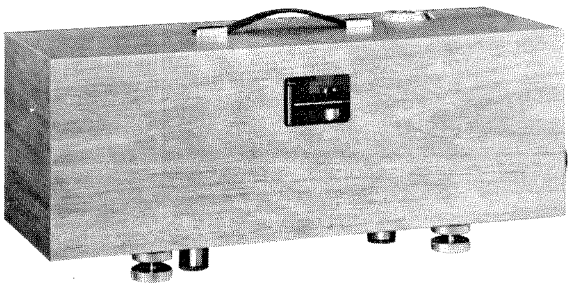
3204

INSTRUCTIONS AND APPLICATIONS

Tapping Machine Type 3204



An impact sound generator designed especially for use in the measurement of impact sound transmission. In accordance with the relevant I.S.O. recommendations.

Accelerometers
Acoustic Standing Wave Apparatus
Artificial Ears
Artificial Voices
Audio Frequency Response Tracers
Audio Frequency Spectrometers
Audio Frequency Vacuum-Tube Voltmeters
Automatic A. F. Response and Spectrum Recorders
Automatic Vibration-Exciter Control Generators
Band-Pass Filter Sets
Beat Frequency Oscillators
Complex Modulus Apparatus
Condenser Microphones
Deviation Bridges
Distortion Measuring Bridges
Frequency Analyzers
Frequency Measuring Bridges
Hearing Aid Test Apparatus
Heterodyne Voltmeters
Level Recorders
Megohmmeters
Microphone Accessories
Microphone Amplifiers
Microphone Calibration Apparatus
Mobile Laboratories
Noise Generators
Noise Limit Indicators
Pistonphones
Polar Diagram Recorders
Preamplifiers
Precision Sound Level Meters
Recording Paper
Strain Gage Apparatus and Accessories
Surface Roughness Meters
Variable Frequency Rejection Filters
VHF-Converters
Vibration Pick-ups
Vibration Pick-up Preamplifiers
Wide Range Vacuum Tube Voltmeters

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BB 3204

Tapping Machine

Type 3204

JUNE 1966

Contents

1. Introduction

1.1. Impact Sound Transmission in Buildings.

The difficulty in assessing the effectiveness of sound insulation in buildings has been to make direct comparisons of the results, and, where impact sounds are concerned, to generate consistent impacts of an appropriate nature. The I.S.O. Recommendation R 140 (January 1960) defines suitable methods of measurement, so that data obtained by different workers may be directly compared.

In the case of sounds produced by impacts, the method adopted is to specify a machine for making standard impacts on a floor, and the transmission is characterized by the spectrum of the noise produced in the receiving room. For field measurement, the receiving room may be any room in the building and not necessarily the room directly beneath the floor being tested. Since the spectrum depends on the absorption in the receiving room, the measured values are adjusted to a reference absorption.

The Type 3204 Tapping Machine has been designed to meet these requirements for a standard impact generator.

1.2. Generation of Impact Sound Field — I.S.O. Recommendations.

The tapping machine should be constructed in accordance with the following specification:

It should have five hammers placed in a line, the distance between the two end hammers being about 40 cm.
The time between successive impacts should be 100 ± 5 milliseconds.
The effective mass af each hammer should be o.5 kg (within ± 2.5 %).

The drop of a hammer on a flat floor should be equivalent to a free drop without friction of 4 cm (within 2.5 %).

The part of a hammer which strikes the floor should be a cylinder of brass or steel, 3 cm in diameter, with a spherical end having a radius of about 50 cm.

In the case of a fragile floor covering, hammers should be used having the part that strikes the floor coated with a layer of rubber, of which the dimensions, composition and vulcanisation are specified. The hammer should strike the floor only once each time it is released and should always fall through an effective height of 4 cm.

2. Description

2.1. General.

The Tapping Machine Type 3204 meets the specification set out in section 1.2. The mechanism, which is solidly constructed on a whip-free cast aluminium chassis, basically converts rotation of an electric motor into carefully controlled and synchronized translatory motion of five hammers. Fig. 1 shows the moving parts.

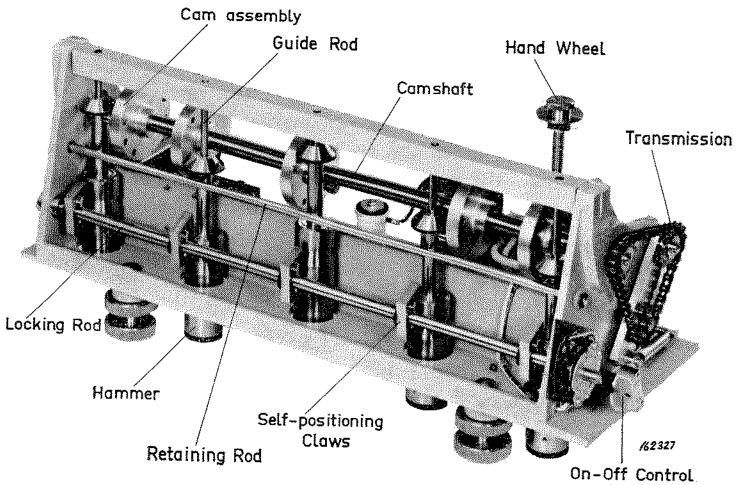


Fig. 1. The mechanism of the Tapping Machine Type 3204.

