PHILIPS

DATA HANDBOOK

PHILIPS ELECTRONIC COMPONENTS AND MATERIALS

COMPONENTS AND MATERIALS

PART 4 APRIL 1971

Magnetic materials

Piezoelectric ceramics

COMPONENTS AND MATERIALS

Part 4 **April 1971**

Comprehensive contents list at the back

DATA HANDBOOK SYSTEM

To provide you with a comprehensive source of information on electronic components, subassemblies and materials, our Data Handbook System is made up of three series of handbooks, each comprising several parts.
The three series, identified by the colours noted, are:

ELECTRON TUBES (9 parts) BLUE

SEMICONDUCTORS AND INTEGRATED CIRCUITS (5 parts) RED

COMPONENTS AND MATERIALS (5 parts) GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued annually; the contents of each series are summarized on the following pages.
We have made every effort to ensure that each series is as accurate, comprehensive and up-to-date as possible, and we hope you will find it to be a valuable source of reference. Where ratings or specifications quoted differ from those published in the preceding edition they will be pointed out by arrows. You will understand that we can not guarantee that all products listed in any one edition of the handbook will remain available, or that their specifications will not be changed, before the next edition is published. If you need confirmation that the pusblished data about any of our products are the latest available, may we ask that you contact our representative. He is at your service and will be glad to answer your inquiries.

January 1970

ELECTRON TUBES (BLUE SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 — **January 1971**

Transmitting tubes (Tetrodes, Pentodes)
Associated accessories

Part 2 — **March 1971**

Tubes for microwave equipment

Part 3 — **March 1970**

Special Quality tubes
Miscellaneous devices

Part 4 — **April 1971**

Receiving tubes

Part 5 — **May 1971**

Cathode-ray tubes
Photo tubes
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Associated accessories

Part 6 — **June 1970**

Photomultiplier tubes
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Radiation counter tubes
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Associated accessories

Part 7 — **July 1970**

Voltage stabilizing and reference tubes
Counter, selector, and indicator tubes
Trigger tubes
Switching diodes
Thyratrons
Ignitrons
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Part 8 — **August 1970**

T.V. Picture tubes

Part 9 — **January 1971**

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SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 Diodes and Thyristors **September 1970**

General
Signal diodes
Tunnel diodes
Variable capacitance diodes
Voltage regulator diodes
Rectifier diodes
Thyristors, diacs, triacs
Rectifier stacks
Accessories
Heatsinks

Part 2 Low frequency; Deflection **October 1970**

General
Low frequency transistors (low power)
Low frequency power transistors
Deflection transistors
Accessories

Part 3 High frequency; Switching **November 1970**

General
High frequency transistors
Switching transistors
Accessories

Part 4 Special types **December 1970**

General
Transmitting transistors
Microwave devices
Field effect transistors
Dual transistors
Microminiature devices for thick- and thin-film circuits
Beam lead devices for thick- and thin-film circuits
Photo devices
Accessories

Part 5 Integrated Circuits **March 1971**

General
Digital integrated circuits
- DTL (FC family)
- TTL (FJ family)
- MOS (FD family)

Linear integrated circuits

COMPONENTS AND MATERIALS (GREEN SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 Circuit Blocks, Input/Output Devices — September 1970

Circuit blocks 100 kHz Series
Circuit blocks 1-Series
Circuit blocks 10-Series
Circuit blocks 20-Series
Circuit blocks 40-Series
Counter modules 50-Series
Norbits 60-Series, 61-Series
Circuit blocks 90-Series
Circuit blocks for ferrite core memory drive
Input/output devices

Part 2 Resistors, Capacitors — December 1970

Fixed resistors
Variable resistors
Non-linear resistors
Ceramic capacitors
Polyester, polycarbonate, polystyrene, paper capacitors
Electrolytic capacitors
Variable capacitors

Part 3 Radio, Audio, Television — February 1971

FM tuners
Coils
Piezoelectric ceramic resonators and filters
Loudspeakers
Audio and mains transformers
Television tuners
Components for black and white television
Components for colour television
Deflection assemblies for camera tubes

Part 4 Magnetic Materials, White Ceramics — April 1971

Ferrites for radio, audio and television
Ferroxcube potcores and square cores
Small coils, assemblies and assembling parts
Ferroxcube transformer cores
Piezoxide
Permanent magnet materials

Part 5 Memory Products, Magnetic Heads, Quartz Crystals, Microwave Devices, Variable Transformers, Electro-mechanical Components — June 1970

Ferrite memory cores
Matrix planes, matrix stacks
Complete memories
Magnetic heads
Quartz crystal units, crystal filters
Isolators, circulators
Variable mains transformers
Electro-mechanical components

April 1971

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Properties of manganese zinc and nickel zinc ferrites

INTRODUCTION

The predominant feature of ferroxcube lies in its high resistivity that allows cores to be made of solid material without the eddy current losses becoming prohibitively high, even if the cores are used in the megacycle range.
Compared with powder-iron, the permeability of ferroxcube is high, whereas the losses remain comparatively low.

Ferroxcube cores are available in convenient shapes such as potcores, square cores* , E- and I-cores, X-cores, toroids, U-cores, aerial rods, yoke rings, screw cores, rods and tubes.
Potcores, E-I cores and X cores enable well-defined air gaps to be used without introducing appreciable stray fields. In this way the permeability of the material may be reduced to an effective value at which core and copper losses are matched. The dependence of the permeability on temperature and time is furthermore reduced to values that guarantee correct operation of the equipment.

This section contains comprehensive data on manganese zinc ferrites (ferroxcube 3) and nickel zinc ferrites (ferroxcube 4) and their various grades. The latter material in general shows higher specific resistance values, lower values of permeability and saturation flux density, higher coercivities and higher Curie points.

APPLICATION

grade	application
3B	potcores, cores for small coils
3B3	frames for i.f. transformers, potcores, rods, screw cores
3B5	potcores
3B7	potcores and square cores
3C1	erasing heads
3C2	yoke rings, L-cores, erasing heads
3C6	E- and U-cores
3C8	U- and I-cores, E-cores
3D3	potcores, square cores, screw cores
3E1	E- and I-cores, toroids, potcores
3E2	H-cores and toroids
3E3	toroids
3H1	potcores, square cores, small toroids, cross cores, erasing heads

*) Square cores actually are square potcores.

grade	application
4A3	aerial rods
4A4	frames for i.f. transformers
4B1	aerial rods, frames for i.f. transformers
4C1	rods and tubes
4C6	potcores, square cores, toroids, frames for i.f. transformers
4D1, 4D2, 4E1	frames for i.f. transformers, screw cores, tubes and rods
4H1 4L1 4L2 4MX	These are special-purpose NiZn ferrites developed for one type of application, namely resonant cavities for particle accelerators. In this field, usually a technical discussion is necessary before the correct material can be determined.

SYMBOLS

l_e — effective length of the magnetic path in cm

A_e — cross-section of a homogeneous part of a core in cm^2

μ_i — relative initial permeability, defined by:

$$\mu_i = \frac{1}{\mu_0} \lim_{H \to 0} \frac{B}{H}$$

μ_Δ — relative incremental permeability, defined by:

$$\mu_\Delta = \frac{1}{\mu_0} \frac{\Delta B}{\Delta H}$$

μ_a — relative amplitude permeability, defined by:

$$\mu_a = \frac{1}{\mu_0} \frac{B}{H}$$

μ_e — relative effective permeability, defined by:

$$\mu_e = \frac{\Sigma \frac{l_e}{A_e}}{\Sigma \frac{l_e}{\mu_i A_e}}$$

V_e — effective volume of a core in cm^3 = volume of an ideal toroid in the same material grade and with the same magnetic properties as the core. V_e is calculated from:

$$V_e = \frac{\left(\Sigma \frac{l_e}{A_e}\right)^3}{\left(\Sigma \frac{l_e}{A_e^2}\right)^2} \text{ cm}^3$$

$T.F. = \frac{1}{\mu^2} \frac{d\mu}{dT}$ — temperature factor =

value for a certain ferroxcube material over a certain temperature range. In order to calculate the temperature coefficient per deg C of a coil the temperature factor has to be multiplied by the effective permeability.

So $\quad t.c. = \frac{\Delta\mu}{\mu_i} \times \frac{\mu_e}{\mu_i} = \frac{\Delta\mu}{\mu_i^2} \times \mu_e$ per deg C

D.F. $= \dfrac{\mu_1 - \mu_2}{\mu_1^2 \log \frac{t_2}{t_1}}$	disaccommodation factor, which gives the permeability variation, measured between 10 and 100 minutes after demagnetisation.
Curie point	critical temperature in $^{\circ}$C above which the ferromagnetic body is paramagnetic.
$\dfrac{\tan\delta}{\mu_i}$	constant for eddy current and residual losses together at a certain frequency, determined at $\hat{B} \leq 1$ gauss through the coil. The resulting R/L value for eddy current and residual losses is: $\frac{R}{L} = \frac{\tan\delta}{\mu_i} \times \mu_e \times 2\pi f$ Ω/H (f in Hz)
q2-24-100	constant for hysteresis losses standardised for an effective volume of 24 cm^3, $\mu_e = 100$ and measured between two currents, corresponding with two B_{max} values.

At 800 Hz for a given volume V_e and for an effective permeability μ_e, we obtain:

$$q_{2\text{-}V\text{-}\mu} = q_{2\text{-}24\text{-}100} \times \left(\frac{\mu_e}{100}\right)^{3/2} \times \sqrt{\frac{24}{V_e}}\ \Omega/\mathrm{H}^{3/2}\ \mathrm{mA}$$

$$\frac{R_h}{L} = q_{2\text{-}V\text{-}\mu} \times \sqrt{L} \times i \times \frac{f}{800}\ \Omega/\mathrm{H}$$

(L in henry, f in Hz and i in mA)

ϱ	specific resistance in Ω cm measured with d.c. current
ϵ	dielectric constant

1 Gs $= 10^{-4}$ T $= 10^{-4}$ Wb/m^2 $= 10^{-4}$ Vs/m^2

1 Oe $= \frac{10^3}{4\pi}$ A/m = 79.6 A/m = 0.796 A/cm

μ_0 = 1 Gs/Oe = 4 $.10^{-7}$ H/m

TECHNICAL DATA

	(approximate values)
Specific heat	0.17 (cal/g)/deg C
Thermal conductivity	8×10^{-3} (cal/cm.s)/deg C
Coefficient of linear expansion	10^{-5}/deg C
Modulus of elasticity	15 000 kg/mm^2 (15×10^4 N/mm^2)
Tensile strength	1.8 kg/mm^2 (18 N/mm^2)
Crushing strength	7.3 kg/mm^2 (73 N/mm^2)

	3B	3B3	3B5	3B7	3C1
μ_i	900 ± 20%	900 ± 20%	1400 ± 25%	2300 ± 20%	~900
B (Gs), ballistically measured, at H = 10 Oe, T = 20 °C T = 100 °C	~ 3450 ~ 2300			~ 4000	
$10^6 \times \frac{\tan \delta}{\mu_i}$ at 4 kHz at 100 kHz at 250 kHz at 450 kHz	 ≤ 50	≤ 7 ≤ 15 ≤ 27 ≤ 50	≤ 2.5 ≤ 10	≤ 1 ≤ 5	
$q_{2-24-100}$ (in $\Omega/H^{3/2}mA$) at 15-30 Gs and 4 kHz		≤ 12	≤ 2.5	≤ 1.8	
ϱ (in Ω.cm), measured with d.c. current	≥ 20	≥ 100	≥ 20	≥ 100	
10^6 x D.F. between 10 and 100 min after demagnetisation at 23 ± 1 °C	≤ 10	≤ 11	≤ 7.5	≤ 4.3	

Continued

	3B	3B3	3B5	3B7	3C1
T.F. (in 10^{-6}/deg C) at +23 to +55 °C	between 0 and +3	between 0 and +2	between +0.5 and +2.3		
at +23 to +70 °C				between −0.6 and +0.6 [1]	
Curie point (in °C)	≥ 150	≥ 150	≥ 150	≥ 170	≥ 150
Specific weight	4.7 - 4.9	4.7 - 4.9	4.7 - 4.9	4.7 - 4.9	4.7 - 4.9

The figures mentioned are valid for toroids of not too small dimensions. For cores of small dimensions and of different shapes translation of these figures in a straightforward way is not always possible.

[1]) Measured 10 min after demagnetisation.

	3C2	3C6	3C8	3D3	3E1	3E2	3E3	3H1
μ_i	900 ± 25%			750 ± 20%	2700 ± 20% 1)	≥ 5000 2)	≥ 10^4 3)	2300 ± 20%
B (in Gs), ballistically measured, at H = 10 Oe, T = 23 °C	~ 3500			~ 3500	~ 3500	~ 4200	~ 4000	~ 3400
T = 70 °C						~ 3400	~ 3000	
T = 100 °C	~ 2450							
at H = 2.5 A/cm, T = 100 °C		≥ 2900	≥ 3300					
$10^6 \times \frac{\tan\delta}{\mu_i}$ at 4 kHz					≤ 2.5	≤ 2.5	≤ 2.5	≤ 1
at 50 kHz							≤ 20	
at 100 kHz				≤ 8	≤ 15	≤ 15	≤ 50	≤ 5
at 500 kHz				≤ 14	≤ 90	≤ 90		
at 1000 kHz				≤ 30				
Core losses (in mW/cm^3), measured with a.c. current of 16 kHz, at B = 2000 Gs, → T = 25 °C		≤ 170	≤ 110					
T = 50 °C		≤ 160						
T = 100 °C		≤ 140	≤ 100					

Continued

	3C2	3C6	3C8	3D3	3E1	3E2	3E3	3H1
$q_{2\text{-}24\text{-}100}$ (in $\Omega/H^{3/2}mA$)								
at 15-30 Gs and 4 kHz					≤ 4	≤ 1.8	≤ 1.8	≤ 1.8
at 3-12 Gs and 100 kHz				≤ 3				
ϱ (in Ω.cm), measured with d.c. current	≥ 10			≥ 150	≥ 30	≥ 10	≥ 5	≥ 100
10^6 x D.F., between 10 and 100 min after demagnetisation at 23 ± 1 °C				≤ 12	≤ 6	≤ 1.9	≤ 1.9	≤ 4.3
T.F. (in 10^{-6}/deg C)								
at +5 to +23 °C								between +0.5 and +1.5 4)
at +23 to +55 °C	between 0 and +4.5				between 0 and +4			between +0.5 and +1.5 4)
at +23 to +70 °C				between 0 and +2 4)				between +0.5 and +1.5 4)5)
Curie point (in °C)	≥ 150	≥ 190	≥ 200	≥ 150	≥ 125	≥ 130	≥ 125	≥ 130
Specific weight	4.7-4.9	4.8-4.9	4.8-4.9	4.5-4.9	4.7-4.9	4.7-4.9	4.8-4.95	4.7-4.9

The figures mentioned are valid for toroids of not too small dimensions. For cores of small dimensions and of different shapes translation of these figures in a straight forward way is not always possible.

