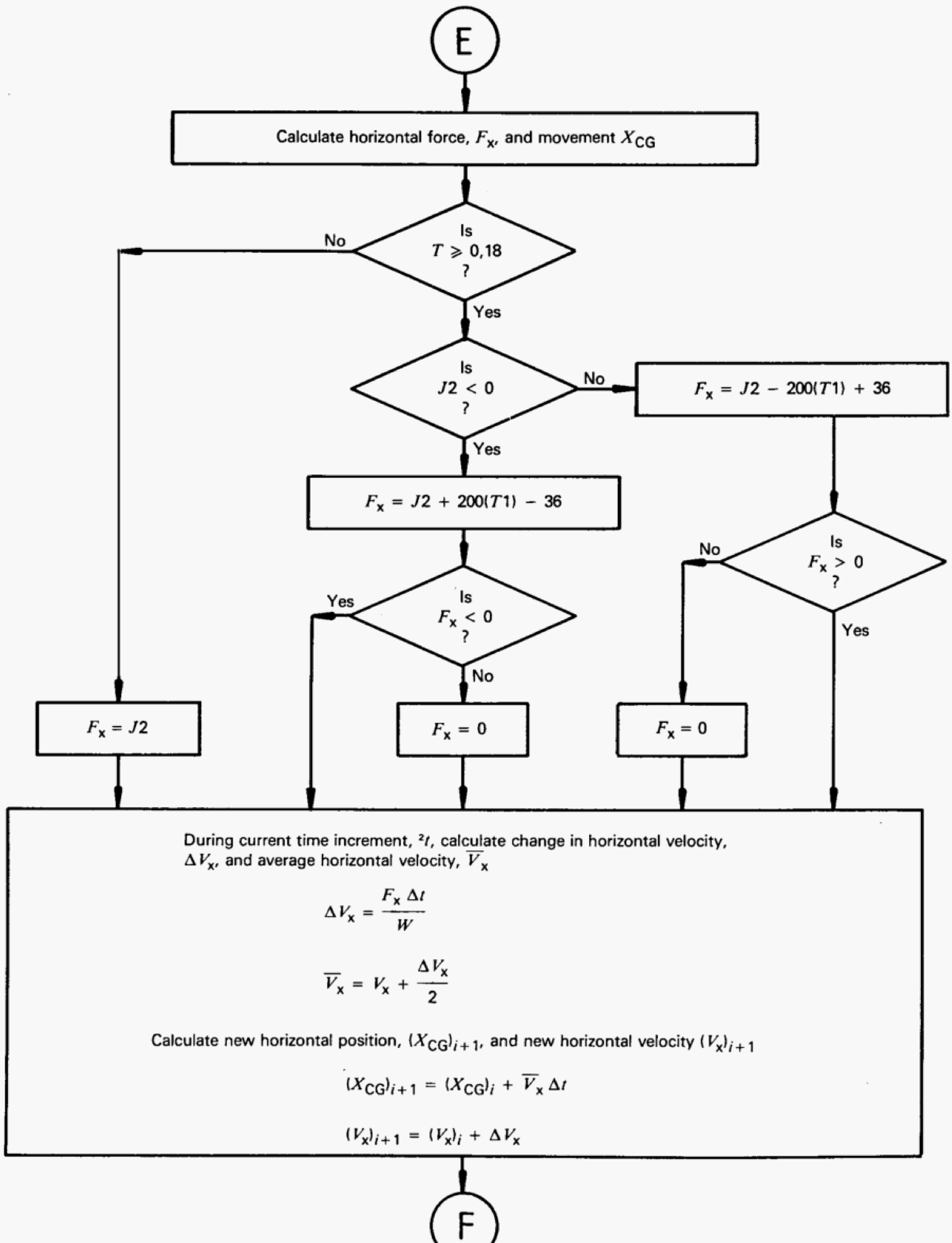
Print out
Input data

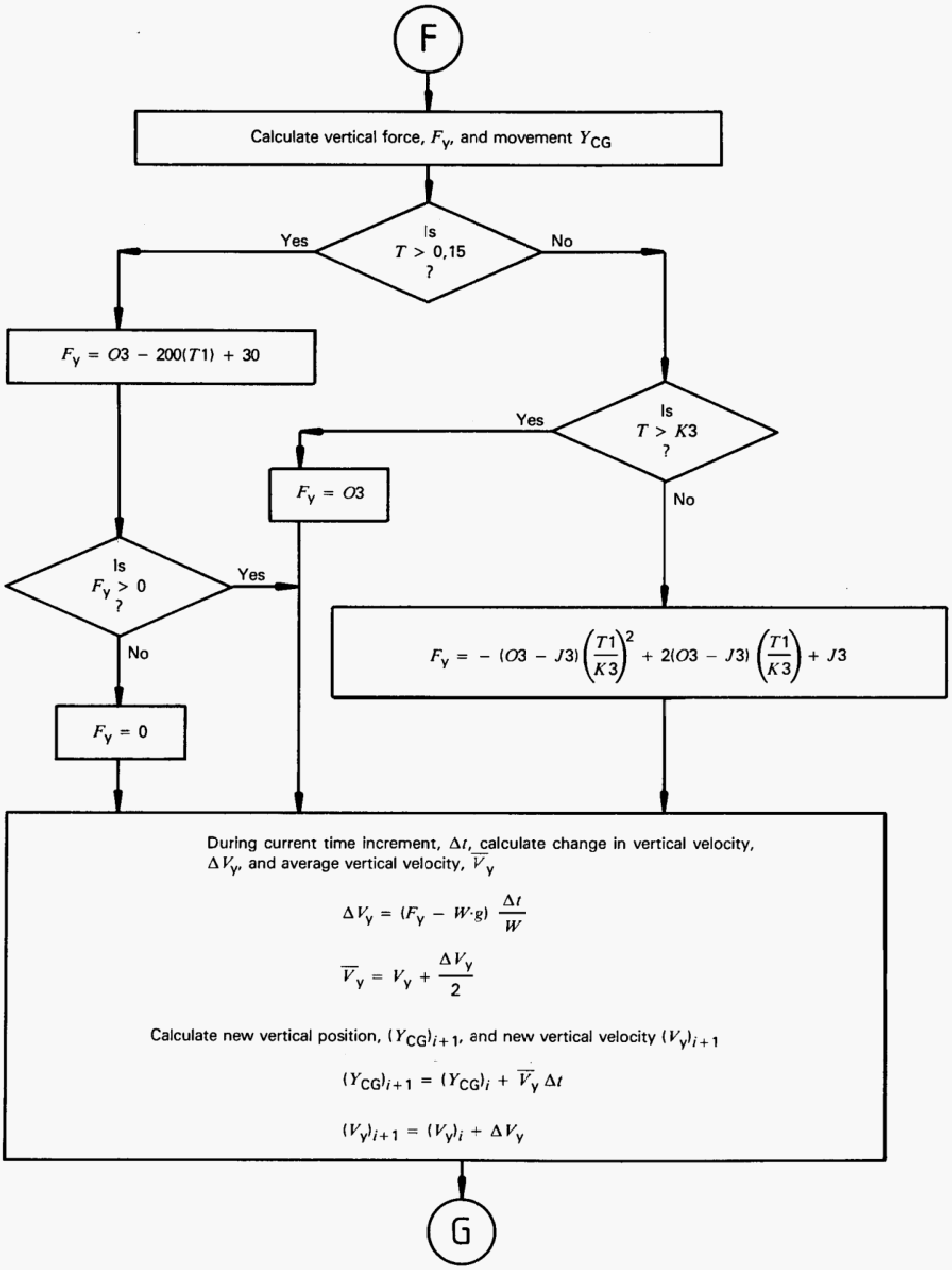
B

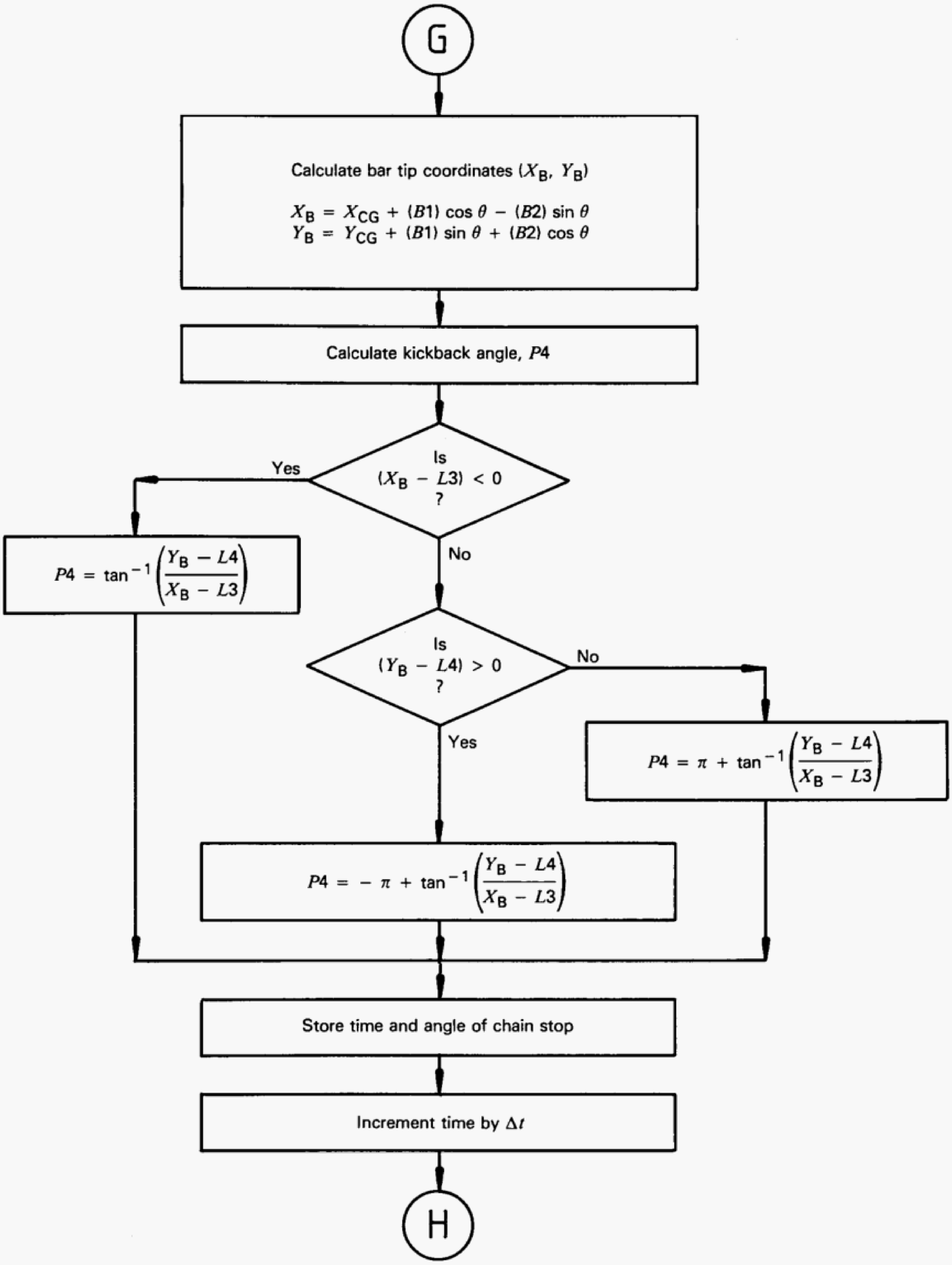

B
Set initial displacements and forces
$\theta = 0$
$X_{CG} = 0$
$Y_{CG} = 0$
$P_{1,1} = 0; P_{2,1} = 0; P_{3,1} = 0$
$P_{4,1} = \tan^{-1}\left(\frac{B2 - L4}{B1 - L3}\right)$
$F_{3,1} = J1; F_{1,1} = J2; F_{2,1} = J3$
Initialize flags
and counters
$N = 1$
$C = 0$
etc.
Initialize time
$T = 0$
Q
$T1 = T + \frac{\Delta t}{2}$
Calculate rotational moment, M_{CG}, and movement, θ
C