2.2. Motor,

The machine is powered by a self-starting single-phase synchronous motor, which is fed through an auto-transformer, tapped so as to allow a number of different mains voltages to be used. Two alternative phase-splitting networks are provided, so that the motor can work under optimum conditions on either 50 c/s or 60 c/s.

2.3. Rotary Transmission.

The motor shaft, which is also attached to the hand-wheel, drives the primary shaft through a worm gear. There are two possible ratios for the chain drive to the camshaft, (see section 3.1), an arrangement which

enables the camshaft to rotate at 60 r.p.m. for either the 50 c/s or 60 c/s synchronous motor speeds. The camshaft runs in ball bearings and all shafts are of St43 stainless steel and generous cross-section so that running tolerances will always be maintained and no spurious modes of motion allowed.

2.4. Cams.

There is a separate cam to actuate each hammer. The five cams are basically discs of Sm steel from each of which project two brass bosses. The "firing" order for the hammers depends upon the relative positions of the ten brass bosses, and is chosen so that the machine works as smoothly as possible, without any tendency to revolve on its own axis or to creep.

As shown in Figure 2, each hammer is lifted vertically twice every revolution of the camshaft. The brass boss is free to rotate on its own axis and so the cam imparts virtually no horizontal force to the hammer.

2.5. Hammers.

Each hammer is guided in pure translatory motion by a single hardened steel rod which is fixed with its axis vertical. The guide rod runs in two

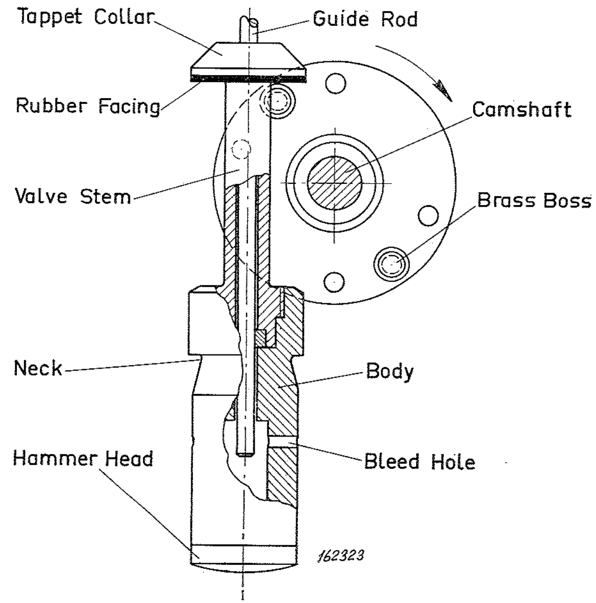


Fig. 2. One of the five hammers, showing its construction, and the tappet mechanism through which vertical motion is obtained.

bronze bushes which are a press fit in the nickel-plated brass valve stem. This in turn is screwed into the hammer body, also of nickel plated brass. See Fig. 2.
The cylindrical body is closed at the bottom end by the hammer head, which is easily interchangeable. Complete sets of stainless steel and rubber-faced heads are supplied, both types having identical external dimensions and mass.
The tolerances between the guide and the bores in which it runs are arranged so as to provide effective directional control whilst avoiding the resonances of the rod from being excited. Bleed holes in the body ensure that the piston effect of the rod does not affect the motion of the hammer.
To avoid large accelerations and "bounce" during lift, the tappet geometry has been carefully calculated and the underside of the collar which contacts the cam is faced with rubber. Fig. 3 shows how hammer displacement, velocity and acceleration vary with camshaft angle.

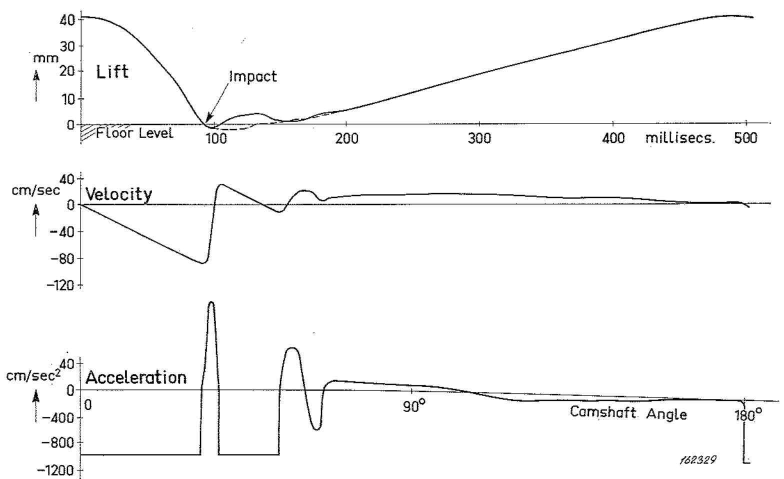
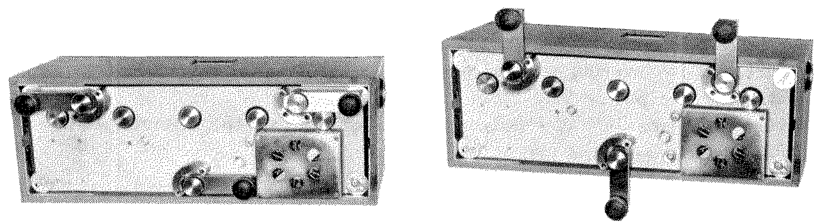


Fig. 3. Typical curves for the displacement, velocity and acceleration of a single hammer during one cycle. (Theoretical). The broken line shows the lift profile for the case where the floor material does not recover.