1) For data on an improved 3E1 grade see page A16.
2) At +23 to +70 °C.
3) At +10 to +70 °C.
4) Measured 24 hours after demagnetisation.
5) **For guidance only.**

		4A3	4A4	4B1	4C1
μ_i		450 ± 20%	500 ± 20%	250 ± 20%	125 ± 20%
B (in Gs), ballistically measured,					
H = 10 Oe, T = 20 °C			approx. 2700		
T = 70 °C			approx. 2100		
H = 20 Oe, T = 20 °C				approx. 3250	
T = 100 °C				approx. 2600	
H = 25 Oe, T = 20 °C					
T = 70 °C					
H = 30 Oe, T = 20 °C					approx. 2750
T = 70 °C					
T = 100 °C					approx. 2450
$\frac{\tan\delta}{\mu_i}$					
at 500 kHz			$\leq 30 \times 10^{-6}$		
at 700 kHz				$\leq 70 \times 10^{-6}$	
at 1 MHz				$\leq 90 \times 10^{-6}$	
at 1.5 MHz		$\leq 40 \times 10^{-6}$	$\leq 40 \times 10^{-6}$	$\leq 140 \times 10^{-6}$	
at 2 MHz		$\leq 70 \times 10^{-6}$	$\leq 70 \times 10^{-6}$		$\leq 120 \times 10^{-6}$
at 3 MHz					$\leq 160 \times 10^{-6}$
at 5 MHz					$\leq 300 \times 10^{-6}$

Continued

		4A3	4A4	4B1	4C1
$q_{2-24-100}$ (in $\Omega/H^{3/2}mA$) at 100 kHz, B = 3-12 Gs			≤ 3		
ρ (in Ω.cm), measured with d.c. current		$\geq 10^5$	$\geq 10^5$	$\geq 10^5$	$\geq 10^5$
ϵ at 11 MHz at 10 and 20 MHz			15-20		
D.F. between 10 and 100 min. after demagnetisation at 23 $\pm$ 1			$\leq 5\times10^{-6}$		
T.F. between +23 and +55 ^{o}C				between 0 and $+8\times10^{-6}$/degC	between 0 and $+12\times10^{-6}$/degC
+23 and +70 ^{o}C			between +5 and $+15\times10^{-6}$/degC*		
Curie point in ^{o}C		≥ 125	≥ 125	≥ 250	≥ 350
Specific weight		4.7 - 5.1	4.7 - 5.1	4.4 - 4.8	4.2 - 4.6

The figures mentioned are valid for toroids of not too small dimensions. For cores of small dimensions and of different shapes translation of these figures in a straight forward way is not always possible.

* Measured 24 hours after demagnetisation

	4C6	4D1	4D2	4E1
μ_i	120 ± 20%	50 ± 20%	60 ± 5%	15 ± 20%
B (in Gs), ballistically measured,				
H = 30 Oe, T = 20 °C	~ 3800			
T = 70 °C	~ 3500			
H = 40 Oe, T = 20 °C		~ 2400		
T = 100 °C		~ 2200		
H = 60 Oe, T = 20 °C				~ 1750
T = 100 °C				~ 1650
$10^6 \times \frac{\tan \delta}{\mu_i}$ at 1.5 MHz				
at 2 MHz	≤ 40			
at 3 MHz		≤ 180		
at 5 MHz		≤ 210		
at 10 MHz	≤ 100	≤ 300	≤ 100	≤ 300
at 20 MHz				≤ 300
at 25 MHz			≤ 200	
at 40 MHz			≤ 600	≤ 360
$q_{2-24-100}$ (in $\Omega/H^{3/2}mA$) at 100 kHz, B = 3-12 Gs	≤ 10			
ϱ (in Ω.cm), measured with d.c. current	≥ 10^5	≥ 10^5		≥ 10^5
ϵ at 1 MHz	10-15			
10^6 x D.F. between 10 and 100 min after demagnetisation at 23 and 70 °C	≤ 10			

Continued

	4C6	4D1	4D2	4E1
T.F. (in 10^{-6}/deg C)				
+5 and +55 °C				
+5 and +23 °C	between −2 and +4 *			
+23 and +55 °C	between 0 and +6 *	between 0 and +15		between 0 and +15
+23 and +70 °C			between 0 and +15	
Curie point (in °C)	≥ 350	≥ 400		≥ 500
Specific weight	4-5	4-4.4		3.5-4

The figures mentioned are valid for toroids of not too small dimensions. For cores of small dimensions and of different shapes translation of these figures in a straight forward way is not always possible.

* Measured 24 hours after thermal demagnetisation.

Improved grade 3E1

μ_i	3800 ± 20%
μ_i (T within 23 to +70 °C)	≥ 3040
B (in Gs), ballistically measured,	
at H = 10 Oe, T = 23 °C	~ 3800
at H = 10 Oe, T = 70 °C	~ 2800
$\frac{\tan \delta}{\mu_i} \times 10^6$ at 4 kHz	≤ 2.5
at 100 kHz	≤ 20
at 500 kHz	≤ 200
$q_{2-24-100}$ (in $\Omega/H^{3/2}mA$) at 4 kHz, measured between 15 and 30 Gs	≤ 3
ρ (in Ω.cm), measured with d.c. current	≥ 30
Curie point (in °C)	≥ 130
Specific weight	4.7-4.9

The figures are valid for toroids with dimensions 30 x 15 x 7.5 mm.

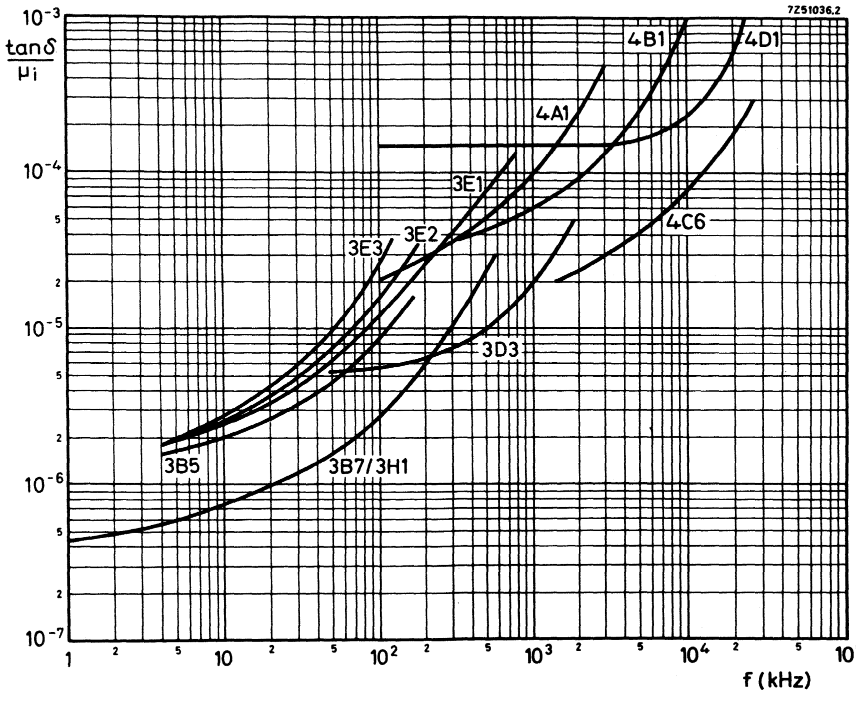
NiZn ferrites for resonant cavities

	4H1	4L1	4L2	4MX
Q80/Q~	0.9	0.7	0.7	0.8
μ_{rem}/μ_i	0.6-0.7	0.7-0.8	0.8-0.9	0.8-0.9
μ in remanent state (μ_{rem}) approx.	170	150	190	130
μQ in remanent state at 1.5 MHz, 50 Gs	21400	17800	21400	21800
at 1.5 MHz, 100 Gs	16000	14000	17000	20500
at 1.5 MHz, 150 Gs	12800	11200	14000	18800
at 1.5 MHz, 200 Gs	8600	9200	9700	14000
at 2.5 MHz, 50 Gs	15000	13000	17000	
at 2.5 MHz, 100 Gs	6000	7200	14500	
at 2.5 MHz, 150 Gs		5000	11000	
at 2.5 MHz, 200 Gs			8200	
at 5 MHz, 50 Gs	5000	10600	12000	19200
at 5 MHz, 100 Gs		4600	9700	16000
at 5 MHz, 150 Gs			6700	12500
at 5 MHz, 200 Gs			4500	5600
at 10 MHz, 50 Gs		4200		11200
at 10 MHz, 100 Gs				8200
at 10 MHz, 150 Gs				5600

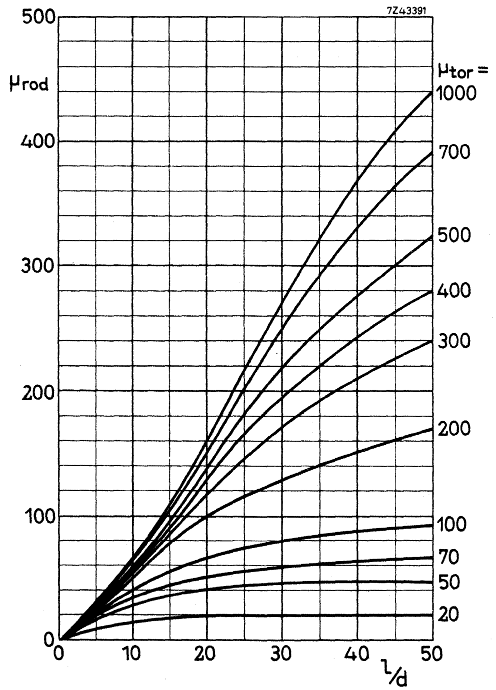
Q80/Q~ indicates the properties under pulse conditions.
Q80 is the quality factor 80 milliseconds after application of a continuous bias of approx. 50 oerstedts.
Q~ is the quality factor in the static state.
μ_{rem}/μ_i indicates the squareness of the hysteresis loop.

CHARACTERISTIC CURVES

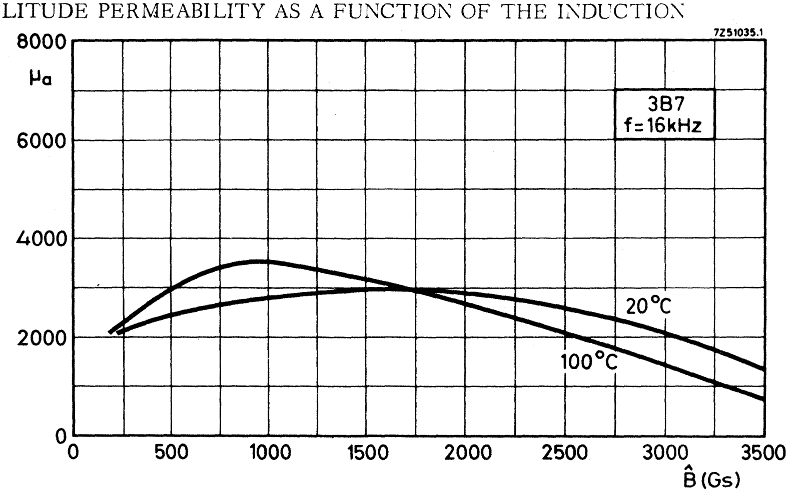
EDDY CURRENT LOSSES AND RESIDUAL LOSSES AS A FUNCTION OF THE FREQUENCY AT LOW INDUCTION LEVEL

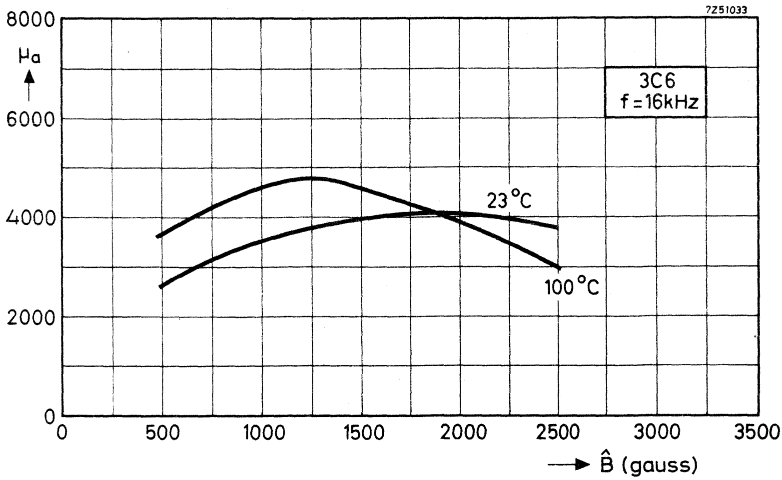


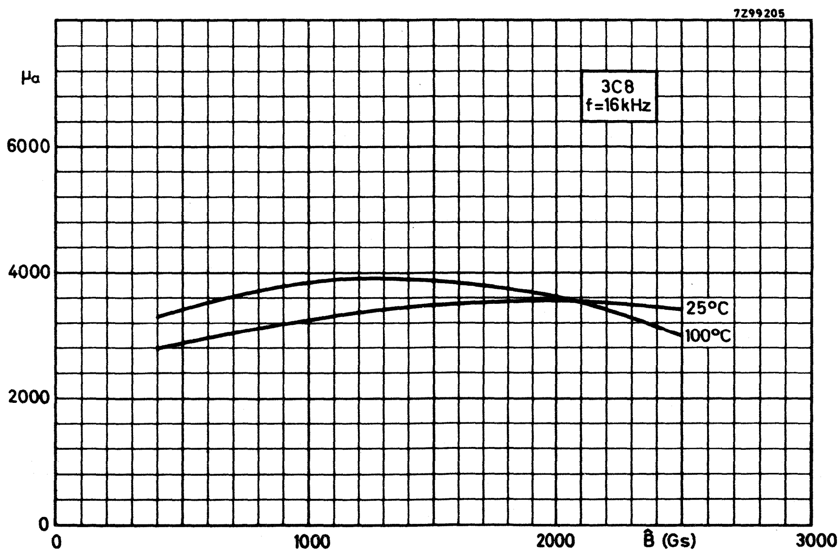
ROD PERMEABILITY AS A FUNCTION OF THE RATIO l/d WITH THE RELATIVE INITIAL PERMEABILITY OF A TOROIDAL CORE AS PARAMETER