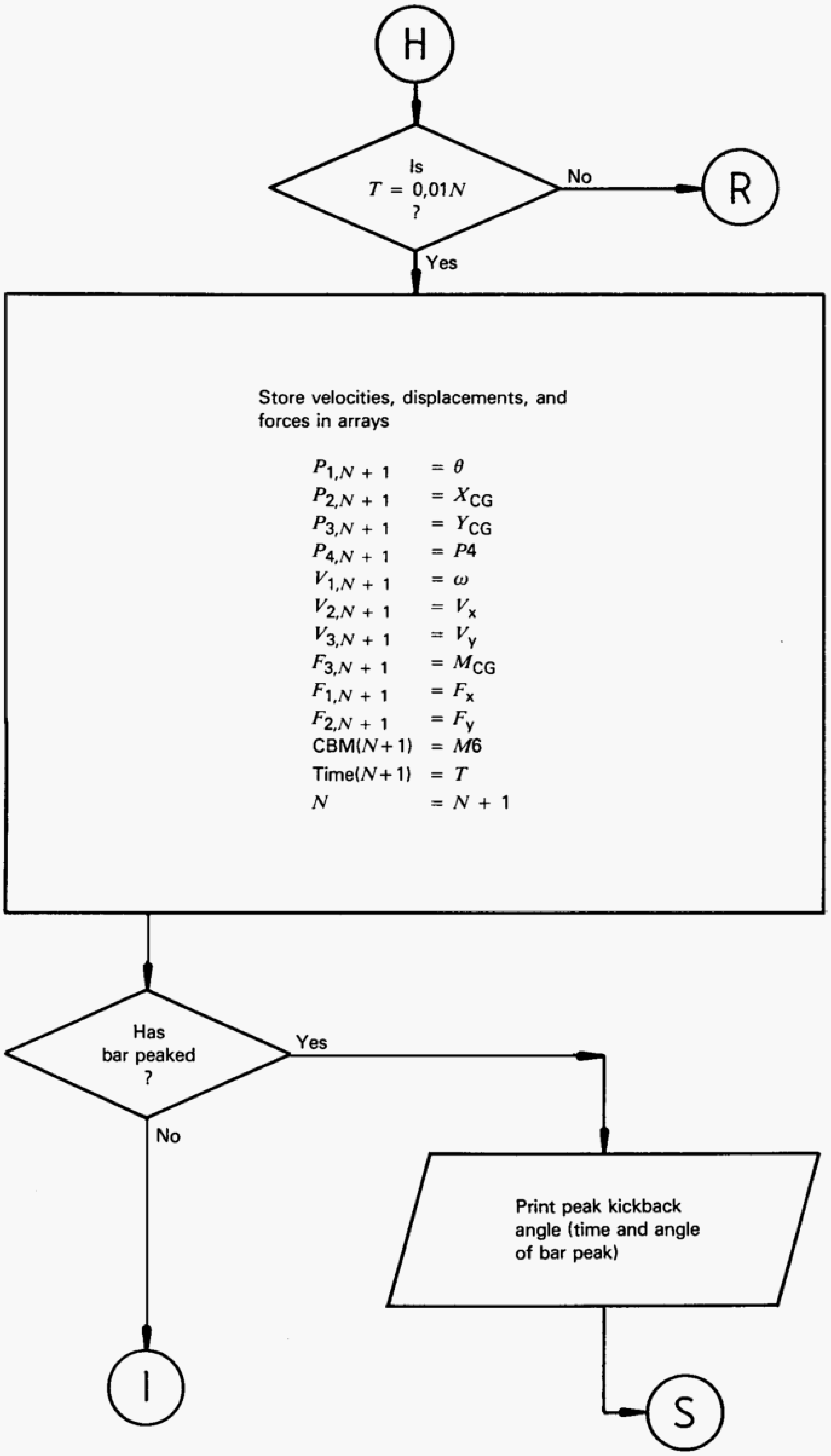

C
Is there a chain brake ?
No
Yes
Is FLAG > 0 ?
Yes
No
Is 57,3 × θ ⩾ A2 ?
Yes
No
FLAG = 1
Is C > 0 ?
No
T4 = T + 0,01 − Δt
C = 1
Yes
Is T < T4 ?
Yes
No
Is T > (T4 + T3 − 0,01 − Δt) ?
Yes
No
M6 = 0
M6 = M5
D

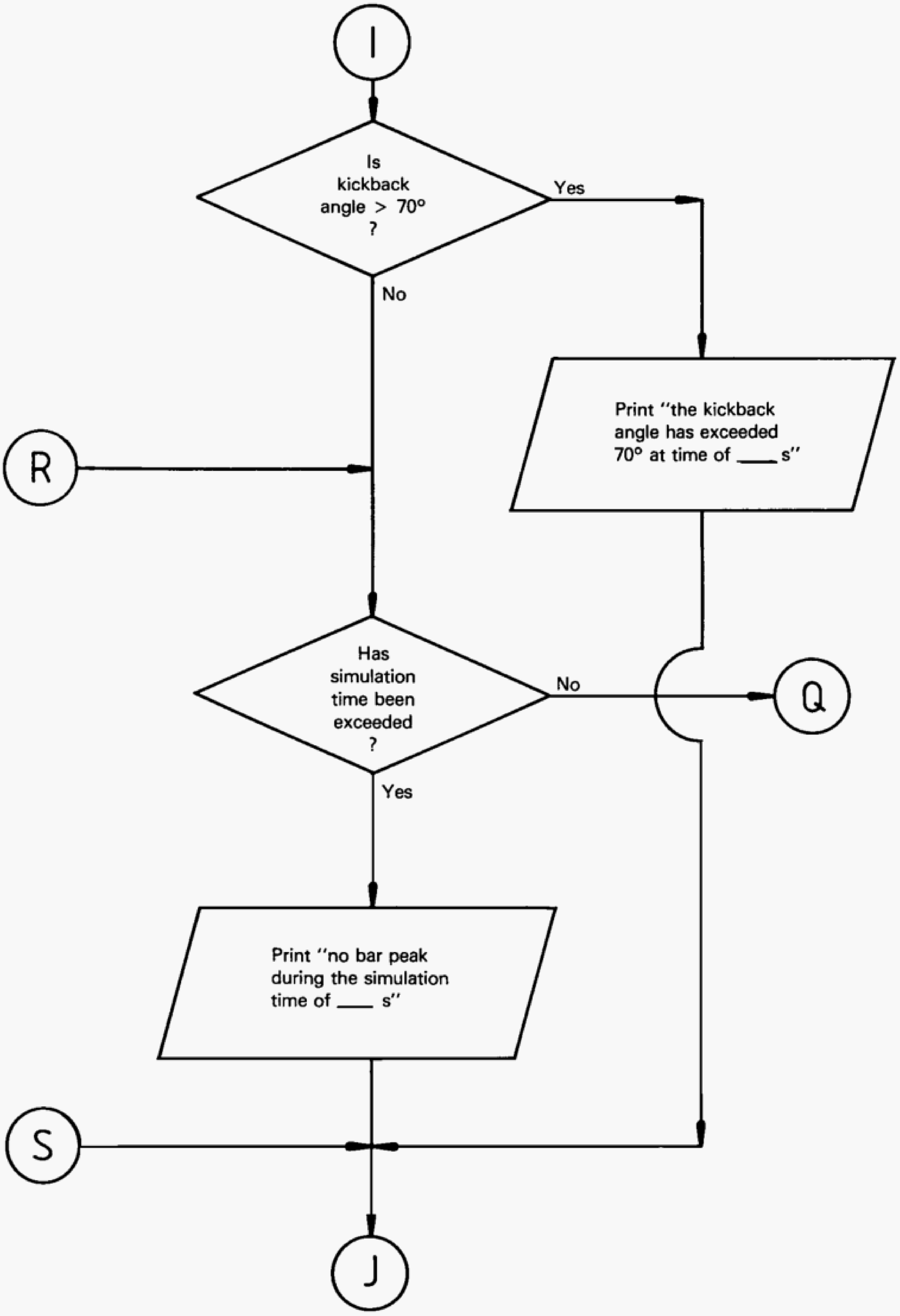

D
Is $T \geqslant 0,16$?
Yes
$M_{CG} = O1 + 1\,741(T1) - 278,56 + M6$
No
Is $T > K1$?
Yes
$M_{CG} = O1 + M6$
Is $M_{CG} \leqslant M4$?
No
Yes
$M_{CG} = M4 + M6$
No
$M_{CG} = -(O1 - J1)\left(\frac{T1}{K1}\right)^2 + 2(O1 - J1)\left(\frac{T1}{K1}\right) + J1 + M6$
During the current time increment, Δt, calculate change in rotational velocity, $\Delta\omega$, and average rotational velocity, $\overline{\omega}$
$\Delta\omega = \frac{M_{CG}\,\Delta t}{1}$
$\overline{\omega} = \omega + \frac{\Delta\omega}{2}$
Calculate new angular position, θ_{i+1} and new rotational velocity, ω_{i+1}
$\theta_{i+1} = \theta_i + \overline{\omega}\,\Delta t$
$\omega_{i+1} = \theta_i + \Delta\omega$
E