It will be seen from the displacement graph that the vertical fall is normally 4.1 cm.
The I.S.O. recommendation quoted in section 1.2. calls for a fall which is *equivalent* to a free drop without friction of 4 cm. In other words, the impact velocity must be 88.6 cm $sec.^{-1}$. In order to achieve this,

exactly compensating for friction in the guide rods, the hammers should fall through 4.1 cm, a conclusion which is explained in Appendix A.

Positioning of Legs.
Because the isolation of the Machine from the floor, and the distance between the hammers and the supporting legs, might influence the proper operation (at low frequencies) the legs have been supplied with hard rubber. Also their position relative to the hammers have been made adjustable, see Fig. 4a. The least possible "interaction" between the hammers and the supports are obtained when the legs are set as shown in Fig. 4b.



a b

Fig. 4. Photograph of Type 3204 showing the positioning of the legs.
a) Legs in inner position.
b) Legs in outer position.

2.6. On/Off Control.
As will be seen from Fig. 1, the On/Off control actuates the locking rod as well as an electrical switch in the motor circuit. When turned to "off", self-positioning claws engage the neck in each hammer just as it reaches the top of its stroke, and hence locks the hammer in this position. When switching "on", all five hammers are simultaneously released and the drive set into motion.

2.7. Accessories.
The five hammer heads not in use are screwed to posts in a convenient recess in the side of the case.
A 4.1 cm long gauge is similarly fixed (see section 3.3), and the power lead may also be stowed away here.
In the bottom left-hand corner of the recess is a little spring which retains an Allen key used for adjustment.

3. Operation

3.1. Adjustment to Correct Power Frequency.

Models for the American market are normally shipped correctly set for 60 c/s operation, and those destined for other markets are set for 50 c/s. If, however, there is any doubt, the case should be removed to check this point.

Removing the case:

The hand wheel and the on/off control knobs must be removed from their shafts, on which they are a push fit. Use a straight outward pull, assisted by levering with a small screw-driver.
Unplug the power lead from the 3204.
Unscrew two ¼″ WG nuts on the underside of the chassis. These are directly beneath the lifting handle.
The case can now be lifted off.

Electrical circuit:

The correct phase-splitting network must be chosen to suit the power frequency. Next to the voltage selector are two holders, into only one of which a shorting link should be placed.

For 50 c/s operation, use the bottom position.
For 60 c/s operation, use the top position. See Fig. 5.

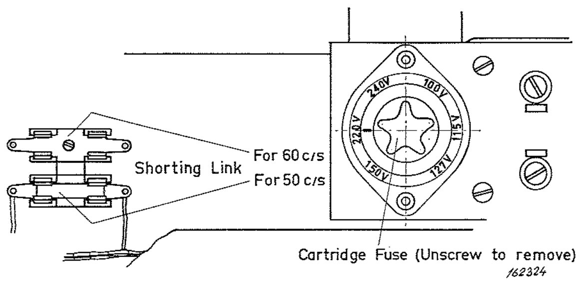


Fig. 5. The shorting link must be correctly positioned to suit the power line frequency. On the right is the voltage adjuster panel, which can be reached without removing the case.

Gear Ratio:

To ensure the correct camshaft speed for either power frequency, the chain drive ratio must be checked.

Referring to Fig. 6, the drive-shaft sprocket must be:
12 tooth, Reynold's 110500 for 50 c/s mains,
10 tooth, Reynold's 110500 for 60 c/s mains.
The spare sprocket is used as idler.

Should it be necessary to change the sprockets, move the idler upwards with the fingers and remove the chain. With a screw-driver, prise out the circlip on the idler shaft and pull off the sprocket, taking care not to lose the two phosphor-bronze washers. Using the Allen key (see section 2.7) supplied, release the *drive-shaft sprocket* (not the camshaft sprocket). Reassemble with the sprockets correctly placed, making sure that there is one phosphor-bronze washer behind each sprocket, and one between the idler and its retaining circlip. The Allen grub screw, which may have to be transferred from one sprocket to the other, should bed down on the flat of the drive shaft. Finally, replace the chain, the case, and the knobs.

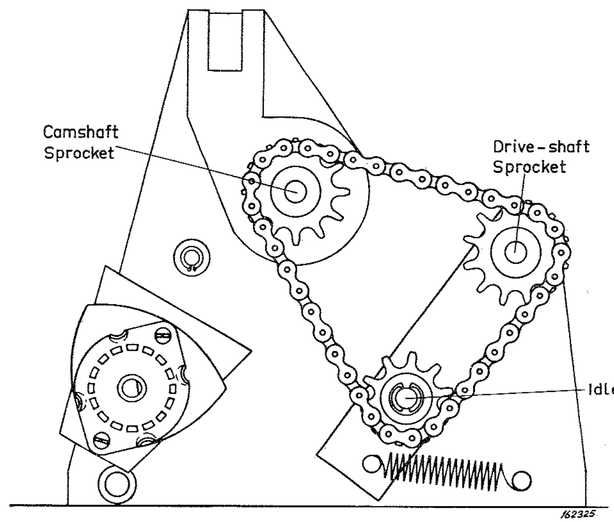


Fig. 6. By interchanging two of the sprockets, the chain drive ratio can be altered so that either 50 c/s or 60 c/s power lines may be used.