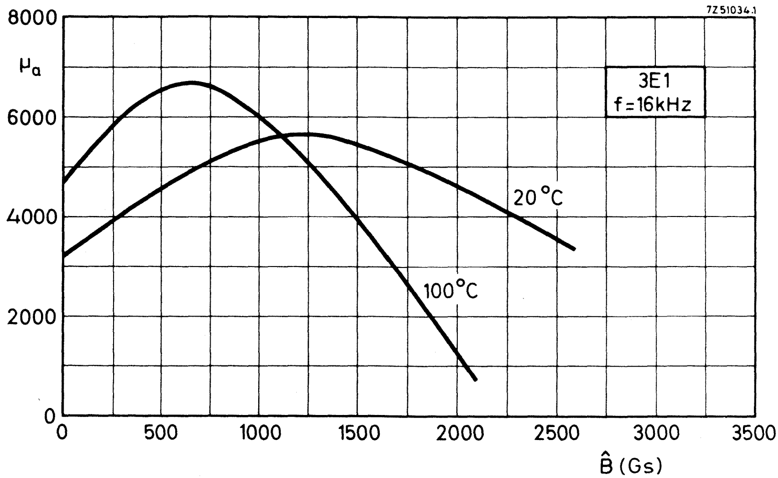


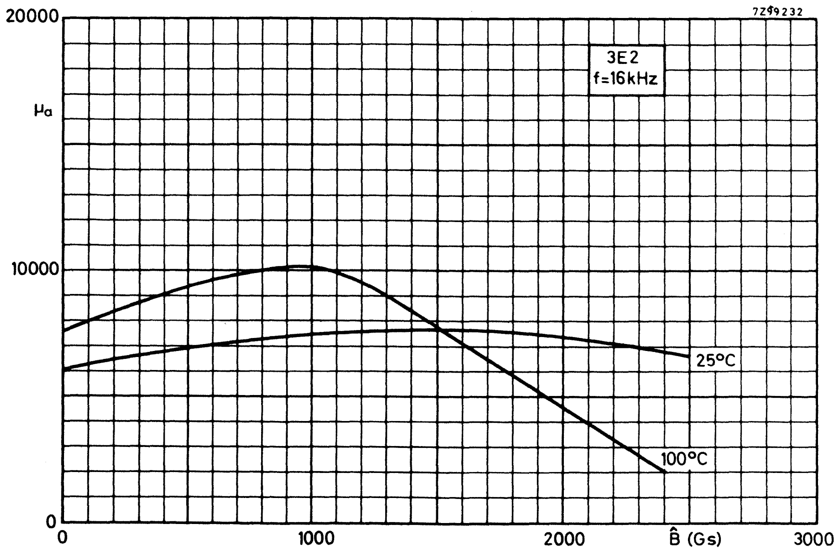
AMPLITUDE PERMEABILITY AS A FUNCTION OF THE INDUCTION

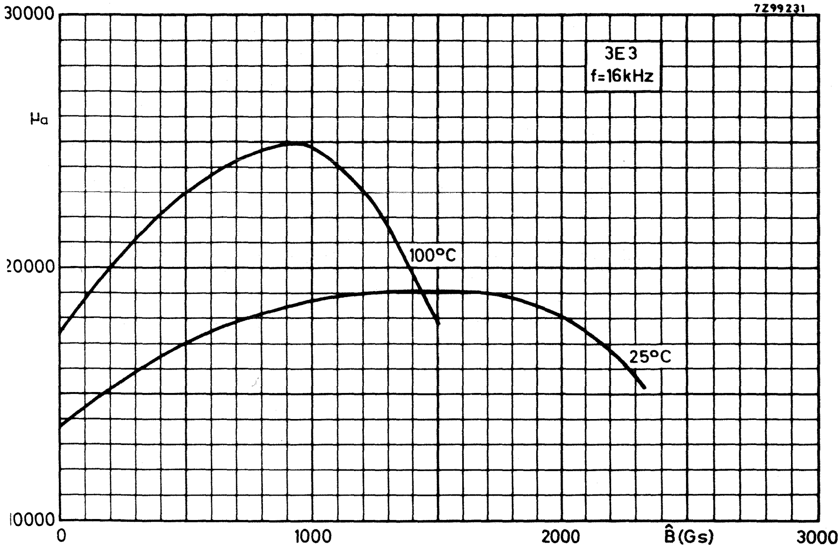


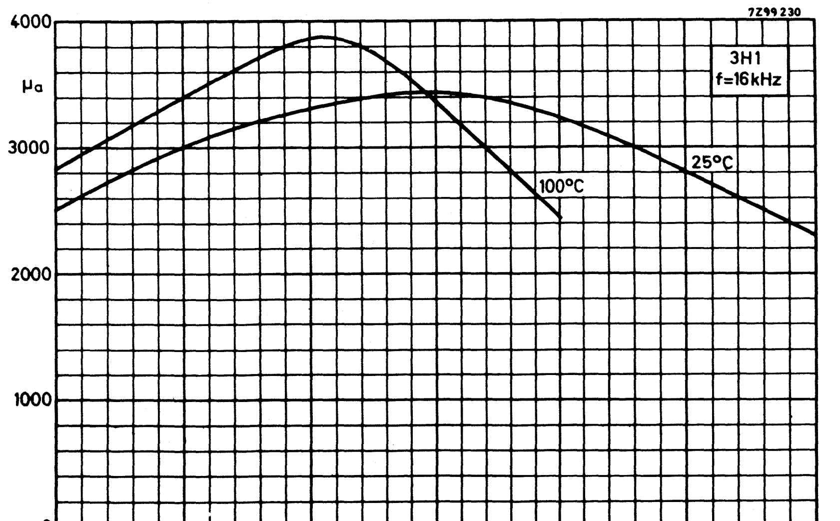

7Z51033
3C6
f = 16kHz
8000
μa
6000
4000
2000
0
0
500
1000
1500
2000
2500
3000
3500
23 °C
100 °C
B̂ (gauss)


7Z99205
3C8
f=16kHz
μa
6000
4000
2000
0
0
1000
2000
B̂ (Gs)
3000
25°C
100°C

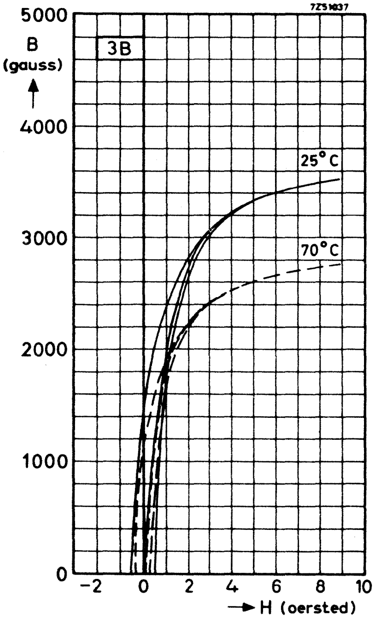

7Z51034.1
8000
μ_a
6000
4000
2000
0
0
500
1000
1500
2000
2500
3000
3500
$\hat{B}$ (Gs)
3E1
f=16kHz
20°C
100°C

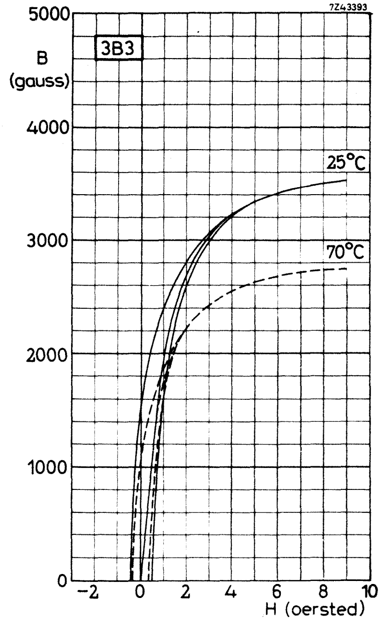

7Z99232
20000
μ_a
10000
0
0
1000
2000
3000
$\hat{B}$ (Gs)
3E2
f=16kHz
25°C
100°C

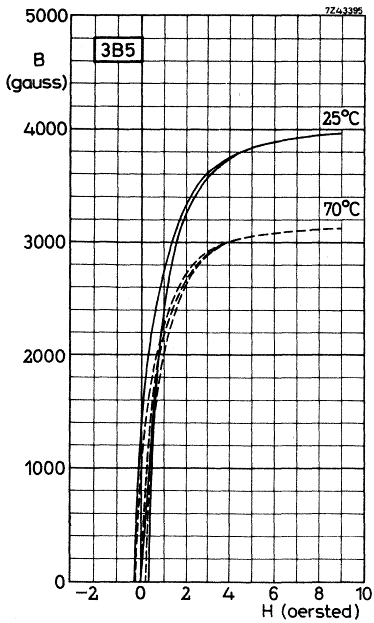

7Z99231
3E3
f=16kHz
30000
μ_a
20000
10000
100°C
25°C
0
1000
2000
$\hat{B}$(Gs)
3000

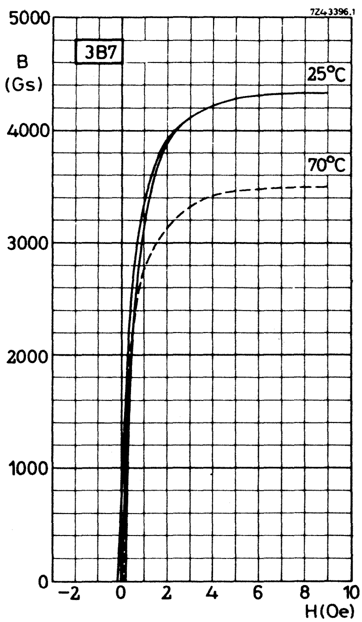

7Z99230
3H1
f=16kHz
4000
μ_a
3000
2000
1000
0
100°C
25°C
0
1000
2000
$\hat{B}$ (Gs)
3000

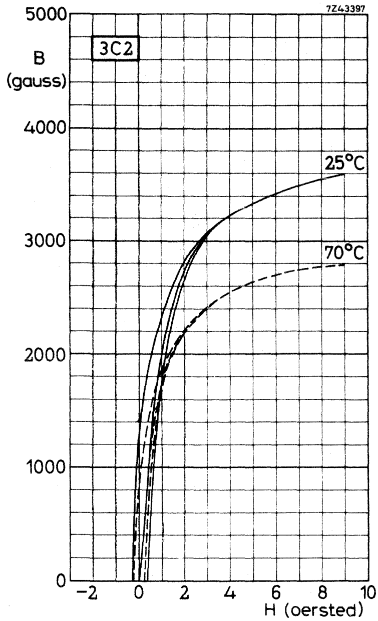
TYPICAL BH-CURVES (ballistically measured)

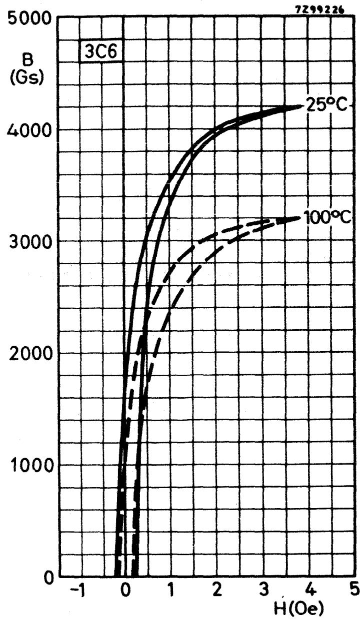


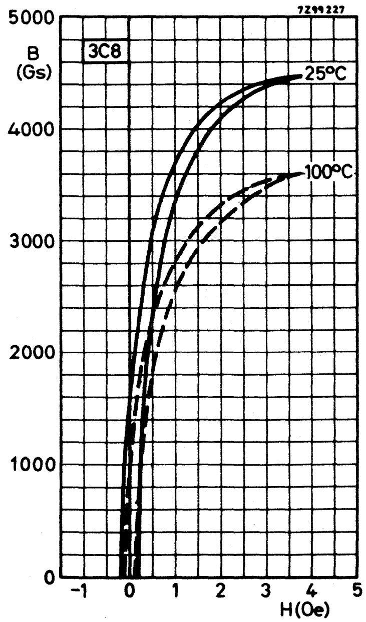


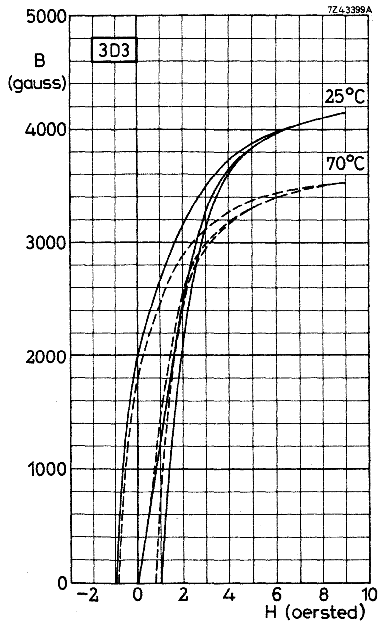


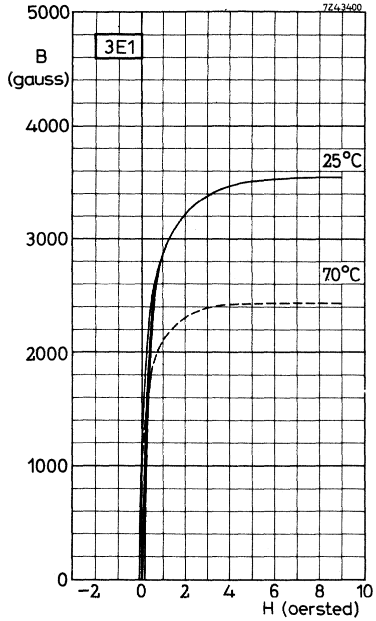


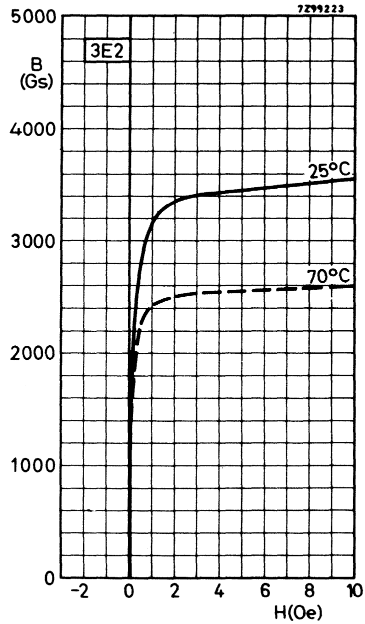

7Z43397
3C2
B
(gauss)
5000
4000
3000
2000
1000
0
25°C
70°C
−2
0
2
4
6
8
10
H (oersted)

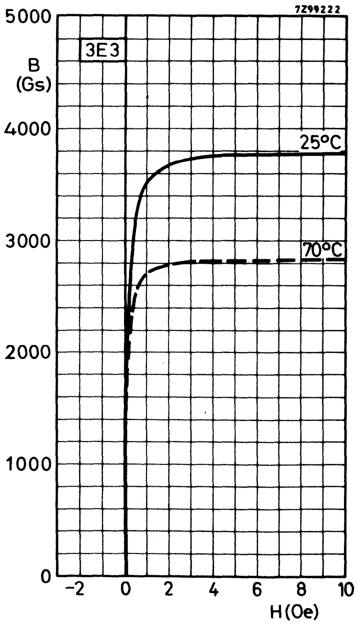

7Z99226
3C6
B
(Gs)
5000
4000
3000
2000
1000
0
25°C
100°C
−1
0
1
2
3
4
5
H(Oe)

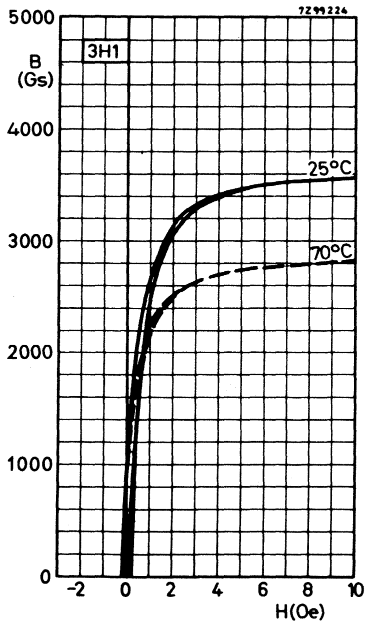

7Z99227
3C8
B
(Gs)
5000
4000
3000
2000
1000
0
25°C
100°C
−1
0
1
2
3
4
5
H(Oe)

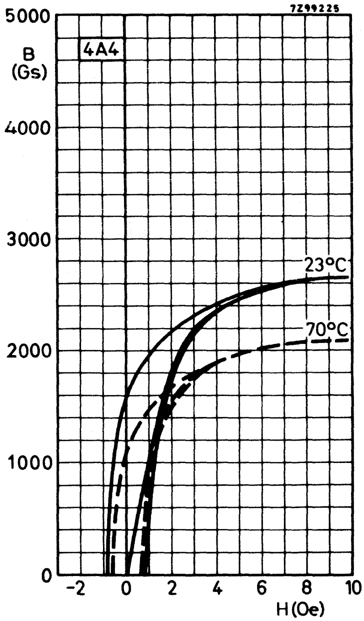

7Z43399A
3D3
B
(gauss)
5000
4000
3000
2000
1000
0
25°C
70°C
−2
0
2
4
6
8
10
H (oersted)