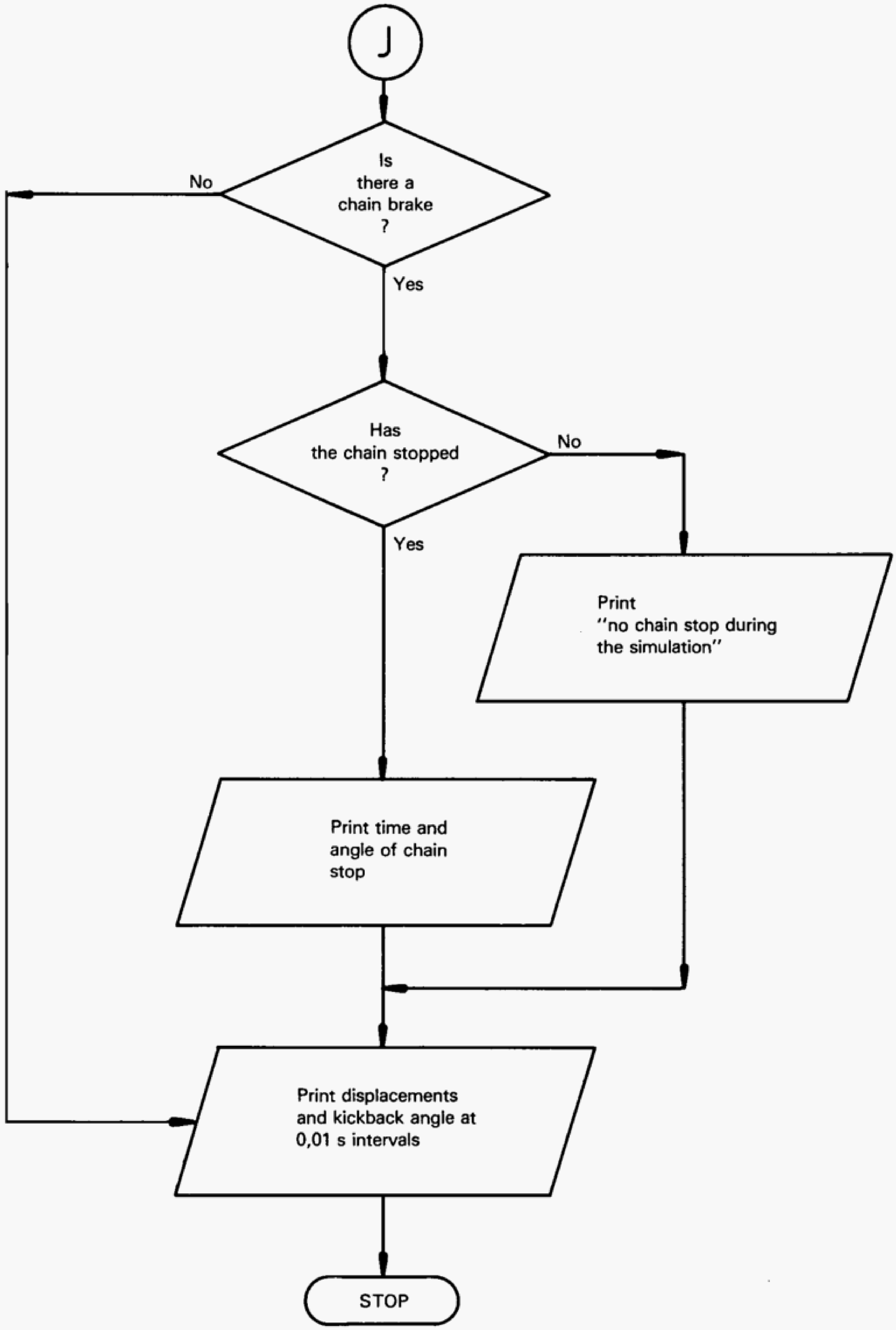

E
Calculate horizontal force, F_x, and movement X_{CG}
Is $T \geqslant 0,18$?
No
Yes
Is $J2 < 0$?
No
$F_x = J2 - 200(T1) + 36$
Yes
$F_x = J2 + 200(T1) - 36$
Is $F_x > 0$?
No
Yes
Is $F_x < 0$?
Yes
No
$F_x = J2$
$F_x = 0$
$F_x = 0$
During current time increment, Δt, calculate change in horizontal velocity, ΔV_x, and average horizontal velocity, $\overline{V}_x$
$\Delta V_x = \frac{F_x \Delta t}{W}$
$\overline{V}_x = V_x + \frac{\Delta V_x}{2}$
Calculate new horizontal position, $(X_{CG})_{i+1}$, and new horizontal velocity $(V_x)_{i+1}$
$(X_{CG})_{i+1} = (X_{CG})_i + \overline{V}_x \Delta t$
$(V_x)_{i+1} = (V_x)_i + \Delta V_x$
F


F
Calculate vertical force, F_y, and movement Y_{CG}
Is $T > 0{,}15$?
Yes
No
$F_y = O3 - 200(T1) + 30$
Is $T > K3$?
Yes
No
$F_y = O3$
Is $F_y > 0$?
Yes
No
$F_y = -(O3 - J3)\left(\frac{T1}{K3}\right)^2 + 2(O3 - J3)\left(\frac{T1}{K3}\right) + J3$
$F_y = 0$
During current time increment, Δt, calculate change in vertical velocity, ΔV_y, and average vertical velocity, $\overline{V}_y$
$\Delta V_y = (F_y - W \cdot g)\frac{\Delta t}{W}$
$\overline{V}_y = V_y + \frac{\Delta V_y}{2}$
Calculate new vertical position, $(Y_{CG})_{i+1}$, and new vertical velocity $(V_y)_{i+1}$
$(Y_{CG})_{i+1} = (Y_{CG})_i + \overline{V}_y \Delta t$
$(V_y)_{i+1} = (V_y)_i + \Delta V_y$
G


G
Calculate bar tip coordinates (X_B, Y_B)
$X_B = X_{CG} + (B1) \cos\theta - (B2) \sin\theta$
$Y_B = Y_{CG} + (B1) \sin\theta + (B2) \cos\theta$
Calculate kickback angle, $P4$
Is $(X_B - L3) < 0$?
Yes
No
$P4 = \tan^{-1}\left(\frac{Y_B - L4}{X_B - L3}\right)$
Is $(Y_B - L4) > 0$?
No
Yes
$P4 = \pi + \tan^{-1}\left(\frac{Y_B - L4}{X_B - L3}\right)$
$P4 = -\pi + \tan^{-1}\left(\frac{Y_B - L4}{X_B - L3}\right)$
Store time and angle of chain stop
Increment time by Δt
H