3.2. Supply Voltage.

The voltage selector panel, which may be reached through the back of the accessory recess without removing the case, should be adjusted to the correct mains voltage. If alteration is necessary, remove the fuse and with a coin rotate the adjuster until the pointer indicates the correct voltage. Having replaced the fuse, the power cable can be connected to the mains.

3.3. Levelling up.

Place the machine on the spot where it is to tap. Using the 4.1 cm gauge, check the height of fall for all five hammers. With the control knob in the "off" position, the hammers are locked about 4 mm lower than the very top of their stroke so, paying attention to one hammer at a time, use the hand wheel to raise each to its peak. To adjust the height of fall, alter the effective lengths of the three legs by loosening the knurled lock-nuts and screwing the legs in or out as necessary. Do not forget to tighten the lock-nuts again.

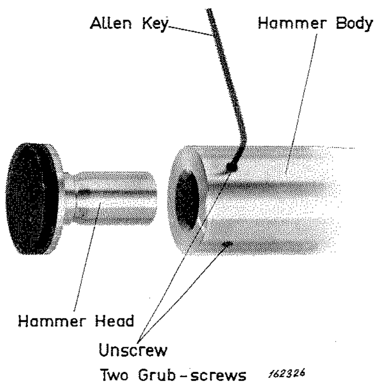


Fig. 7. When changing the hammer heads, two Allen grub screws must be slackened off. There is no need to remove the case for this operation.

3.4. Running the Machine.

The machine is started and stopped in a very straightforward manner, using the "on/off" control. The hand-wheel need not be touched.

Always keep the case on to prevent dust from accumulating on the mechanism and to reduce extraneous noise. The case need only be removed when adjusting for a change in mains frequency (3.1) or when carrying out the two-yearly service (Part 5).

3.5. Changing Hammer Heads.

If it is necessary to change the heads (see Section 4.5), disconnect the mains lead and then switch the control knob to "On".

Tilt the machine on its side,—it is not necessary to remove the case,— and at least one hammer can then be extended. Using the Allen key provided (2.7), unscrew the two grub screws at the base of the hammer by several turns. As shown in Fig. 7 the head can be removed and replaced by one of the alternative type, which has been unscrewed from its securing post in the storage recess.

By turning the hand-wheel, other hammers can be extended so that their heads may also be changed. Note: The hand-wheel must only be turned in the *direction of the arrow:* reversal may damage the cams.

4. Application

4.1. General.

The tapping machine generates standard impacts at a point A, whilst noise receiving and analysing equipment is placed at B. By the I.S.O. definition, the properties of *impact sound transmission* between A and B are *characterized by the spectrum* of the noise produced at B.

A and B may be on opposite sides of a test specimen floor structure which is being investigated in the laboratory, or they may be two points in a building where impact sound transmission properties are to be studied in situ. Both categories, *laboratory* measurements and *field* measurements will be considered, basing the principles on the I.S.O Recommendation R 140.

4.2. Frequency Bands for Measurements.

The received noise due to the tapping machine is to be analysed and r.m.s. sound pressure levels determined in *octave bands.*

This is most simply achieved by using an analyser incorporating 1/1 octave filters, but filters with any pass-band of width between 1/1 octave and 1/3 octave may be employed. If 1/n octave filters are used, the average sound pressure levels so obtained should be corrected to correspond sufficiently to 1/1 octave bands by the addition of 10 log n db to the average level.

The following frequency bands should be covered, though if necessary and possible, the range may be extended to both higher and lower values.

62.5 — 125 — 250 — 500 — 1000 — 2000 — 4000 c/s.

If the sound pressure levels vary greatly with frequency, care must be taken to ensure that the discrimination characteristics of the filters are adequate. The I.S.O. Recommendation offers some guidance on this point, but if B & K equipment is used, excellent discrimination is assured and there is no problem.

4.3. Instrumentation.

Basically, a microphone, amplifier, filters, and an instrument reading r.m.s. sound pressure levels are required. There are a number of B & K instrument systems which are suitable, and these may be broadly grouped under three headings:

i) Those with which the complete analysis may be carried out "on the spot",

ii) Where the received noise is recorded on magnetic tape and subsequently analysed in the laboratory,

iii) Where all the receiving equipment, including the tape recorder, is battery operated.

Groups ii) and iii) are particularly well suited to field measurements, but in principle all groups can be used for both laboratory and field investigations.

Suitable combinations of instruments may be found by reading down any one column in Table 1. All the analysing instruments incorporate meters from which the necessary values of sound pressure level may be read off, but if a graphical record is required this may be obtained from a level recorder such as the 2305. This instrument, which is included in the 3313, yields frequency response curves on pre-printed paper (see Fig. 8), and can be synchronized with the analysers, except in arrangement No. 8. This last combination, 2203 + 1613, is in fact one portable instrument which is extremely convenient for field work.

If very accurate measurements are required, the complete system, from microphone to recording, may be calibrated with an accuracy of ± 0.2 db using a B & K Pistonphone Type 4220.

TABLE 1

Current types of B & K instruments suitable for the sound analysis.