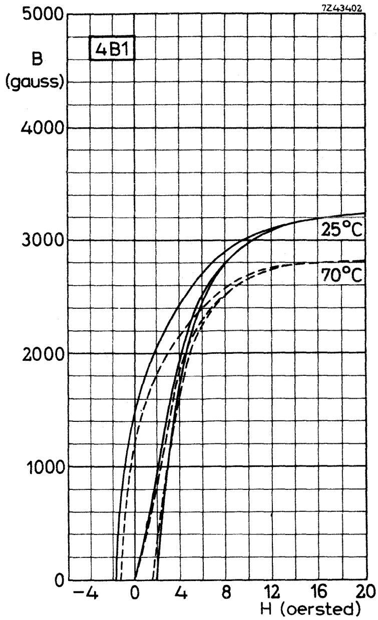

7Z43400
3E1
B (gauss)
5000
4000
3000
2000
1000
0
25°C
70°C
−2
0
2
4
6
8
10
H (oersted)

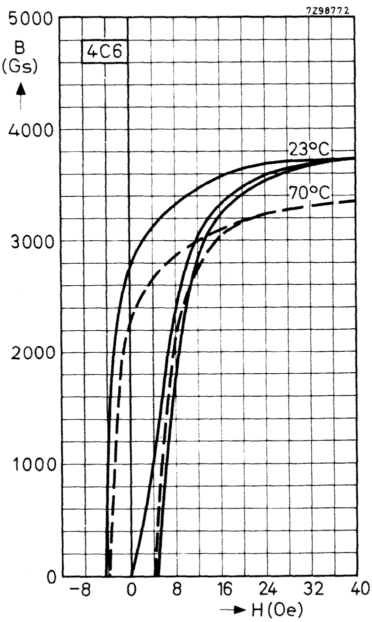

7Z99223
3E2
B (Gs)
5000
4000
3000
2000
1000
0
25°C
70°C
−2
0
2
4
6
8
10
H(Oe)

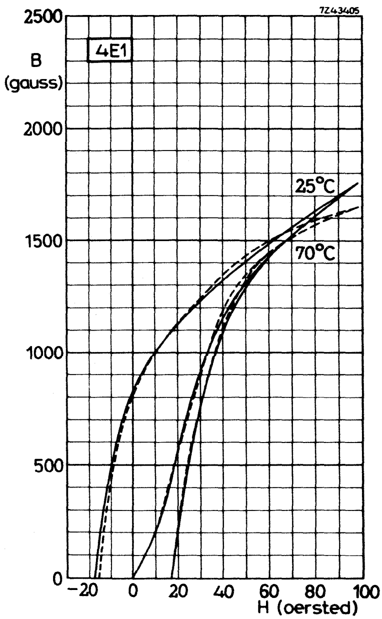

7Z99222
3E3
B (Gs)
5000
4000
3000
2000
1000
0
25°C
70°C
−2
0
2
4
6
8
10
H(Oe)


7Z99224
3H1
B (Gs)
5000
4000
3000
2000
1000
0
25°C
70°C
−2
0
2
4
6
8
10
H(Oe)

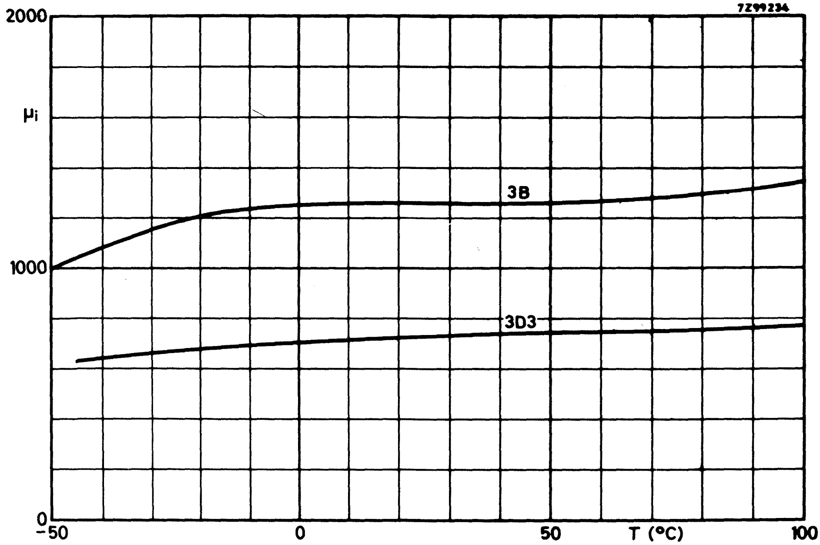

7Z99225
4A4
5000
B
(Gs)
4000
3000
2000
1000
0
23°C
70°C
-2
0
2
4
6
8
10
H (Oe)

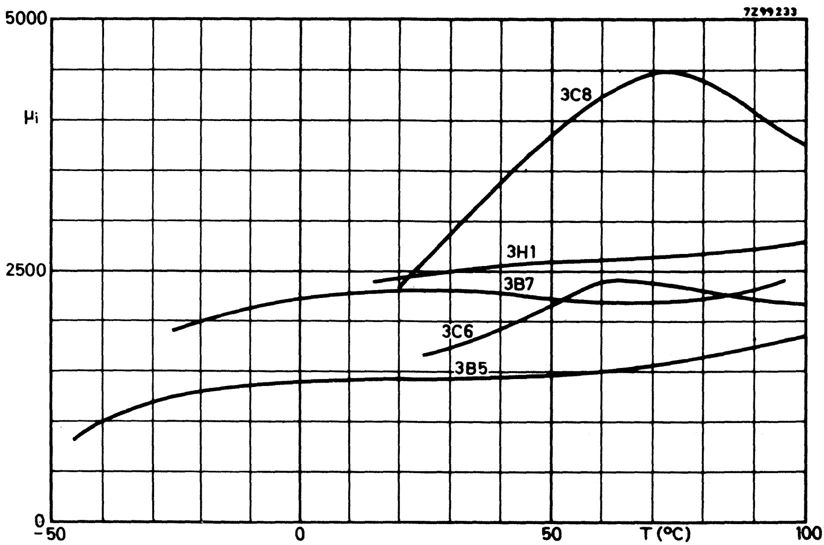

7Z43402
4B1
5000
B
(gauss)
4000
3000
2000
1000
0
25°C
70°C
−4
0
4
8
12
16
20
H (oersted)

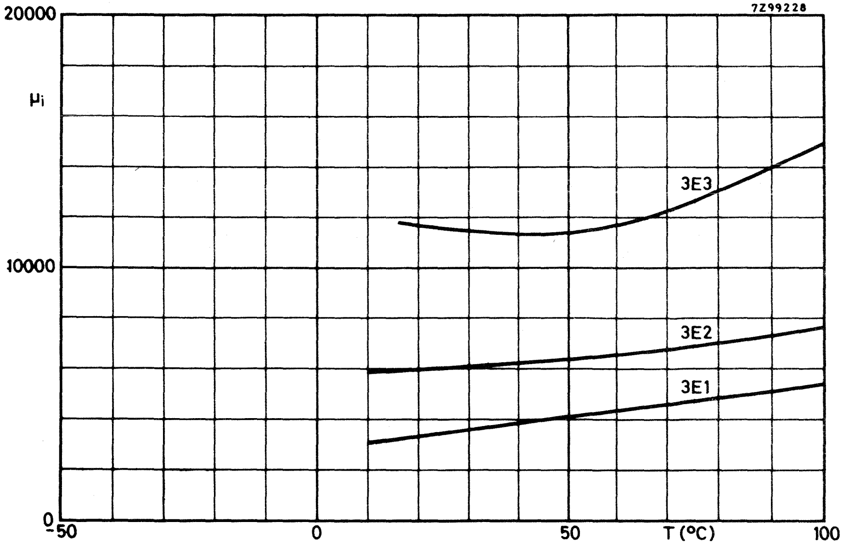

7Z98772
4C6
5000
B
(Gs)
4000
3000
2000
1000
0
23°C
70°C
−8
0
8
16
24
32
40
H (Oe)

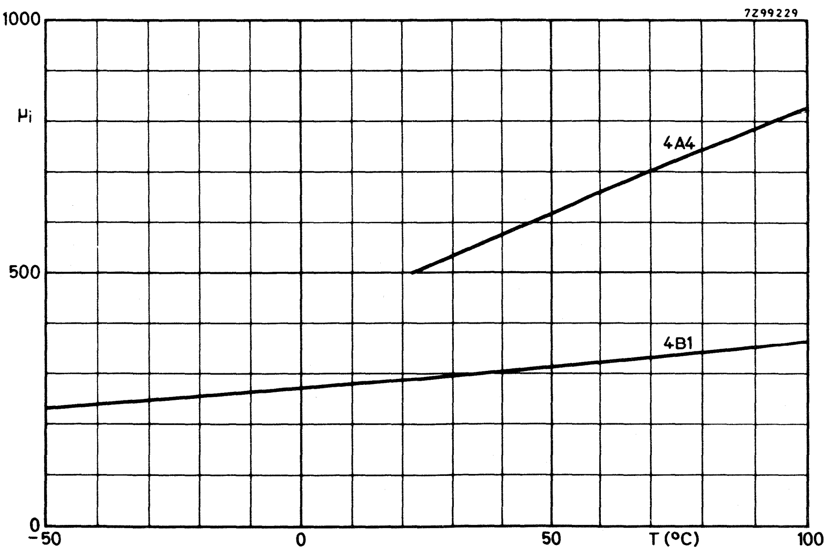

7Z43405
4E1
2500
B
(gauss)
2000
1500
1000
500
0
25°C
70°C
−20
0
20
40
60
80
100
H (oersted)