H
Is
$T = 0,01N$
?
No
R
Yes
Store velocities, displacements, and forces in arrays
$P_{1,N+1} = \theta$
$P_{2,N+1} = X_{CG}$
$P_{3,N+1} = Y_{CG}$
$P_{4,N+1} = P4$
$V_{1,N+1} = \omega$
$V_{2,N+1} = V_x$
$V_{3,N+1} = V_y$
$F_{3,N+1} = M_{CG}$
$F_{1,N+1} = F_x$
$F_{2,N+1} = F_y$
CBM(N+1) = $M6$
Time(N+1) = T
$N = N + 1$
Has
bar peaked
?
Yes
No
Print peak kickback angle (time and angle of bar peak)
I
S


I
Is
kickback
angle > 70°
?
Yes
No
Print "the kickback
angle has exceeded
70° at time of ____ s"
R
Has
simulation
time been
exceeded
?
No
Q
Yes
Print "no bar peak
during the simulation
time of ____ s"
S
J


J
Is there a chain brake ?
No
Yes
Has the chain stopped ?
No
Yes
Print "no chain stop during the simulation"
Print time and angle of chain stop
Print displacements and kickback angle at 0,01 s intervals
STOP

Annex B
(informative)

Basic computer program

```
95 INIT
100 REM****************************************************
102 P$="KICKBACK ANGLE COMPUTATION (JUNE 1986)"
105 REM****************************************************
130 REM  This program computes the kickback angle (see figure 1)
135 REM  from the saw characteristics and energy data
140 REM  specified as input.
170 DIM P(4,32),V(3,32),F(3,32)
180 REM  ***********************************************
190 REM  DATA STATEMENTS OF TIME PERIOD & TIME INCREMENTS
200 REM  ***********************************************
210 DATA 1.0E-3,0.3
220 READ T9,T2
230 PAGE
240 REM  **************
250 REM  INPUT SAW DATA
260 REM  **************
262 PRINT P$
264 PRINT
266 PRINT "INPUT SAW DATA -"
270 PRINT " Model: ";
275 INPUT A$
280 PRINT " Weight(kg): ";
285 INPUT G
287 W=G*2.20462
290 PRINT " Inertia(kg*m↑2): ";
295 INPUT J
297 I=J*8.85075
298 PRINT " Coordinates(mm) -"
300 PRINT "  Front handle - FHX: ";
302 INPUT L5
304 L1=L5/25.4
306 PRINT "                 FHY: ";
308 INPUT L6
309 L2=L6/25.4
310 PRINT "  Rear handle -  RHX: ";
312 INPUT L7
314 L3=L7/25.4
316 PRINT "                 RHY: ";
318 INPUT L8
319 L4=L8/25.4
320 PRINT "  Bar tip -      BTX: ";
322 INPUT B5
323 B1=B5/25.4
326 PRINT "                 BTY: ";
328 INPUT B6
329 B2=B6/25.4
340 REM  ***********************************************
350 REM  INPUT ENERGY MEASUREMENTS FROM KICKBACK MACHINE
360 REM  ***********************************************
365 PRINT
370 PRINT "KBM horizontal energy(joules): ";
380 INPUT W1
381 E1=W1*8.85075
390 PRINT "KBM rotary energy(joules): ";
400 INPUT W0
401 E0=W0*8.85075
405 IF E1/E0>0.333 THEN 430
410 E2=E1
415 E0=E0-E2
```

```
420 GO TO 445
430 E2=0.333*E0
440 E0=E0-E2
445 PRINT
450 PRINT "Was a chain brake used, Y/N: ";
455 INPUT F$
460 IF F$="N" THEN 550
490 PRINT
500 PRINT "Rotary energy with chain brake(Joules): ";
505 INPUT W4
506 R4=W4*8.85075
510 PRINT "Chain brake actuation angle(deg): ";
515 INPUT A2
520 PRINT "Chain brake stopping time(sec): ";
525 INPUT T3
535 A2=-A2
538 E5=E2*R4/(E2+E0)
540 E3=R4-E5
550 E=E0+E1+E2
560 M2=W/386.4
570 M3=I
580 IF F$="N" THEN 680
590 REM  ****************************************
600 REM  CALCULATE TORQUE PRODUCED BY CHAIN BRAKE
610 REM  ****************************************
630 M5=SQR(2*M3)/(T3-0.01)*(SQR(E0)-SQR(E3))
635 REM
640 REM  The chain brake is considered to start slowing the chain
650 REM  .010 seconds after the chain brake activation angle has
660 REM  been reached with the acceleration considered to be constant.
680 REM  **************************************************
690 REM  CALCULATE THE SUM OF THE MOMENT ARMS OF HANDLES
700 REM  **************************************************
710 A1=SQR(L1↑2+L2↑2)+SQR(L3↑2+L4↑2)
720 REM  *********************************
730 REM  CALCULATE MAXIMUM REACTION MOMENT
740 REM  *********************************
750 M4=A1*15
760 REM  ****************************
770 REM  CALCULATE INITIAL VELOCITIES
780 REM  ****************************
790 R1=-SQR(2*E0/M3)
800 H2=SQR(2*E1/M2)
810 V3=SQR(2*E2/M2)
820 V(1,1)=R1
830 V(2,1)=H2
840 V(3,1)=V3
850 REM  ******************************************************
860 REM  CALCULATE INTERCEPTS OF THE HAND FORCE EQUATIONS
870 REM  K(i)=TIME INTERCEPT; J(i)=FORCE INTERCEPT; O(i)=OFFSET
880 REM  ******************************************************
890 J1=1.3*E0↑0.25*SQR(SQR(L1↑2+L2↑2)+SQR(L3↑2+L4↑2))*SQR(I*386.4)
900 J2=-3.614*(E1*W)↑0.25+6.012
910 J3=0.0713*J1+3.047*W-5.215*SQR(E2)+2.989
920 K1=0.107
930 REM  J2= A CONSTANT
940 K3=0.1128
950 O1=0
960 O3=0.32764*W+2.863
970 REM  ******************
980 REM  DISPLAY INPUT DATA
990 REM  ******************
1000 PAGE
1010 PRINT P$
1015 PRINT
1020 PRINT "MODEL: ";A$
1030 PRINT
1035 PRINT "PHYSICAL CHARACTERISTICS OF SAW -"
1040 PRINT " Weight(kg): ";G
```

```
1045 PRINT " Inertia(kg*m↑2): ";J
1050 PRINT " Coordinates(mm) -"
1060 PRI USI "FA,14T,2(5X,4A,5D.1D)":" Front handle","FHX:",L5,"FHY:",L6
1070 PRI USI "FA,14T,2(5X,4A,5D.1D)":" Rear handle","RHX:",L7,"RHY:",L8
1080 PRINT USING "FA,14T,2(5X,4A,5D.1D)":" Bar tip","BTX:",B5,"BTY:",B6
1100 IF F$="N" THEN 1140
1110 PRINT
1115 PRINT "CHAIN BRAKE CHARACTERISTICS -"
1120 PRINT " Actuation angle(deg): ";-A2
1130 PRINT USING "FA,FD.3D":" Stopping time(sec): ",T3
1140 PRINT
1145 PRINT "KBM ENERGY(Joules) MEASUREMENTS -"
1150 PRINT " Horizontal:                  ";W1
1151 IF F$="N" THEN 1156
1152 PRINT " Rotary w/o chain brake:  ";(E0+E2)/8.85075
1154 PRINT " Rotary with chain brake: ";W4
1155 GO TO 1160
1156 PRINT " Rotary:                      ";(E0+E2)/8.85075
1160 PRINT