	Group i)			Group ii)		Group iii)		
	1	2	3	4	5	6	7	8
Microphones	4131/32 + 2612/13 or 4133/34 + 2614/15			4131/32 + 2612/13 4133/34 + 2614/15		4131 4132	2203	
Amplifiers and/or mic. power supplies		2603 2604		2603 2604	2801	2630		
			2112 (2107)	Tape Recorder		Tape Recorder		1613
Filters	3313	1612		*	*			
				2112	2112			
Recorder		2305		2305				

* Represents any suitable time interval.

4.4. Arrangement for Laboratory Measurements.

The test floor should be inserted between two reverberant rooms, and the edge conditions, which should be as near to practical conditions as possible, must be stated. The sound transmitted by any indirect path should be negligible compared with the sound transmitted directly from the test specimen.

The size of the test floor should be approximately 10 m^2, with a minimum dimension of not less than 2.5 m.

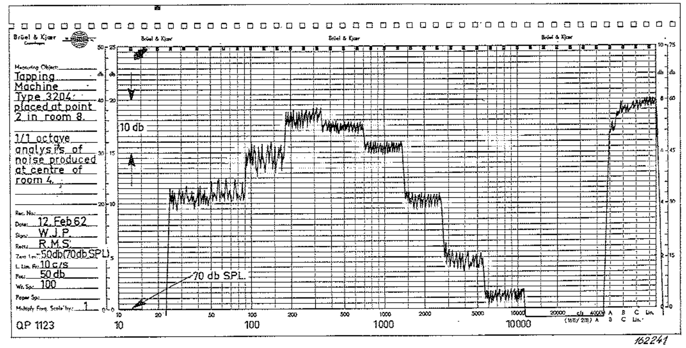


Fig. 8. A typical 1/1 octave spectrogram of the received noise from the Tapping Machine, as recorded on a Level Recorder Type 2305.

The shape of the rooms both above and below the test floor should be chosen to give an adequately diffuse sound field : this means that each room should have a volume of at least 100 m^3.

An outline of the experimental technique, which is the same for both laboratory and field measurements, is given in the next section.

4.5. Measurements to be Taken in the Field.

The tapping machine must be placed successively in at least three positions on the test floor. The true standard hammers are those with stainless steel heads and these should be used wherever possible. Only if the floor surface would be permanently damaged by these should the rubber faced hammers be employed. Details of the particular floor under investigation, and all testing positions, should be noted on a diagram, and where the floor is not homogeneous in the horizontal direction, the orientation of the machine should be described also.

The receiving room may be any other room in the building and not necessarily the room directly beneath the tapping machine.

Using an r.m.s. reading instrument, take several measurements of the sound pressure level, covering the entire room with the exception of those parts where the influence of the boundaries (walls etc.) is significant. The readings should be converted to the *squares of absolute sound pressures,* and the mean value of these squares then calculated. This value is to be compared with the square of the reference sound pressure, and hence the *space average sound pressure level (L)* calculated,

$$\text{where } L = 10 \log_{10} \frac{p_1^2 + p_2^2 + \ldots p_n^2}{n p_0^2} \text{ db}$$

p_1, p_2, ... p_n = r.m.s. sound pressures at n different positions in the room.

p_0 = reference sound pressure

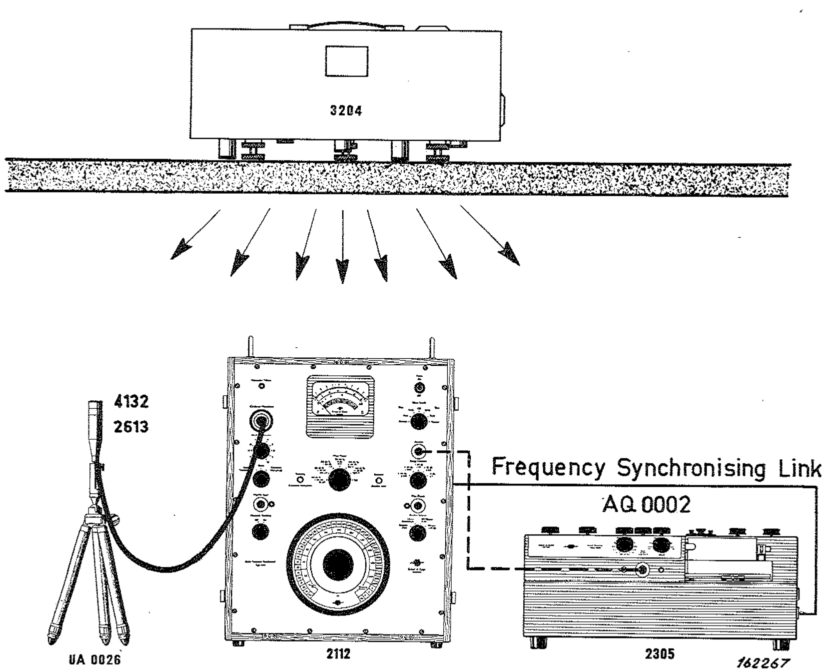


Fig. 9. Impact sound being analysed by an A.F. Spectrometer. This is the arrangement shown in column 3 of the table: the level recorder is not essential but provides an ideal basis for the presentation of results.

$= 2 \times 10^{-4}$ dyn.cm^{-2} $= 2 \times 10^{-5}$ Newton. m.$^{-2}$

L must be derived for all the specified frequency bands.