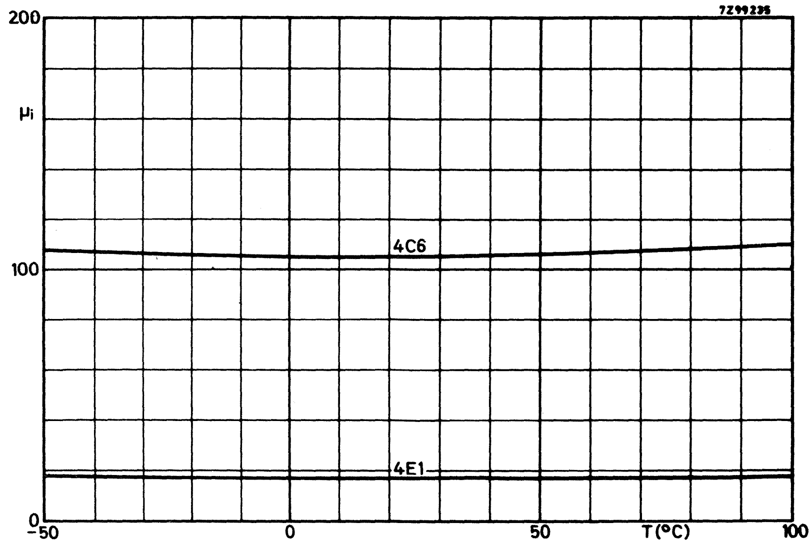
RELATIVE INITIAL PERMEABILITY AS A FUNCTION OF THE TEMPERATURE



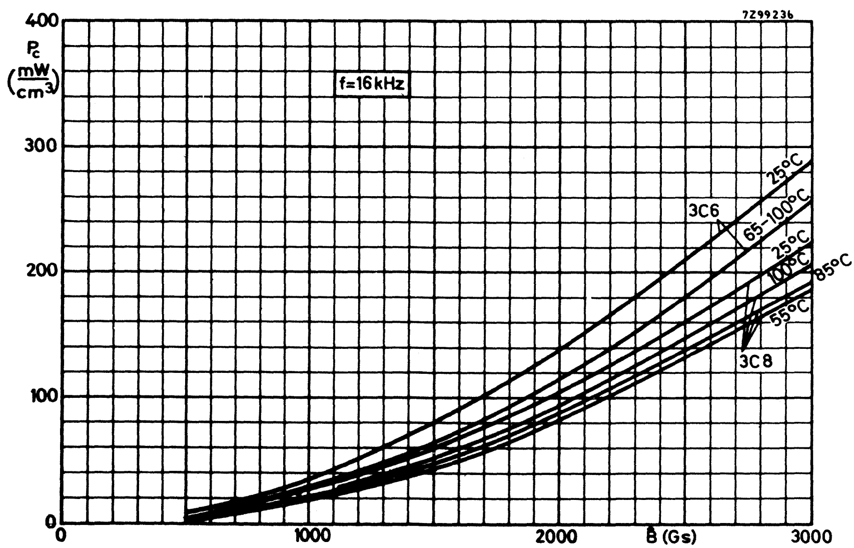


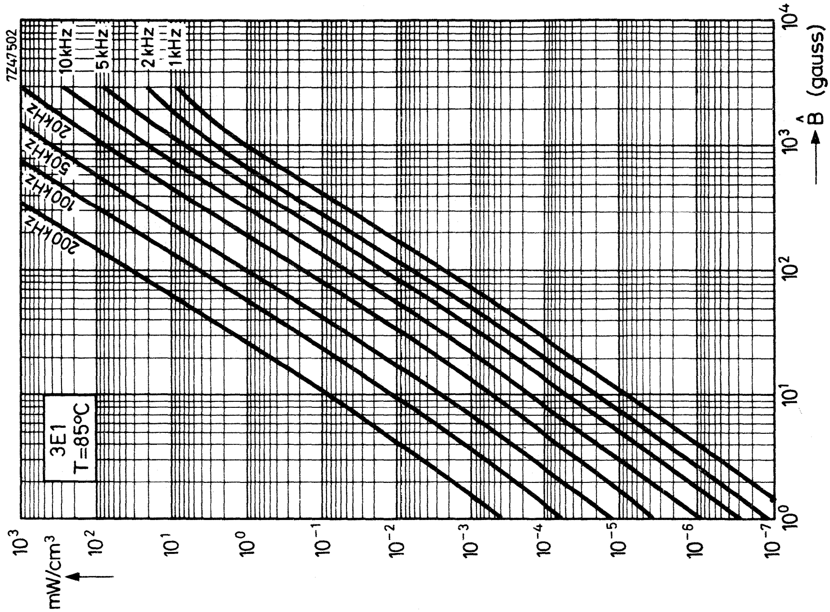

7Z99228
20000
μi
10000
0
-50
0
50
T (°C)
100
3E3
3E2
3E1

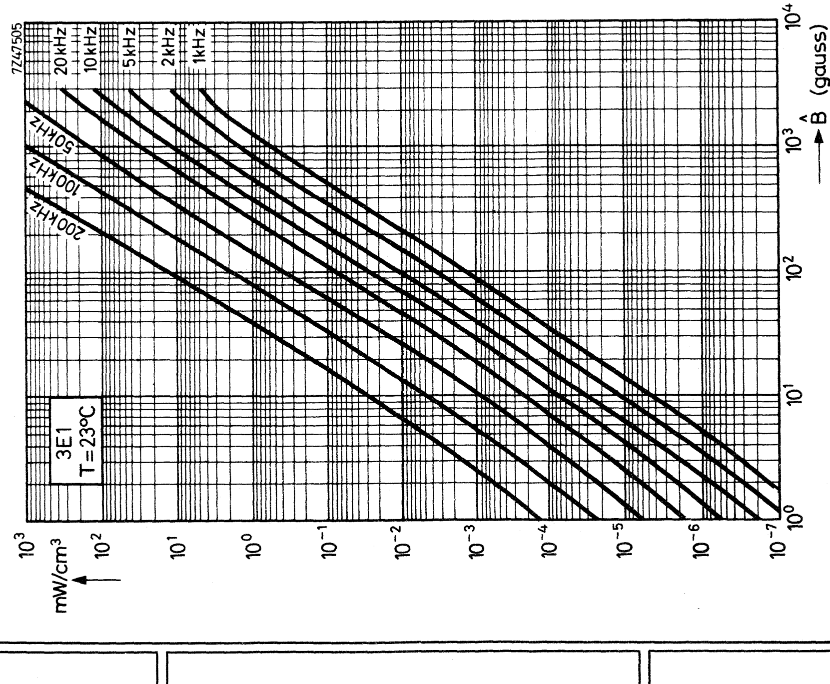

7Z99229
1000
μi
500
0
-50
0
50
T (°C)
100
4A4
4B1

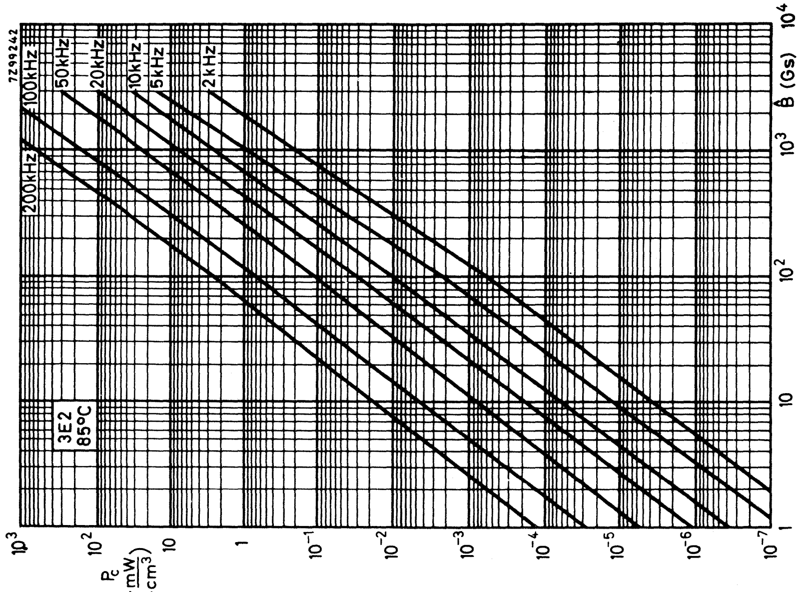


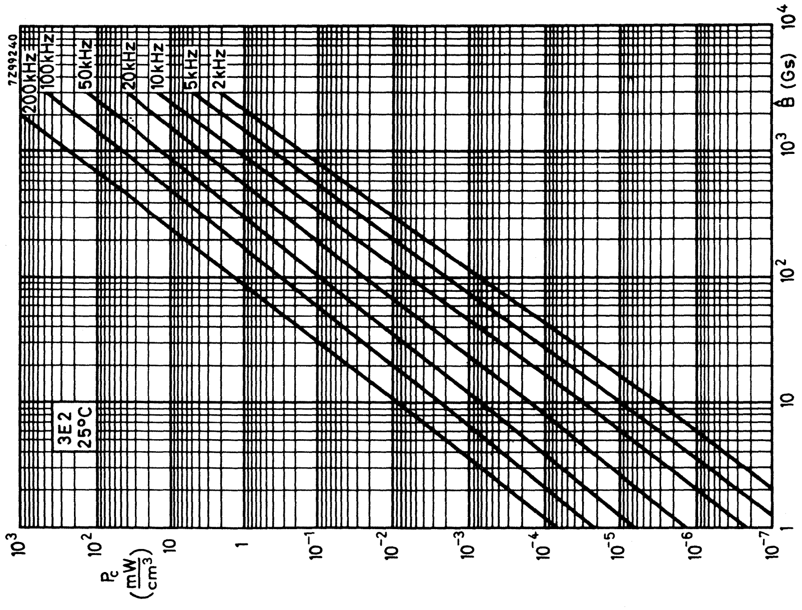
CORE LOSSES AS A FUNCTION OF THE INDUCTION

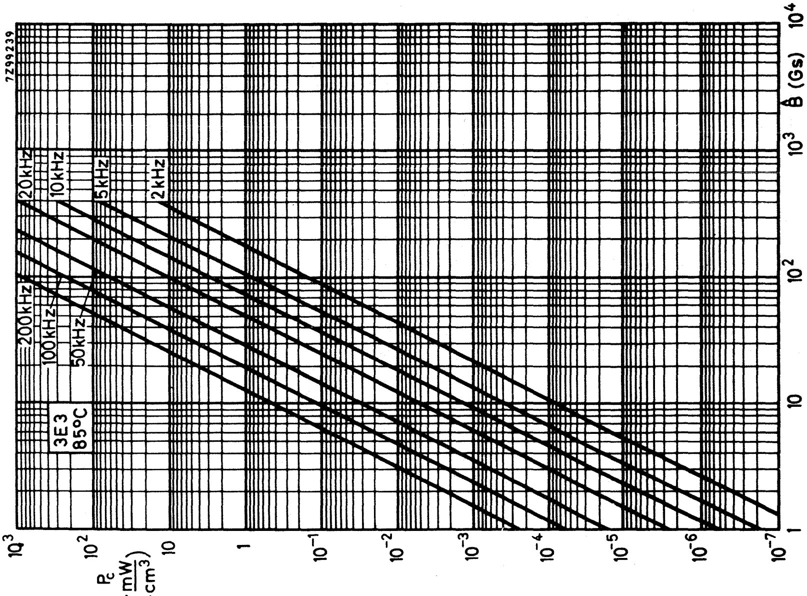


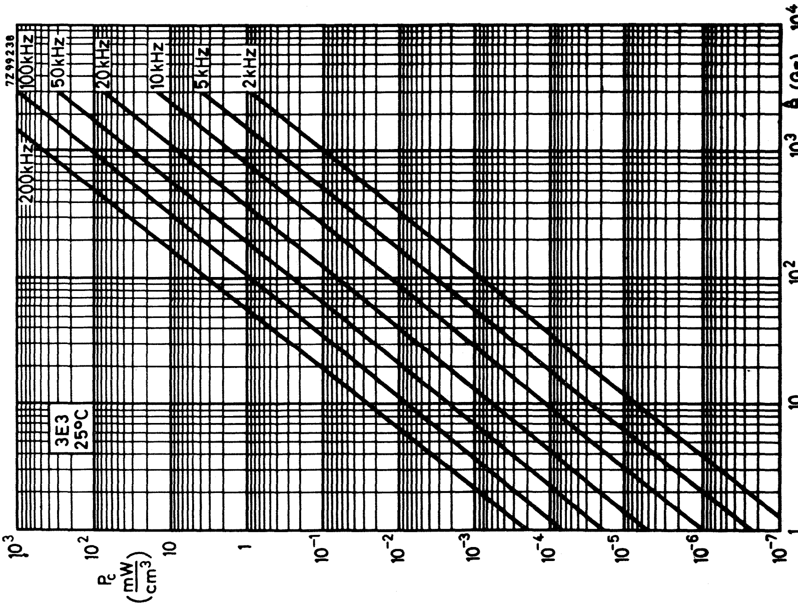

7Z47502
10kHz
5kHz
2kHz
1kHz
20kHz
50kHz
100kHz
200kHz
3E1
T=85°C
mW/cm³
B̂ (gauss)
10⁰
10¹
10²
10³
10⁴
10³
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷

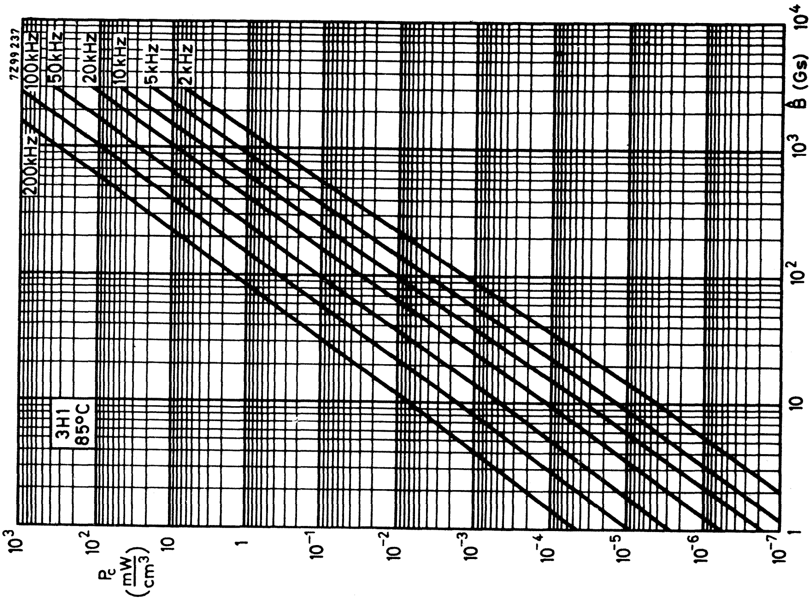

7Z47505
20kHz
10kHz
5kHz
2kHz
1kHz
50kHz
100kHz
200kHz
3E1
T=23°C
mW/cm³
B̂ (gauss)
10⁰
10¹
10²
10³
10⁴
10³
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷

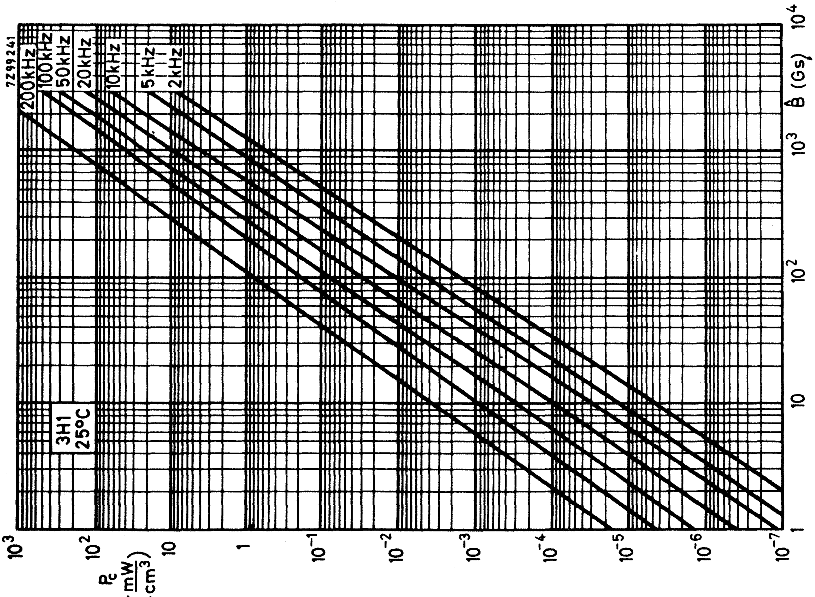

7Z99242
3E2
85°C
200kHz
100kHz
50kHz
20kHz
10kHz
5kHz
2kHz
B̂ (Gs)
Pc
(mW/cm3)
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7


7Z99240
3E2
25°C
200kHz
100kHz
50kHz
20kHz
10kHz
5kHz
2kHz
B̂ (Gs)
Pc
(mW/cm3)
10^4
10^3
10^2
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7

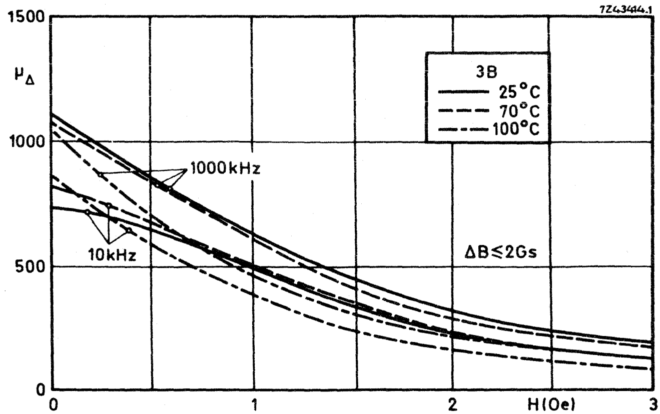

7299239
3E3
85°C
20kHz
10kHz
5kHz
2kHz
200kHz
100kHz
50kHz
P_c (mW/cm³)
B̂ (Gs)

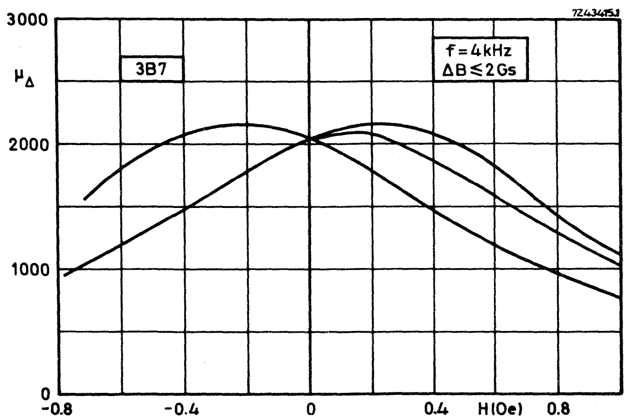

7299238
3E3
25°C
100kHz
50kHz
20kHz
10kHz
5kHz
2kHz
200kHz
P_c (mW/cm³)
B̂ (Gs)

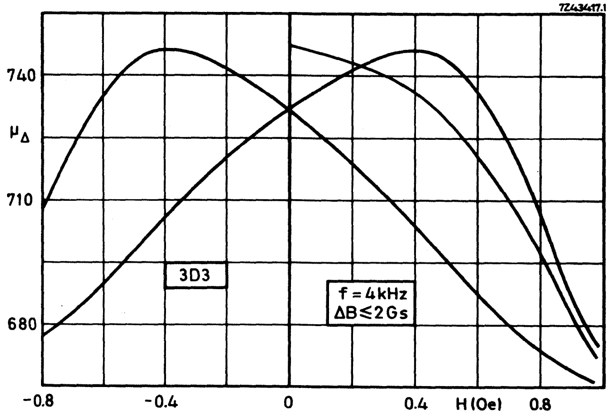

7299237
100kHz
50kHz
20kHz
10kHz
5kHz
2kHz
200kHz
3H1
85°C
B̂ (Gs)
Pc (mW/cm3)

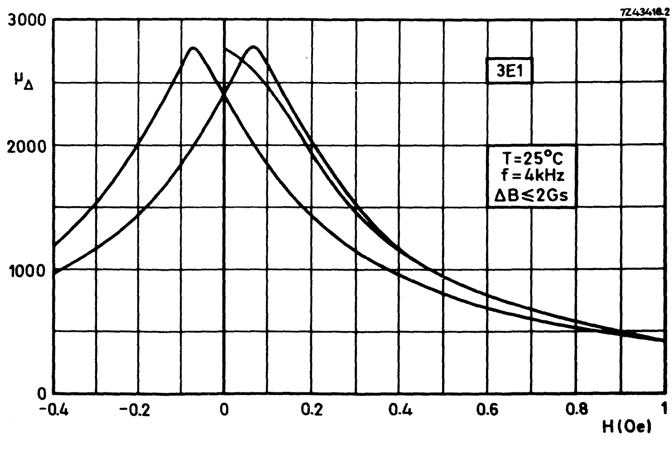

7299241
200kHz
100kHz
50kHz
20kHz
10kHz
5kHz
2kHz
3H1
25°C
B̂ (Gs)
Pc (mW/cm3)