1170 PRI "ENERGY(joules) COMPONENTS - Horizontal  Vertical  Rotational"
1175 IF F$="N" THEN 1285
1210 PRI USI "24A,3(8D.2D)":" w/o chain brake:",W1,E2/8.85075,E0/8.85075
1270 PRI USI "24A,3(8D.2D)":"with chain brake:",W1,E5/8.85075,E3/8.85075
1280 GO TO 1290
1285 PRINT USING "24T,3(8D.2D)":W1,E2/8.85075,E0/8.85075
1290 PRINT
1295 PRINT "KICKBACK RESULTS -"
1300 N=1
1305 P1=0
1310 P2=0
1315 P3=0
1320 P(1,1)=0
1330 P(2,1)=0
1340 P(3,1)=0
1350 P(4,1)=ATN((B2-L4)/(B1-L3))
1360 F(3,1)=J1
1370 F(1,1)=J2
1380 F(2,1)=J3
1390 C=0
1399 F9=0
1400 FOR T=0 TO T2 STEP T9
1410 T1=T+T9/2
1420 REM  ***************************************************
1430 REM  CALCULATE ROTATIONAL MOMENT & CORRESPONDING MOVEMENT
1440 REM  ***************************************************
1450 IF F$="N" THEN 1540
1455 IF F9>0 THEN 1470
1460 IF P1*57.3=>A2 THEN 1540
1465 F9=1
1470 IF C>0 THEN 1500
1480 T4=T+0.01-T9
1490 C=1
1500 IF T<T4 THEN 1540
1510 IF T>T4+T3-0.01-T9 THEN 1540
1520 M6=M5
1530 GO TO 1550
1540 M6=0
1550 IF T=>0.16 THEN 1610
1560 IF T>K1 THEN 1590
1570 M1=-(O1-J1)/K1↑2*T1↑2+2*(O1-J1)/K1*T1+J1+M6
1580 GO TO 1640
1590 M1=O1+M6
1600 GO TO 1640
1610 M1=O1+1741*T1-278.56+M6
1620 IF M1<=M4 THEN 1640
1630 M1=M4+M6
1640 R9=M1/M3*T9
1650 R8=R1+R9/2
1660 P1=P1+R8*T9
```

```
1670 R1=R1+R9
1680 REM  ****************************************************
1690 REM  CALCULATE HORIZONTAL FORCE & CORRESPONDING MOVEMENT
1700 REM  ****************************************************
1710 IF T=>0.10 THEN 1740
1720 F1=J2
1730 GO TO 1820
1740 IF J2<0 THEN 1790
1750 F1=J2-200*T1+36
1760 IF F1>0 THEN 1820
1770 F1=0
1780 GO TO 1820
1790 F1=J2+200*T1-36
1800 IF F1<0 THEN 1820
1810 F1=0
1820 H9=F1*T9/M2
1830 H8=H2+H9/2
1840 P2=P2+H8*T9
1850 H2=H2+H9
1860 REM  **************************************************
1870 REM  CALCULATE VERTICAL FORCE & CORRESPONDING MOVEMENT
1880 REM  **************************************************
1890 IF T>0.15 THEN 1950
1900 IF T>K3 THEN 1930
1910 F2=-(O3-J3)/K3↑2*T1↑2+2*(O3-J3)/K3*T1+J3
1920 GO TO 1980
1930 F2=O3
1940 GO TO 1980
1950 F2=O3-200*T1+30
1960 IF F2>0 THEN 1980
1970 F2=0
1980 V9=(F2-W)*T9/M2
1990 V8=V3+V9/2
2000 P3=P3+V8*T9
2010 V3=V3+V9
2020 REM  ************************
2030 REM  CALCULATE KICKBACK ANGLE
2040 REM  ************************
2050 C1=COS(P1)
2060 S1=SIN(P1)
2070 D1=P2+B1*C1-B2*S1
2080 D2=P3+B1*S1+B2*C1
2090 IF D1-L3<0 THEN 2120
2100 IF D2-L4>0 THEN 2140
2110 IF D2-L4<0 THEN 2160
2120 P4=ATN((D2-L4)/(D1-L3))
2130 GO TO 2161
2140 P4=-PI+ATN((D2-L4)/(D1-L3))
2150 GO TO 2161
2160 P4=PI+ATN((D2-L4)/(D1-L3))
2161 IF F$="N" OR C=0 THEN 2170
2163 IF T<>T4+INT(1000*(T3+5.0E-4))/1000-0.01 THEN 2170
2164 A5=P4*57.3
2165 T5=T+T9
2170 IF T+T9<>N*0.01 THEN 2350
2180 REM  ******************************************************
2190 REM  STORE VELOCITIES, DISPLACEMENTS, & FORCES (MOMENTS)
2210 REM  ******************************************************
2220 P(1,N+1)=P1
2230 P(2,N+1)=P2
2240 P(3,N+1)=P3
2250 P(4,N+1)=P4
2260 V(1,N+1)=R1
2270 V(2,N+1)=H2
2280 V(3,N+1)=V3
2290 F(3,N+1)=M1
2300 F(1,N+1)=F1
2310 F(2,N+1)=F2
2320 N=N+1
```

```
2330 IF P4>P(4,N-1) THEN 2360
2340 IF P4<-70/57.3 THEN 2400
2350 NEXT T
2351 PRINT "NO BAR PEAK DURING SIMULATION TIME OF ";T2;" SEC."
2353 GO TO 2371
2360 PRI USI "FA,FD.D":" COMPUTED KICKBACK ANGLE(deg): ",-P(4,N-1)*57.3
2370 PRINT USING "FA,D.3D":"                      at time(sec): ",T+T9-0.01
2371 IF F$="N" THEN 2430
2372 IF T5<T+T9-0.01 THEN 2380
2373 PRINT " NO CHAIN STOP DURING THE SIMULATION."
2374 GO TO 2430
2380 PRINT USING """ CHAIN STOP ANGLE(deg): "",FD.D":-A5
2381 PRINT "           at time(sec): ";T5
2390 GO TO 2430
2400 B$=" The COMPUTED KICKBACK ANGLE has exceeded 70 degrees at time: "
2405 PRINT USING "//,FA,D.3D":B$,T+T9
2410 GO TO 2371
2430 INPUT S$
2440 PAGE
2450 REM  **********************************
2460 REM  DISPLAY VELOCITIES & DISPLACEMENTS
2470 REM  **********************************
2472 PRINT P$
2474 PRINT
2480 PRINT USING 2490:"HORIZONTAL","VERTICAL","ROTATIONAL"
2490 IMAGE 11X,10A,9X,8A,10X,10A
2500 PRI USI 2520:"TIME","VEL.","DISP.","VEL.","DISP.","VEL.","DISP."
2510 PRINT "KB ANGLE"
2520 IMAGE X,4A,5X,4A,4X,5A,5X,4A,4X,5A,6X,4A,4X,5A,4X,S
2530 PRINT USING 2550:"sec","mm/sec","mm","mm/sec","mm","deg/sec","deg"
2540 PRINT "deg"
2550 IMAGE 2X,3A,4X,6A,4X,2A,6X,6A,4X,2A,6X,7A,4X,3A,7X,S
2560 FOR S1=0 TO N-1
2570 S=S1+1
2580 PRINT USING "D.3D,7D.2D,5D.2D,S":S1/100,V(2,S)*25.4,P(2,S)*25.4
2590 PRI USI "7D.2D,5D.2D,8D.2D,S":V(3,S)*25.4,P(3,S)*25.4,-V(1,S)*57.3
2600 PRINT USING "5D.2D,9D.2D":-P(1,S)*57.3,-P(4,S)*57.3
2620 NEXT S1
2640 PRINT
2650 PRINT "WOULD YOU LIKE TO CONTINUE Y/N?GGG";
2660 INPUT S$
2670 PAGE
2680 IF S$="N" THEN 2740
2690 PRINT "WOULD YOU LIKE TO RERUN THE SAME SAW Y/N?GGG"
2700 INPUT S$
2710 PAGE
2720 IF S$="Y" THEN 350
2730 GO TO 95
2740 END
```

```
KICKBACK ANGLE COMPUTATION (JUNE 1986)

MODEL: 'Checkout #1' (without chain brake)

PHYSICAL CHARACTERISTICS OF SAW -
 Weight(kg): 5.8
 Inertia(kg*m↑2): 0.0948
 Coordinates(mm) -
 Front handle      FHX:  -11.2     FHY:  109.5
 Rear handle       RHX:   95.3     RHY:   58.7
 Bar tip           BTX: -396.8     BTY:  -23.9

KBM ENERGY(joules) MEASUREMENTS -
 Horizontal:                0.79
 Rotary:                    7.12

ENERGY(Joules) COMPONENTS - Horizontal  Vertical  Rotational
                                0.79      0.79       6.33

KICKBACK RESULTS -
 COMPUTED KICKBACK ANGLE(deg): 51.6
                at time(sec): 0.220
```