4.6. Corrections for Absorption.

The sound level in the receiving room will depend on, among other things, the absorptive qualities of the room. In order to prevent this factor from influencing the results, the figure L must be corrected for all standard frequency bands, and a *normalised impact sound level* (L_n arrived at.

L_n is adjusted to a reference absorption (A_0) of 10 m^2, so that

$$L_n = L + 10 \log_{10} \frac{A}{A_0}$$

where A is measured absorption in the receiving room, discussed further in Appendix B.

4.7. Assessing Improvements in Impact Sound Insulation.

The effect of laying additional material on top of existing floors can be investigated whenever it is possible to make measurements before and after treatment. Improvements, denoted by Δ L, may be quoted in the form of a graph covering all the standard frequency bands.

Any samples of floor covering placed under the tapping machine should be not less than about 1 m^2 in area. The I.S.O. recommend that floor coverings and also floating floors should be tested on a standard floor of reinforced concrete, 12 cm $\pm$ 2 cm thick.

4.8. Statement of Results.

The normalised octave band sound pressure levels should be given at all frequencies of measurement, preferably in the form of a graph, attached to which should be all the plan drawings and structural data necessary for intelligent interpretation of the results.

When the rubber faced hammers have been used, this must be explicitly stated in the report with the remark that the results so obtained are not directly comparable with those obtained when using standard hammers.

If the sound pressure level in any band is not measurable on account of background noise (acoustical or electrical), this should be stated, and the lower limit of measurement given.

Always state the estimated accuracy of the results.

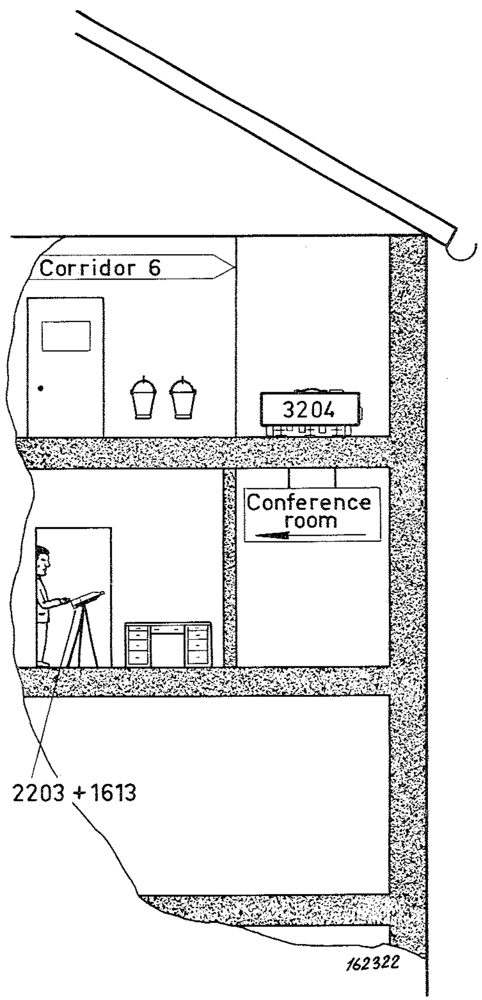


Fig. 10. Simple and reliable field measurements may be taken with this battery powered instrument system, mentioned in column 8 of Table 1.

5. Maintenance

5.1. General.

The mechanism of the 3204 does not require routine lubrication, but occasionally it should be partly dismantled, cleaned, and re-oiled. Providing the case is normally in position, servicing need only be carried out once every two years or every 500 running hours, whichever is the more frequent.

After removing the case (see section 3.1), the machine may be cleaned, if necessary using a little motor gasoline, or similar solvent. The following points must then be attended to:

5.2. Camshaft Bearings.

Take care not to wash the grease out of the ball races with solvent. After some years, the ball bearings should be repacked with grease such as Shell RB or Shell Retinax A.

5.3. Other Bearings.

Lubricate with S.A.E. 20 oil.

5.4. Chain.

Lubricate with S.A.E. 30 oil or a grease such as Shell Retinax A.

5.5. Cams.

Clean the cams, ensuring that the brass bosses run freely on their bearings, which should be lubricated with one or two drops of S.A.E. 30 oil. Wipe off all surplus oil and leave external surfaces dry.

5.6. Guide Rods and Hammers.

In order to clean these perfectly, it is advisable to remove the hammers. The retaining rod (see Fig. 1) may be slipped aside as soon as one of the two circlips holding it in place has been prised off. By turning the handwheel in the direction of the arrow, each hammer in turn may be released and withdrawn.

When the head has been separated from the hammer body (see section 3.5), both parts can easily be cleaned internally.

Lubricate the guide rod sparingly, using thin machine oil, and reassemble. Do not allow oil or grease to come in contact with the rubber parts.

These must be carefully cleaned should they be contaminated with lubricant.

5.7. Motor.

The synchronous motor must not be dismantled, but put a little S.A.E. 10 oil on the top and bottom bearings.

5.8. Worm Drive.

Lubricate with Shell Retinax A or other high pressure grease.

N.B. Do not over-lubricate: too much oil and grease only collect dust. Help to keep the dust out by not removing the case except when necessary.

Appendix A

Hammer Dynamics Considered in Detail.