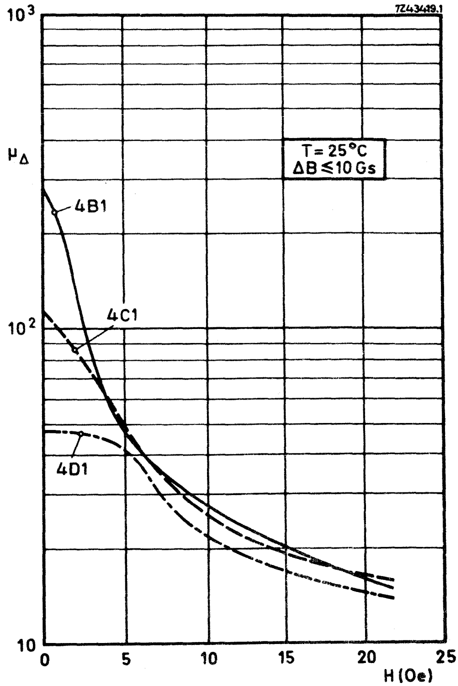
INCREMENTAL PERMEABILITY AS A FUNCTION OF THE FIELD STRENGTH






7Z43417.1
740
μ_Δ
710
680
3D3
f = 4kHz
ΔB≤2Gs
-0.8
-0.4
0
0.4
H (Oe)
0.8


7Z43418.2
3000
μ_Δ
2000
1000
0
3E1
T=25°C
f = 4kHz
ΔB≤2Gs
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
H (Oe)


7Z43419.1
10^3
μ_Δ
T = 25 °C
ΔB ≤ 10 Gs
4B1
4C1
10^2
4D1
10
0
5
10
15
20
25
H (Oe)

Ferrites for radio, audio and television

ANTENNA RODS AND PLATES

RZ 22938-2

RODS (standard types)

Grade 4A3 (for long wave and medium wave reception)

dimensions (mm)	catal. No.
(ϕ 10 - 0.5) x (240 - 7)	3122 104 93440
(230 - 7)	4311 020 53120
(220 - 6)	4311 020 52740
(210 - 6)	3122 104 93700
(200 - 6)	3122 104 93420
(190 - 6)	4311 020 53230
(180 - 6)	3122 104 93450
(170 - 6)	4311 020 52760
(160 - 5)	4311 020 52610
(150 - 5)	4311 020 52770
(140 - 5)	3122 104 93460
(130 - 5)	4311 020 52780
(120 - 4)	4311 020 53300
(100 - 4)	4311 020 52590

Grade 4A3 (continued)

dimensions (mm)	catal. No.
(ϕ 7.8 $\pm$ 0.2) x (190-6)	4311 020 52700
(160-5)	4311 020 54020
(140-5)	4311 020 52690
(130-5)	4311 020 52680
(100-4)	4311 020 52790
(ϕ 6.35 $\pm$ 0.2) x (130-5)	3122 104 94972
(110-4)	4311 020 53524
(100-4)	4311 020 52810

Grade 4B1 (for long wave and medium wave reception)

(dimensions (mm)	catal. No.
(ϕ 10 - 0.5) x (207 - 8)	3122 104 91250
(180 - 10)	4311 020 52240
(143 - 6)	3122 104 91240
(132 - 4)	4311 020 52230
(ϕ 9.8 - 0.6) x (207 - 8)	4311 020 52220
(164 - 8)	4311 020 52210
(103 - 6)	4311 020 52200
(ϕ8 - 0.4) x (207 - 8)	4311 020 52190
(204 - 8)	4311 020 50040
(143 - 6)	4311 020 50250
(102 - 4)	4311 020 52170
ϕ (6.55 - 0.4) x (168.5 - 7)	4311 020 52160

Measurements on typical antenna rods of 10 mm ϕ x 200 mm

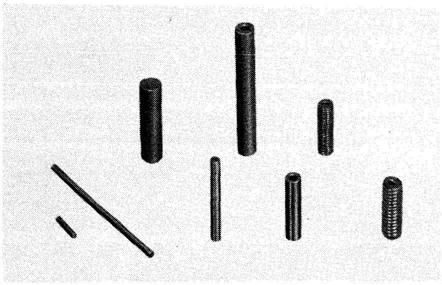
Material grade	4A3	4B1
Frequency	1	1
Inductance	200	200
Number of turns	40	44
Rod quality Q_o'	135	128
Effective height h	7.6×10^{-3}	6.6×10^{-3}
h^2	58×10^{-6}	44×10^{-6}
Sensitivity hQ_o'	1.02	0.86
Signal output h^2Q_o'	7.8×10^{-3}	5.63×10^{-3}

PLATES (standard types)

Grade 4B1 (for long wave and medium wave reception)

dimensions (mm)	catal. No.
(19 - 1) x (3.8 - 0.3) x (150 - 6)	4311 020 52410
x (125 - 5)	4311 020 52400
x (100 - 4)	4311 020 52390
x (75 - 3)	4311 020 52380
(13.4 - 0.8) x (4.15 - 0.3) x (120 - 2)	3122 104 92140
x (94 - 1)	3122 104 92120
x (62 - 1)	3122 104 92150

CORES FOR SMALL COILS



A 52810-1

Ferroxcube rods, tubes and screws to be used as cores in r.f. and h.f. coils with an open magnetic circuit such as in i.f. transformers. Only preferred types are listed.

RODS

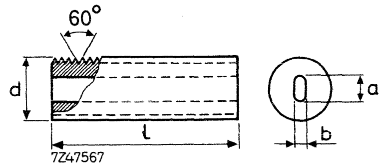
dia. (mm)	length (mm)	grade	catal. No.
0.95 - 0.15	10 - 2.5	3B	3522 200 03750
1.25 - 0.04	6.2 - 0.4	3B	4322 020 32080
1.65 - 0.05	9.2 - 0.4	3B	3122 104 91070
	9.2 - 0.4	4B1	3122 104 91060
	11.5 - 0.4	3B	4322 020 32100
	11.5 - 0.4	4E1	4322 020 32110
	12.2 - 0.4	3B	3122 104 91100
	12.2 - 0.4	4B1	3122 104 91110
	19.2 - 0.4	3B	3122 104 91230
	25.2 - 0.4	3B	3122 104 91170
	25.2 - 0.4	4B	3122 104 91180
	28.2 - 0.4	3B	3122 104 91090
	28.2 - 0.4	4B1	4322 020 32090
1.7 - 0.15	15.2 - 0.4	4D1	4322 020 32170
	28.2 - 0.4	4C1	4322 020 32120
	28.2 - 0.4	4D1	4322 020 32130
	28.2 - 0.4	4E1	4322 020 32140
1.7 - 0.15	30.5 - 1	3B	3122 104 91200
1.75 - 0.2	10.2 - 0.4	3B	3122 104 91130
	18.5 - 1	3B	3122 104 91140
	18.5 - 1	4B1	3122 104 91150
6 - 0.075	46.2 - 0.4	3C1	3122 104 91310

TUBES

outside dia. (mm)	inside dia. (mm)	length (mm)	grade	catal. No.
2.8 - 0.03	1.2 + 0.1	8.2 - 0.4	3B	4322 020 34340
3.7 - 0.4	1.2 + 0.2	3.5 - 0.5	3B	4322 020 34400
			4B1	4322 020 34420
		6.5 - 0.5	3B	4022 101 80010
3.7 - 0.3	1.7 + 0.2	13.7 - 0.4	4E1	4322 020 34330
4.15 - 0.05	2 + 0.2	7.2 - 0.4	4A1	4322 020 34440
		12.2 - 0.4	4B1	4322 020 34450
			4C1	4322 020 34460
			4D1	4322 020 34470
		15.2 - 0.4	4B1	4322 020 34380
			4C1	4322 020 34370
		21.2 - 0.4	4A1	4322 020 34390
			4B1	4322 020 34480
4.3 - 0.2	2 + 0.2	7.2 - 0.4	3B	3122 104 92900
		12.5 - 1	3B	4322 020 34490
		15.2 - 0.4	4D1	4322 020 36760
		15.4 - 0.8	3B	4322 020 36750
		18.5 - 1	3B	4322 020 36770
		25.5 - 1	3B	4322 020 36780
			4B1	3122 104 90810
			4C1	3522 200 10950
			4D1	3522 200 10960
		30.2 - 0.4	3B	4322 020 36790
		40.5 - 1	3B	3122 104 90800
		55.5 - 1	3B	4322 020 36800
4.95 - 0.1	1.3 + 0.2	40.5 - 1	3C3	3122 104 93110
5.3 - 0.2	3 + 0.2	22.4 - 0.8	3B	4322 020 36810
6.2 - 0.4	2.85 + 0.3	30.2 - 0.4	4C1	4322 020 36820
8 - 0.4	4.2 + 0.6	51.4 - 2.8	3B	4322 020 34310
			4B1	4322 020 34320

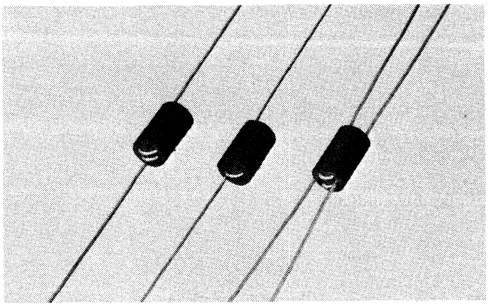
SCREW CORES

The standard cores are available in grade 3D3 with an initial permeability of 750 ±20%.



screw thread	l (mm)	d (mm)	a (mm)	b (mm)	catalogue number
M4 x 0.50	12 ± 0.3	3.65 + 0.05	1.6 ± 0.1	0.7 ± 0.1	4312 020 32040
M5 x 0.75	12 ± 0.3	4.55 + 0.05	2.15 ± 0.15	0.8 ± 0.1	4312 020 32050
M6 x 0.75	25 ± 0.5	5.55 + 0.05	2.65 ± 0.15	1.1 ± 0.1	4312 020 32070
M6 x 0.75	13 ± 0.3	5.55 + 0.05	2.65 ± 0.5	1.1 ± 0.1	4312 020 32060
M8 x 1.25	25 ± 0.5	7.35 + 0.05	3.65 ± 0.15	1.3 ± 0.1	4312 020 32120
M8 x 1.25	16 ± 0.5	7.35 + 0.05	3.65 ± 0.15	1.3 ± 0.1	4312 020 32110

BEADS FOR SCREENING AND DAMPING, AND WIDE-BAND H.F. CHOKES



RZ 22959-1

APPLICATION

Beads and chokes are available in ferroxcube grades 3B and 4B. They are used in v.h.f. radio and TV receivers and in electric motors, ignition systems etc. to reduce in- or outgoing interference, and also in v.h.f. circuits to avoid troublesome coupling. The supply leads in radio, TV and other electronic equipment often transfer unwanted r.f. and v.h.f. energy from one circuit or stage to another. Capacitive decoupling of the leads will not always be effective by reason of possible resonances. On the same grounds the addition of a series inductance will not always have the required results. In these cases a number of beads (the total length of which is small compared with the wavelength) simply threaded on the supply leads, or a single wideband choke may be used successfully. For the same volume chokes are more effective than beads.

In "damping circuits" either beads or chokes may be used in conjunction with small capacitors, to provide additional filtering of the self-resonant frequency of that capacitor and its leads.

Ferroxcube beads and ferroxcube-cored chokes have the following advantages over air-cored chokes:

small volume;
wide band;
no sharp fall-off;
insensitive to stray circuit capacitance;
no parasitic resonances;
no additional resistor required for damping;
low price.

BEADS (without wire)

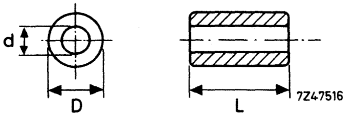


Fig.1

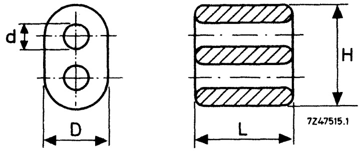


Fig.2

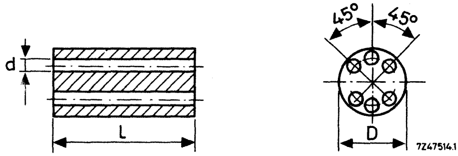


Fig.3

Fig.	grade	L (mm)	D (mm)	H (mm)	d (mm)	catalog number
1	3B	3	3.5 ± 0.2	-	1.3 ± 0.2	4322 020 34400
1	4B	3	3.5 ± 0.2	-	1.3 ± 0.2	4322 020 34420
1	3B	5	3.5 ± 0.2	-	1.3 ± 0.2	4312 020 31060
2	4B1	8 ± 0.3	8.5 - 0.5	14 ± 0.5	3.5 + 0.5	4312 020 31570
2	4B1	14 ± 0.4	8.5 - 0.5	14 ± 0.5	3.5 + 0.5	4312 020 31520
3	3B	10 ± 0.5	6 ± 0.3	-	0.7 + 0.2	4312 020 31500
3	4B1	10 ± 0.5	6 ± 0.3	-	0.7 + 0.2	4312 020 31550

The beads may be threaded with insulated or bare wire, but if grade 3B is used on bare wire a maximum fall-off in resistance of 8 % can be expected, as a result of its lower resistivity.

Fig.4 shows some performance details of the 3 mm long tube beads in the two material grades. It will be noted that above about 60 MHz the impedance of the 3B type is substantially resistive.

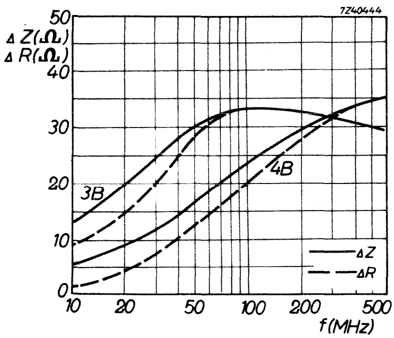


Fig.4

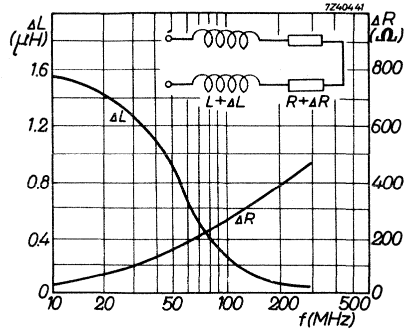


Fig.5

With twin beads the advantages of mutual inductance can be utilized. Fig.5 gives the increase of the inductance L and loss resistance R caused by a twin bead 4312 020 31520 on two straight wires.
Grade 4B provides ample insulation between the two wires even if bare.

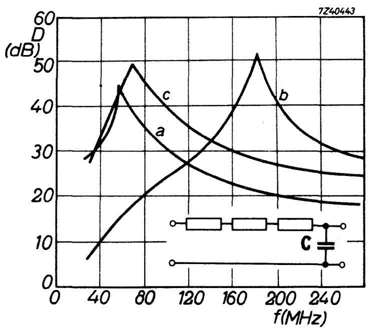


Fig.6. Damping in an LC circuit consisting of a string of three beads 4322 020 34400 and a ceramic capacitor.