KICKBACK ANGLE COMPUTATION (JUNE 1986)

	HORIZONTAL		VERTICAL		ROTATIONAL		
TIME	VEL.	DISP.	VEL.	DISP.	VEL.	DISP.	KB ANGLE
sec	mm/sec	mm	mm/sec	mm	deg/sec	deg	deg
0.000	522.14	0.00	522.14	0.00	662.17	0.00	-9.53
0.010	482.99	5.03	720.37	6.25	544.50	6.01	-4.07
0.020	443.84	9.66	874.69	14.26	448.90	10.97	0.90
0.030	404.69	13.90	989.37	23.61	372.88	15.06	5.45
0.040	365.53	17.75	1068.67	33.93	314.24	18.48	9.63
0.050	326.38	21.21	1116.88	44.88	270.74	21.39	13.51
0.060	287.23	24.28	1138.25	56.18	240.11	23.94	17.13
0.070	248.07	26.96	1137.08	67.57	220.09	26.23	20.53
0.080	208.92	29.24	1117.62	78.86	208.44	28.37	23.75
0.090	169.77	31.14	1084.15	89.88	202.88	30.42	26.81
0.100	130.62	32.64	1040.94	100.51	201.16	32.44	29.74
0.110	91.46	33.75	992.26	110.68	201.03	34.45	32.55
0.120	52.31	34.47	942.12	120.35	201.03	36.46	35.22
0.130	13.16	34.79	891.96	129.52	201.03	38.47	37.76
0.140	-25.99	34.73	841.81	138.19	201.03	40.48	40.16
0.150	-65.15	34.27	791.65	146.35	201.03	42.49	42.44
0.160	-104.30	33.43	733.90	154.00	201.03	44.50	44.58
0.170	-143.45	32.19	660.72	160.98	195.08	46.49	46.58
0.180	-182.61	30.56	572.19	167.16	177.25	48.36	48.34
0.190	-214.08	28.56	474.16	172.39	147.53	50.00	49.79
0.200	-230.21	26.33	376.01	176.64	105.91	51.27	50.85
0.210	-232.52	24.01	277.87	179.91	52.41	52.07	51.47
0.220	-232.52	21.68	179.72	182.20	-12.98	52.28	51.58
0.230	-232.52	19.36	81.58	183.51	-90.26	51.78	51.11

WOULD YOU LIKE TO CONTINUE Y/N?

```
KICKBACK ANGLE COMPUTATION (JUNE 1986)

MODEL: 'Checkout #1' (with chain brake)

PHYSICAL CHARACTERISTICS OF SAW -
 Weight(kg): 5.8
 Inertia(kg*m↑2): 0.0948
 Coordinates(mm) -
 Front handle      FHX:  -11.2     FHY:  109.5
 Rear handle       RHX:   95.3     RHY:   58.7
 Bar tip           BTX: -396.8     BTY:  -23.9

CHAIN BRAKE CHARACTERISTICS -
 Actuation angle(deg): 20
 Stopping time(sec): 0.100

KBM ENERGY(joules) MEASUREMENTS -
 Horizontal:                 0.79
 Rotary w/o chain brake:     7.12
 Rotary with chain brake:    5.88

ENERGY(joules) COMPONENTS - Horizontal   Vertical   Rotational
 w/o chain brake:                0.79        0.79        6.33
with chain brake:                0.79        0.56        4.52

KICKBACK RESULTS -
 COMPUTED KICKBACK ANGLE(deg): 43.2
                at time(sec): 0.200
 CHAIN STOP ANGLE(deg): 37.8
         at time(sec): 0.146
```

KICKBACK ANGLE COMPUTATION (JUNE 1986)

TIME	HORIZONTAL VEL.	HORIZONTAL DISP.	VERTICAL VEL.	VERTICAL DISP.	ROTATIONAL VEL.	ROTATIONAL DISP.	KB ANGLE
sec	mm/sec	mm	mm/sec	mm	deg/sec	deg	deg
0.000	522.14	0.00	522.14	0.00	662.17	0.00	-9.53
0.010	482.99	5.03	720.37	6.25	544.58	6.01	-4.07
0.020	443.84	9.66	874.69	14.26	448.90	10.97	0.90
0.030	404.69	13.90	989.37	23.61	372.88	15.06	5.45
0.040	365.53	17.75	1060.67	33.93	314.24	18.40	9.63
0.050	326.38	21.21	1116.88	44.88	270.74	21.39	13.51
0.060	287.23	24.28	1138.25	56.10	234.39	23.92	17.12
0.070	248.07	26.96	1137.08	67.57	202.95	26.10	20.42
0.080	208.92	29.24	1117.62	78.86	179.87	28.01	23.44
0.090	169.77	31.14	1084.15	89.88	162.88	29.72	26.22
0.100	130.62	32.64	1040.94	100.51	149.73	31.28	28.77
0.110	91.46	33.75	992.26	110.68	138.18	32.72	31.11
0.120	52.31	34.47	942.12	120.35	126.75	34.05	33.23
0.130	13.16	34.79	891.96	129.52	115.32	35.26	35.14
0.140	-25.99	34.73	841.81	138.19	103.90	36.35	36.84
0.150	-65.15	34.27	791.65	146.35	98.18	37.35	38.36
0.160	-104.30	33.43	733.90	154.00	98.18	38.33	39.75
0.170	-143.45	32.19	660.72	160.98	92.24	39.29	41.01
0.180	-182.61	30.56	572.19	167.16	74.40	40.13	42.05
0.190	-214.08	28.56	474.16	172.39	44.68	40.74	42.79
0.200	-230.21	26.33	376.01	176.64	3.07	40.99	43.15
0.210	-232.52	24.01	277.87	179.91	-50.44	40.76	43.07