The I.S.O. Recommendation allows a tolerance of ± 2½ % on the 4 cm effective hight of free fall for the hammers. The 3204 is operating within these limits even if the hammers are simply set to fall 4.0 cm, because the retarding forces have been kept to an absolute minimum. It is, however, worth while to consider the nature of the forces concerned and the manner in which it has been arranged that the mechanical characteristics shall be as exact as possible.

During the fall of a hammer, the following forces are acting upon it:

i) Gravity
ii) Friction on the guide rod
iii) Air resistance
iv) Force due to any pressure difference inside and outside the hammer

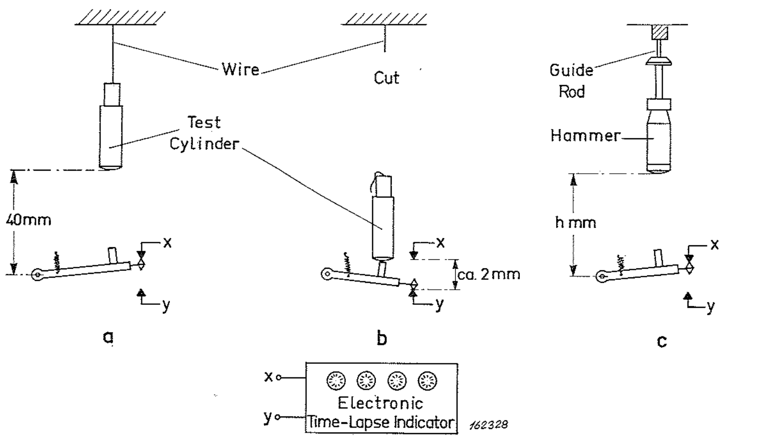


Fig. 11. Diagrams to show how B & K assessed and corrected for the effects of friction in the guide rods.
a) and b). A test cylinder of the same weight and cross-section as a hammer falls through the correct height without friction. The distance between the contacts is traversed in time t.
c). An actual hammer slides down its guide rod a height h such that the contacts are again switched in time t.

The last point is in fact entirely insignificant because

a) the volume change inside the hammer is small;
b) the cross-section of the guide rod is small, and this is the only area over which any pressure difference would be effective in lift; and
c) the bore of the bleed holes (see Fig. 2) is such that if a pressure difference were suddenly established, this would be equalized in about 3 μsec.

The air resistance forces are approximately proportional to velocity. Integration shows that the work done on the air represents only a few millionths of the impact kinetic energy. In any case, discrepancies here are not true errors as the I.S.O. specification presumably allows air resistance.

Any apparent retardation must be caused by friction forces. Although these are approximately independent of velocity, it is best to measure their effect dynamically, rather than attempt to make direct static measurements.

B & K's rig for these tests is sketched in Fig. 11. The height of fall of the hammer is adjusted until it carries the moving contact across the gap XY in exactly the same time as does the test cylinder when the latter makes a frictionless drop.

By this means, it has been found that in order to achieve the correct impact velocity, the hammers of the 3204 should fall through 4.10 cm.

Appendix B

Estimating Total Absorption in the Receiving Room.

As explained in section 4.6, it is important to know the total absorption in square meters (A) for the receiving room. This figure, which can be considered as the equivalent boundary area which is perfectly absorbing, may be deduced simply in two ways, and should always be found for all the recommended frequency bands.

From Reverberation Time.
This is the more reliable method and is based on Sabine's treatment of the energy transfer from oscillations in the air to losses in the absorbers. If

T = reverberation time in secs.,
V = volume of room in m^3,
S = area of room boundary in m^2,
a = mean absorption coefficient, and
A = total absorption as already defined,

then **A = Sa.**

It is found that

$$\ln\left(\frac{1}{1-a}\right) = 0.16\,\frac{V}{ST}$$

and if a is small, as is often the case, this reduces to

$$a = 0.16\,\frac{V}{ST}$$

The only problem here is to measure T. The analyzer and recorder are probably in the room already for the insulation measurements, and these instruments can be used to give curves showing the rate of sound decay. A sharp hand-clap or report from a pistol are useful sound sources but for accurate work a beat frequency oscillator (B & K type 1014) or a noise generator with filters (B & K types 1403 plus 1612) are needed to drive a loudspeaker. Details of reverberation time measurements are given in the manuals for the A.F. Spectrometer 2112 and for the Level Recorder 2305. Draft I.S.O. Recommendation No. 477 on "Measurement of Absorption Coefficients in a Reverberation Room" may also be helpful.

If it is not considered worth while going to the trouble of making such investigations, the total absorption can be roughly estimated by

The Direct Assessment Method.
The room boundaries consist of different substances, and there is a particular area S_1 of material with absorption coefficient α_1 %, etc. The necessary values of α can be found in Table 2 and A calculated from

$$100\,A = \alpha_1 S_1 + \alpha_2 S_2 + \ldots \alpha_n S_n.$$

TABLE 2

Absorption Coefficients in Percentage.