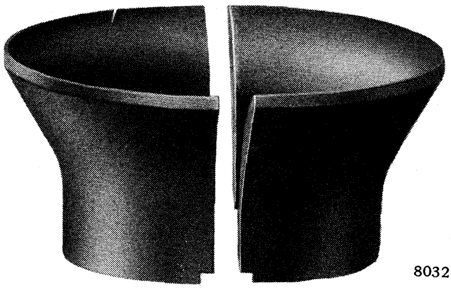
a. C = 1500 pF tubular
b. C = 190 pF tubular
c. C = 1500 pF disc.

H.F. CHOKES

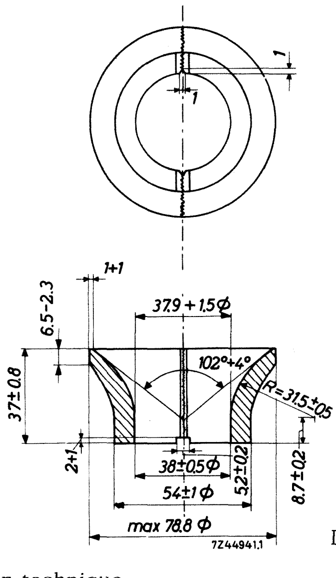
See section "Wide-band h.f. chokes" of chapter C "Small coils, assemblies and assembling parts".

YOKE RINGS FOR USE IN DEFLECTION COILS FOR PICTURE TUBES

FOR 110° BLACK AND WHITE PICTURE TUBES



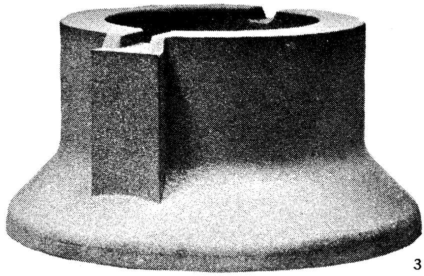
8032/6



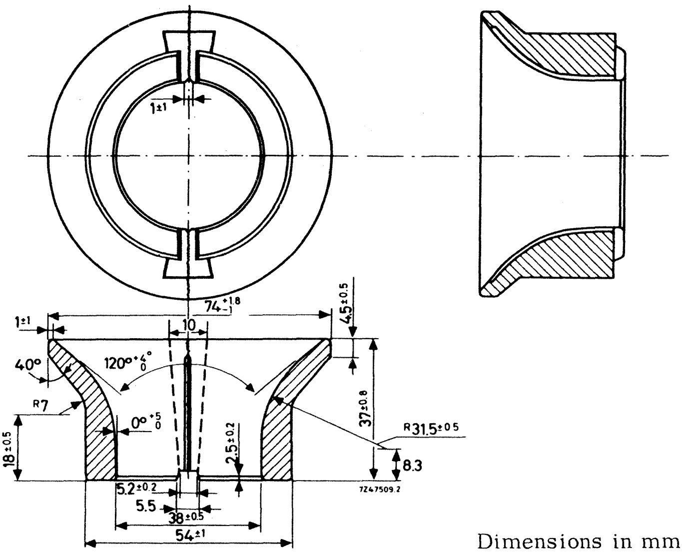
Dimensions in mm

European technique
Material : Ferroxcube 3C2
Catalog number: 3122 104 92180 (standard type)

FOR 110° BLACK AND WHITE PICTURE TUBES (continued)



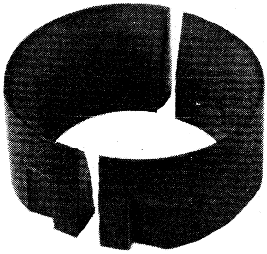
31172-1



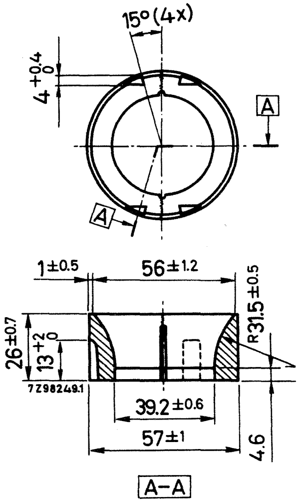
Dimensions in mm

European technique
Material : Ferroxcube 3C2
Catalog number: 4322 020 35070

FOR 110° BLACK AND WHITE PICTURE TUBES (continued)



RZ 24668-2



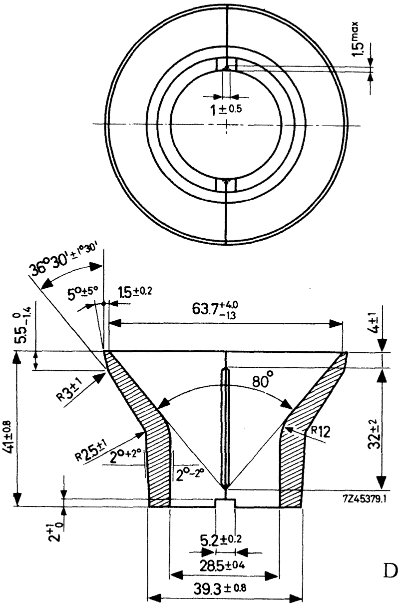
Dimensions in mm

Material : Ferroxcube 3C2
Catalog number: 3122 104 93840

Springs for assembling can be supplied.
Catalogue number: 3122 101 06340.

FOR TINYVISION PICTURE TUBES (90°, 11 inch)

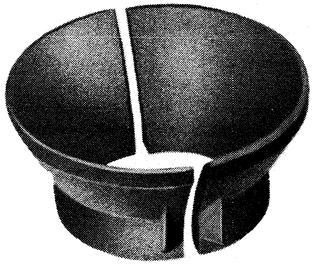
RZ 22938-4



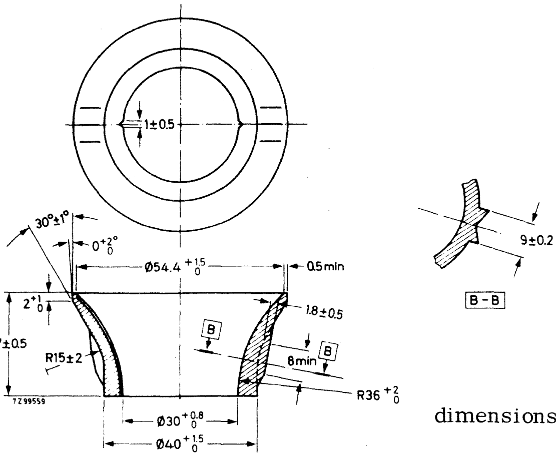
Dimensions in mm

Material : Ferroxcube 3C2
Catalog number: 3122 104 90514

FOR 110° BLACK AND WHITE PICTURE TUBES (12 inch)



RZ 29121-5

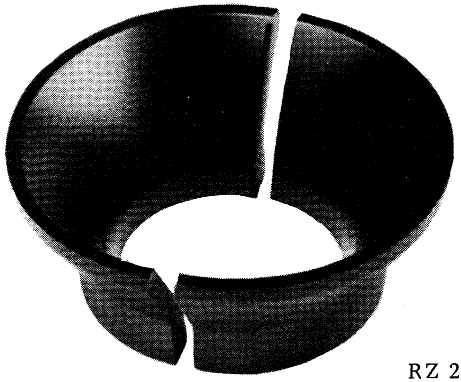


dimensions in mm

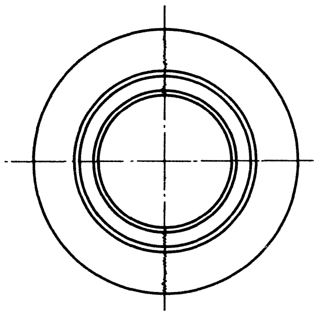
Material : Ferroxcube 3C2
Catalogue number: 3122 104 94790

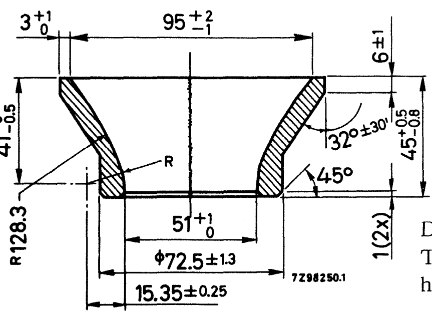
Spring clips for assembling can be supplied.
Catalogue number: 3122 101 91850

FOR 90° COLOUR PICTURE TUBES



RZ 24668-1

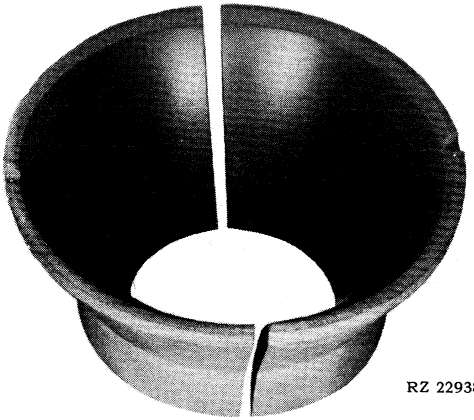




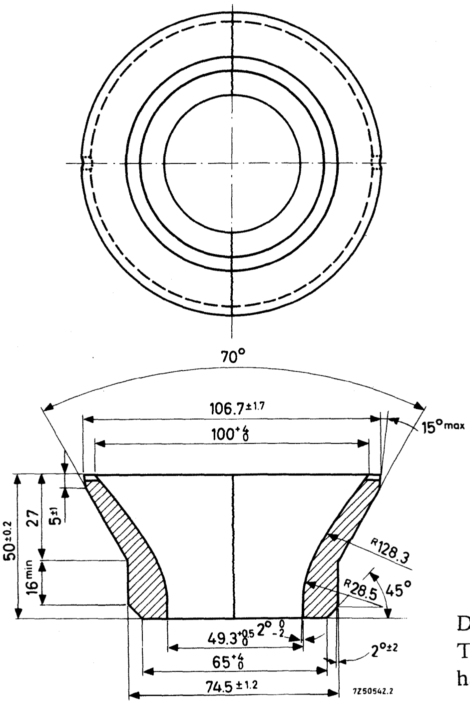
Dimensions in mm
The inner surface
has been lacquered.

Material : Ferroxcube 3C2
Catalog number: 3122 104 99170

FOR 90° COLOUR PICTURE TUBES



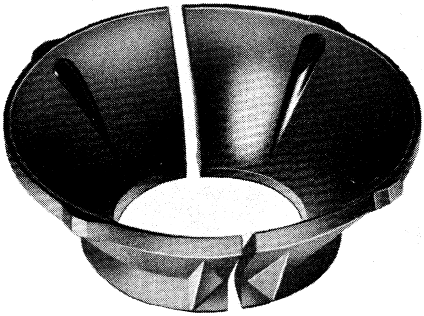
RZ 22938-1



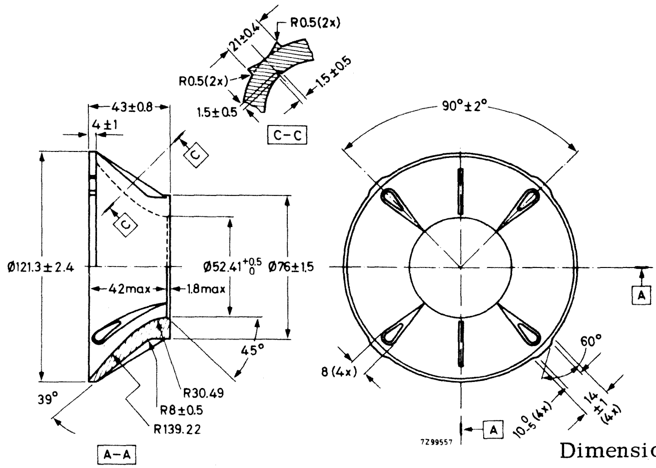
Dimensions in mm
The inner surface
has been lacquered.

Material : Ferroxcube 3C2
Catalog number: 3122 108 12160

FOR 110° COLOUR PICTURF TUBES



RZ 29121-6



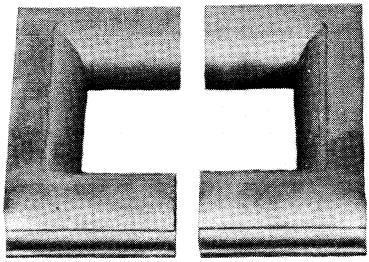
Dimensions in mm

The inner surface has been lacquered.

Material : Ferroxcube 3C2
Catalogue number: 3122 107 52200

Spring clips for assembling can be supplied.
Catalogue number: 3122 101 57351

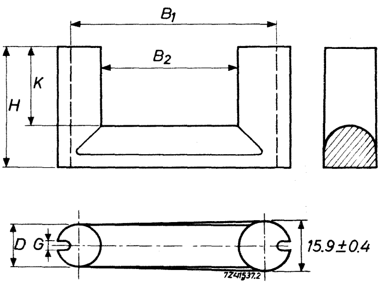
CORES FOR LINE-OUTPUT TRANSFORMERS

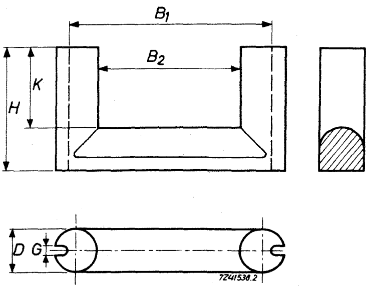


RZ 22938-3B

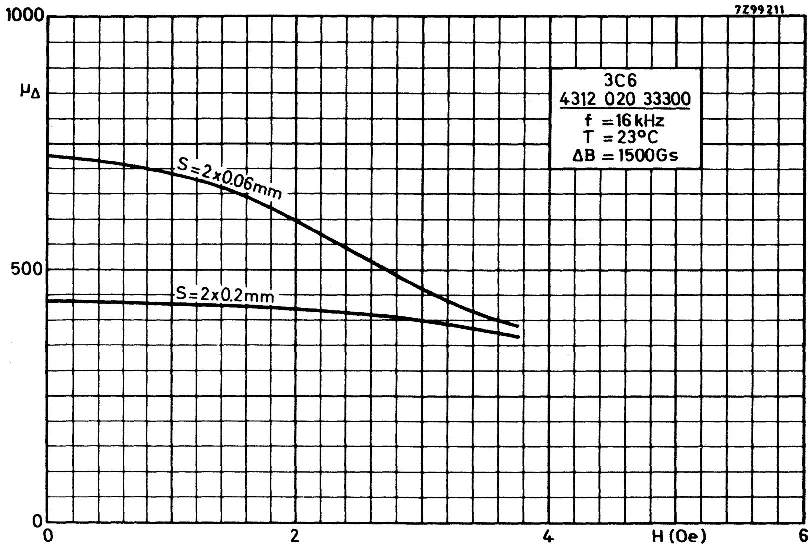
U-CORES

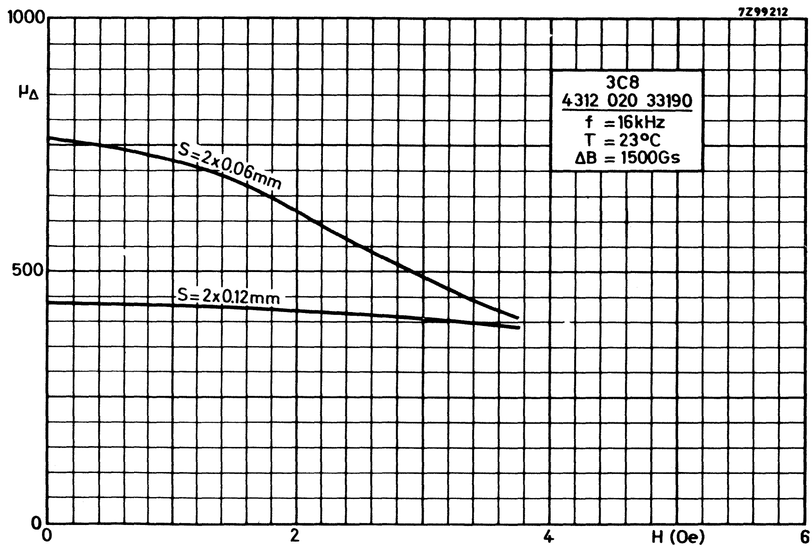
All types of core are available in ferroxcube grade 3C6 and some types in 3C8. The difference in splay between two U-cores taken at random from one packing will never exceed half the total tolerance on dimension B_1.