WOULD YOU LIKE TO CONTINUE Y/N?

```
KICKBACK ANGLE COMPUTATION (JUNE 1986)

MODEL: 'Checkout #2' (with chain brake)

PHYSICAL CHARACTERISTICS OF SAW -
 Weight(kg): 6.13
 Inertia(kg*m↑2): 0.101
 Coordinates(mm) -
 Front handle      FHX:   35.1     FHY:  120.7
 Rear handle       RHX:  169.9     RHY:   76.2
 Bar tip           BTX: -469.9     BTY:   -3.1

CHAIN BRAKE CHARACTERISTICS -
 Actuation angle(deg): 15
 Stopping time(sec): 0.100

KBM ENERGY(joules) MEASUREMENTS -
 Horizontal:                 0.915
 Rotary w/o chain brake:     4.89
 Rotary with chain brake:    3.22

ENERGY(joules) COMPONENTS - Horizontal  Vertical  Rotational
 w/o chain brake:                0.92      0.92        3.98
with chain brake:                0.92      0.60        2.62

KICKBACK RESULTS -
 COMPUTED KICKBACK ANGLE(deg): 18.9
                 at time(sec): 0.170
 NO CHAIN STOP DURING THE SIMULATION.
```

KICKBACK ANGLE COMPUTATION (JUNE 1986)

TIME	HORIZONTAL VEL.	HORIZONTAL DISP.	VERTICAL VEL.	VERTICAL DISP.	ROTATIONAL VEL.	ROTATIONAL DISP.	KB ANGLE
sec	mm/sec	mm	mm/sec	mm	deg/sec	deg	deg
0.000	546.60	0.00	546.60	0.00	508.37	0.00	-7.07
0.010	505.37	5.26	744.75	6.49	388.16	4.46	-3.27
0.020	464.14	10.11	898.85	14.75	290.36	7.84	-0.04
0.030	422.91	14.54	1013.18	24.34	212.64	10.34	2.72
0.040	381.68	18.57	1092.03	34.89	152.70	12.15	5.10
0.050	340.45	22.18	1139.69	46.07	108.22	13.44	7.16
0.060	299.22	25.37	1160.44	57.60	76.91	14.36	8.98
0.070	257.99	28.16	1158.56	69.21	56.45	15.02	10.62
0.080	216.76	30.53	1138.35	80.71	43.47	15.52	12.11
0.090	175.53	32.50	1104.07	91.93	27.14	15.87	13.45
0.100	134.30	34.05	1060.03	102.75	14.73	16.07	14.64
0.110	93.07	35.18	1010.51	113.11	3.95	16.17	15.68
0.120	51.84	35.91	959.51	122.96	-6.70	16.15	16.58
0.130	10.61	36.22	908.51	132.30	-17.35	16.03	17.33
0.140	-30.62	36.12	857.50	141.13	-28.00	15.80	17.94
0.150	-71.85	35.61	806.49	149.45	-38.64	15.47	18.40
0.160	-113.08	34.68	749.30	157.24	-49.29	15.03	18.72
0.170	-154.31	33.34	675.50	164.37	-64.46	14.47	18.88
0.180	-195.54	31.60	583.18	170.70	-81.20	13.75	18.84

WOULD YOU LIKE TO CONTINUE Y/N?

Additional checkout model

MODEL: "Checkout #3" (with chain brake)

Date:	960502		
Physical characteristics of saw			
Weight (kg):	8,45		
Inertia (kg·m^2):	0,159		
Coordinates (mm)			
Front handle	FHX: -22	FHY: 155	
Rear handle	RHX: 248	RHY: 5	
Bar tip	BTX: -473	BTY: -28	
Chain brake characteristics			
Actuation angle (deg):	10		
Stopping time (s):	0,1		
KBM energy measurements			
Horizontal (J):	9,2		
Rotary w/o chain brake (J):	60,8		
Rotary with chain brake (J):	20,8		
Energy components (J)	Horizontal	Vertical	Rotational
w/o chain brake:	9,2	9,2	51,6
with chain brake:	9,2	3,1	17,7
Kickback results			
Computed kickback angle (deg):	65,8		
at time (s):	0,2		
Chain stop angle (deg):	58,3		
at time (s):	0,108		

Time	Horizontal		Vertical		Rotational		KB Angle
	Vel.	Disp.	Vel.	Disp.	Vel.	Disp.	
s	m/s	m	m/s	m	deg/s	deg	deg
0	1,476	0	1,476	0	1459,809	0	-2,621
0,01	1,389	0,014	1,635	0,016	1252,764	13,529	7,653
0,02	1,302	0,028	1,755	0,033	1064,096	25,154	17,122
0,03	1,215	0,04	1,842	0,051	862,897	34,762	25,535
0,04	1,127	0,052	1,898	0,069	692,321	42,515	32,83
0,05	1,04	0,063	1,928	0,088	548,39	48,698	39,06
0,06	0,953	0,073	1,934	0,108	427,127	53,558	44,299
0,07	0,866	0,082	1,921	0,127	324,557	57,303	48,632
0,08	0,779	0,09	1,893	0,146	236,7	60,099	52,15
0,09	0,692	0,098	1,852	0,165	159,582	62,073	54,937
0,1	0,605	0,104	1,803	0,183	89,225	63,313	57,066
0,11	0,517	0,11	1,749	0,201	41,867	63,897	58,609
0,12	0,43	0,114	1,694	0,218	41,867	64,316	59,911
0,13	0,343	0,118	1,639	0,235	41,867	64,735	61,088
0,14	0,256	0,121	1,584	0,251	41,867	64,153	62,148
0,15	0,169	0,123	1,528	0,266	41,867	65,572	63,095
0,16	0,082	0,125	1,468	0,281	41,867	65,991	63,934
0,17	-0,005	0,125	1,397	0,296	38,321	66,397	64,661
0,18	-0,093	0,125	1,316	0,309	27,685	66,733	65,243
0,19	-0,174	0,123	1,224	0,322	9,957	66,927	65,644
0,2	-0,246	0,121	1,126	0,334	-14,863	66,909	65,837
0,21	-0,307	0,118	1,027	0,345	-46,773	66,606	65,794

ICS 65.060.80

Descriptors: forest equipment, portable equipment, mechanically-operated devices, saws, chain saws, tests, impact tests.

Price based on 41 pages