Material	Frequency c/s					
	125	250	500	1000	2000	4000
Rockwool, ord. 2.5 cm	5.8	19	39	54	59	75
Rockwool, ord. 10.0 cm	42	66	73	74	76	79
Glasswool, ord. loose, 10 cm	29	55	64	75	80	85
Glasswool, ord. loose, 6 cm	9.3	39	61	74	83	87
Cottonwool, loose, 17 cm	—	62	89	96	97	93
Felt, light, soft, 1.2 cm	1.6	4	10	21	57	92
Axminster carpet	11	14	20	33	52	82
Carpet, 5 mm	4	—	15	—	52	—
Coco matting	9	—	17	—	30	—
Coco carpet	1.8	2	3.6	7.7	16	27
Cotton (0.5 kg/m^2) hanging at the wall	4	—	13	—	32	—
Cotton draped to 75 % of area	4	23	40	57	53	40
Cotton draped to 50 % of area	7	31	49	81	66	54
Velvet (0.6 kg/m^2) hanging against wall	5	—	35	—	38	—
Velvet 10 cm from wall	6	27	44	50	40	35
Velvet draped to half the area	14	35	55	72	70	65
Wood fibre board, ord. soft ¾"	8.5	13	16	30	35	35
Wood fibre, very soft, grooved ¾"	6	12	30	67	95	—
Wood fibre, 3-sheet, ½", soft	—	15	17	32	34	—
Wood concrete, 5.0 cm	—	9	18	45	66	—
Glasswool with paper, 9 cm	20	43	62	53	30	12
Parquet flooring on sand foundation	20	15	13	12	9.1	6
Parquet, teak, on joists	16	14	12	11	9	7
Floor boards, ord. varnished on beams	15	11	10	7	6	7
Parquet, ¾" hardwood in asphalt	4	4	7	6	6	7
Plywood, 6 mm, 10 cm glasswool	30	11	6.2	4.6	2.5	2
Plywood, 3 mm on 5 cm battens	20	28	26	9	12	11
Plywood, 3 mm, 5 cm air space	11	21	10	5.2	2.5	2
Laminated plate, 16 mm thick on 4 cm battens	18	12	10	9	8	7
Glass, large panes	18	6.2	4.1	3	2	1.8
Windows, ord. window glass	35	25	18	12	7	4

Continued overleaf.

TABLE 2 (*Continued*)
Absorption Coefficients in Percentage.

Material	Frequency c/s					
	125	250	500	1000	2000	4000
Timber board, 1″	—	16	13	10	5.6	5.6
Water	1	1	1	2	2	3
Concrete, hard, rendered, sound-space N	0.4	0.4	0.5	0.6	0.8	1.5
Concrete, painted in oils	1	1	1	2	2	2
Marble	1	—	1	—	2	—
Whitewash, ord. on brick wall	—	1.9	2.3	2.2	2.6	2.8
Distemper on wall	1	1	2	2	3	3
Wall, rendered	0.8	1.5	2.2	2.6	4.1	7.4
Wallpaper pasted on wall with newspaper underlay	2	—	4	—	7	—
Plastering, smooth	1.5	1.8	2	3	3.6	5.2
Linoleum, ¼″ thick on concrete	1	1.2	1.5	1.8	2.6	2.6
Cork squares on concrete	2	2.3	2.6	3.1	3.6	4
Rubber flooring on concrete	1.9	3.3	4	3.6	1.8	2
Ventilating apertures and the like	16	20	30	35	29	21

Reference:
P. V. Brüel: Sound Insulation and Room Acoustics:
Chapman and Hall, London.

Specification

Frequency: 10 impacts per second. Deviation determined only by mains frequency.

Impact Dynamics: Total weight of each hammer: 500 g ± 5 g.
Fall equivalent to free drop of 4.0 cm ± 0.1 cm.
Velocity at impact: 88.6 cm $sec.^{-1}$
Momentum at impact: 4.43×10^4 $g.cm.sec.^{-1}$.
Kinetic energy at impact: 1.96×10^6 $g.cm.^2.sec^{-2}$.
Theoreticaly generated sound power at 100 % radiation efficiency: 1.97 watts (whole machine).

Hammers: Cylindrical. Five in line, 10 cm between axis of each. Nickel plated brass bodies.

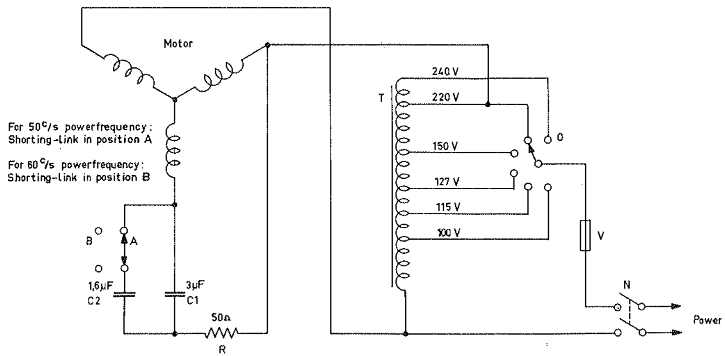
Hammer Heads: Stainless steel or I.S.O. specified rubber.
Diameter: 3 cm.
Face: spherical surface, 50 cm radius.

Dimensions: Height: 8″ (20 cm) cabinet only,
9½″ (24 cm) overall.
Length: 22″ (55 cm).
Width: 8″ (20 cm).
Weight: 35 lbs. (16 kg).

Power Consumption: 60 watts approx.

Power Line Frequency: Either 50 c/s or 60 c/s.

Power Line Voltage: 100 — 115 — 127 — 150 — 220 — 240 V.



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Brüel & Kjær
Copenhagen

Tapping Machine
Type 3204 P1

BD 3204/1