Incremental permeability as a function of the static field strength





U- and I-CORES

Shapes

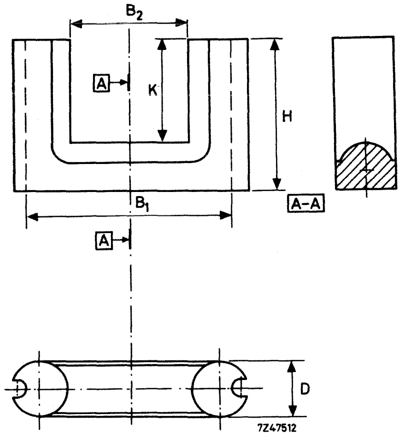


Fig.3

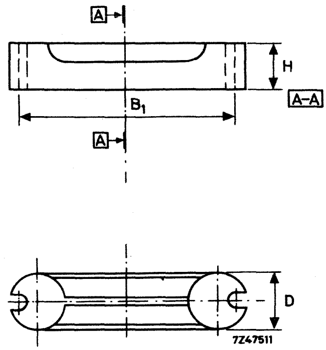


Fig. 4

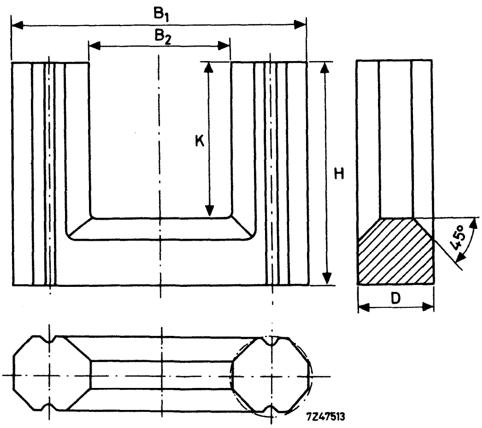


Fig. 5

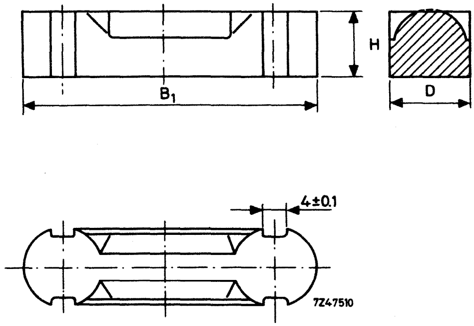
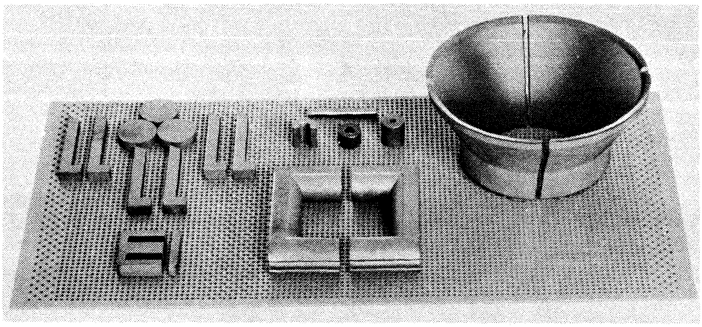


Fig. 6

type	dimensions (mm)						grade	Fig. number	catalogue number
	B_1	B_2	D	G	H	K			
U 57	49.8 ± 0.8	≥ 26.9	15.5 ± 0.4	4.8 ± 0.2	28.4 ± 0.2	15.5 + 1	3C6	1	4312 020 33300
							3C8	1	4312 020 33190
U 70/30	60.3 ± 1	≥ 34.2	17.25 ± 0.4	4.8 ± 0.2	30.85 ± 0.2	16.50 + 1	3C6	2	3122 104 93570
U 70/32	60.35 ± 0.9	≥ 37.05	15.9 ± 0.4	4.8 ± 0.2	31.8 ± 0.2	18.55 + 1	3C6	2	4312 020 33330
U 70/33	60.35 ± 0.9	≥ 35.4 ± 1.2	17.25 ± 0.4	4.8 ± 0.2	33.35 ± 0.2	19.05 ± 0.5	3C6	2	4312 026 33040
	60.35 ± 0.9	≥ 35.4 ± 1.2	17.25 ± 0.4	4.8 ± 0.2	33.35 ± 0.2	19.05 ± 0.5	3C8	2	3122 104 93950
UI 46	40.7 ± 1.3	24.4 + 1.2	11.4 − 0.5	3.2 $^{+0.3}_{-0}$	33 ± 0.2	23.1 + 0.9	3C6	3	3122 104 90480
	39.6 ± 0.4		11.4 − 0.5	3.2 $^{+0.3}_{-0}$	9.5 ± 0.2		3C6	4	3122 104 90470
UI 57	49.6 ± 0.8	27 ± 1	15.6 ± 0.4	4.8 ± 0.2	44.2 ± 0.2	> 31	3C6	3	4312 020 33380
	50 ± 0.8		15.6 ± 0.4	4.8 ± 0.2	12.6 ± 0.2		3C6	4	4312 020 33390
UI 58	58 + 1.3	28 ± 1	15 ± 0.4		44.6 ± 0.5	31.5 ± 0.5	3C6	5	4312 020 33340
	58 + 1.3	28 ± 1	15 ± 0.4		44.6 ± 0.5	31.5 ± 0.5	3C8		3122 104 94760
	59.4 ± 0.8		15 $^{+0.4}_{-0.2}$		13.5 ± 0.2		3C6	6	4312 020 33360
	59.4 ± 0.8		15 $^{+0.4}_{-0.2}$		13.5 ± 0.2		3C8		3122 104 94770
UI 82	73 − 1.8	45.3 ± 1.2	18.2 ± 0.4	3.5 ± 0.2	65 − 1.5	49.9 ± 0.8	3C6	3	3122 104 93120
	73 − 1.8	45.3 ± 1.2	18.2 ± 0.4	3.5 ± 0.2	65 − 1.5	49.9 ± 0.8	3C8		3122 104 93920
	73 − 1.8		18.2 ± 0.4	3.5 ± 0.2	14.8 ± 0.2		3C6	4	3122 104 93130
	73 − 1.8		18.2 ± 0.4	3.5 ± 0.2	14.8 ± 0.2		3C8		3122 104 93910

FERRITES FOR COLOUR TV COMPONENTS

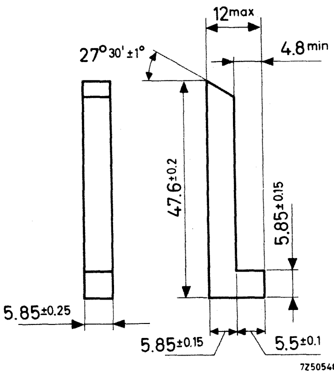


RZ 22938-3A

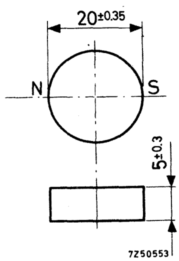
1. Yoke rings — See chapter "Yoke Rings"
2. U-cores — See chapter "Cores for line-output transformers"

Special ferrite parts are:

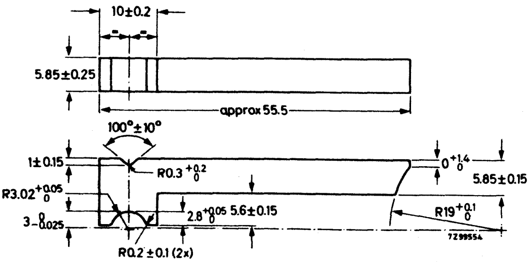
3. Ferroxcube L-core and ferroxdure magnet for convergence units



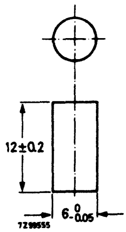
L-core
Ferroxcube 3C6
Catalog number: 3122 104 90680



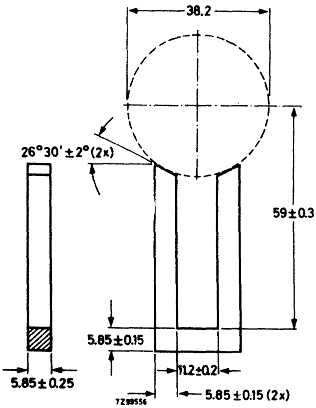
Disc magnet, diametrically magnetized
Ferroxdure 100
Catalog number: 3122 104 90620



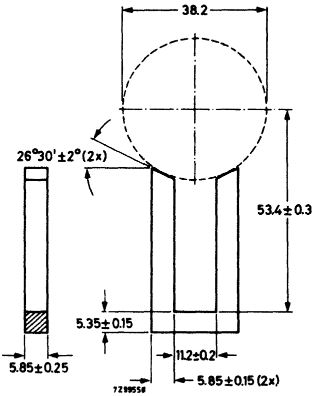
L-core
Ferroxcube 3C2
catalogue number: 3122 104 94090
3122 104 94601



Ferroxdure 100 Magnet
catalogue number: 3122 104 94330

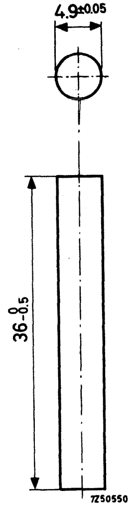


U-core
Ferroxcube 3C2
catalogue number: 3122 104 94490

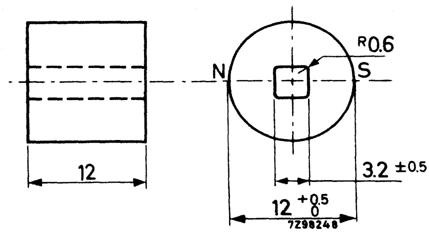


U-core
Ferroxcube 3C2
catalogue number: 3122 104 93780

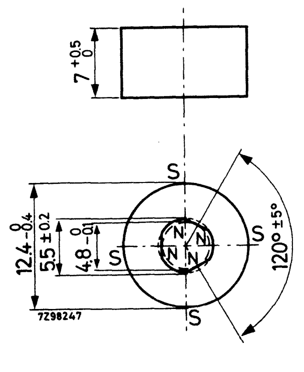
4. Ferroxcube rod and ferrite magnets for linearity-control units



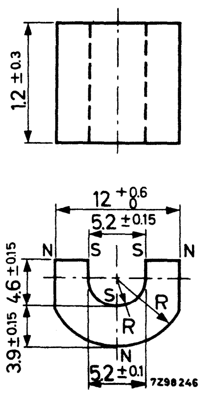
Rod core
Ferroxcube 3C6
Catalog number: 3122 104 90490



Ring magnet, diametrically magnetized Ferroxdure 100. Catalog number 3122 104 92690

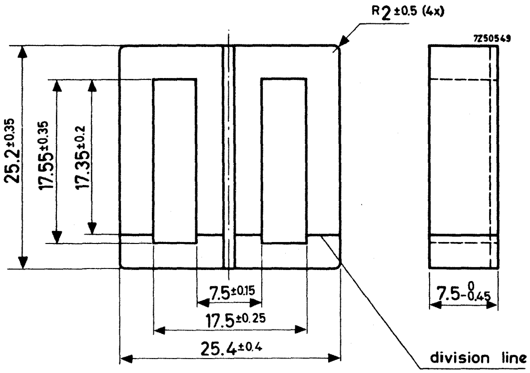


Ring magnet, radially magnetized. Plastic bonded ferroxdure P40. Catalog number: 3122 104 93530.



Magnet, segment, radially magnetized. Plastic bonded ferroxdure P40. Catalog number: 3122 104 93770

5. Ferroxcube E + I core for a raster correction transductor



E + I core
Ferroxcube 3C6
l_e = 5.75 cm
A_e = 0.55 cm^2
Catalog number:
3122 104 93210

FERROXPLANA, FOR V.H.F. AND U.H.F.

MATERIAL PROPERTIES

Ferroxplana is a hexagonal ferrite suitable for very high and ultra high frequencies. The main properties are:

	grade 1Z2
Initial permeability μ_i	15
$\frac{\tan\delta}{\mu_i}$ at 50 MHz	1.0×10^{-3}
100 MHz	2×10^{-3}
200 MHz	6×10^{-3}
300 MHz	-
500 MHz	-
Temp. factor $\frac{\Delta\mu}{\mu^2 \Delta T}$	80×10^{-6}
Spec. resistance (Ωcm)	10^6
Frequency range (MHz)	50 - 200

FERROXPLANA BEADS

Preferred types (grade 1Z2)

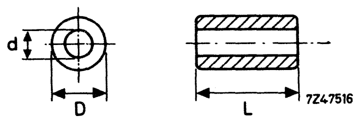


Fig. 1. Tube

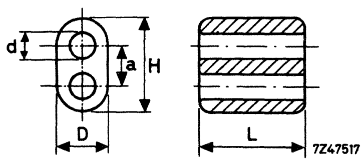


Fig. 2. Twin-bead for balun transformers

Fig.	L (mm)	D (mm)	d (mm)	H (mm)	a (mm)	catalog number
1	15 ± 0.4	8.5 ± 0.3	3.9 ± 0.2	-	-	3122 104 91710
1	10 ± 0.6	4 + 0.6	2 + 0.4	-	-	91760
1	5 ± 0.3	4.6 - 0.6	2 + 0.4	-	-	91780
1	3.5 - 0.5	3.7 - 0.4	1.5 + 0.2	-	-	3122 104 90230
2	14 ± 0.5	8.25 ± 0.25	3.4 + 0.6	14 ± 0.5	5.85 ± 0.25	4322 020 69750

Other shapes: on request

POWDER IRON CORES

MATERIAL PROPERTIES

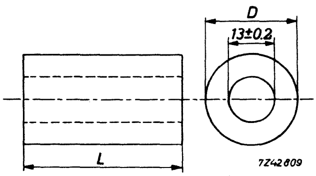
Main properties of the various grades of powder iron: 1P1, 1P2, 1P3.

freq. range	grade	Q-factor measured on a small ring	μ_i	particle size
up to 10 MHz	1P1	300 at 10 MHz	10 appr.	6 - 8 μm
up to 40 - 80 MHz	1P2	350 at 30 MHz	8.5 appr.	4 - 6 μm
up to 40 - 80 MHz	1P3 [1]	350 at 30 MHz	8.5 appr.	4 - 6 μm

[1] Only for cast parts

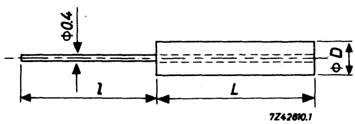
CORES FOR SMALL I.F. COILS

Tube



Grade 1P1
L = 31.7 ±0.2 mm
D = 18 ±0.2 mm
Catalog number:
4322 020 69520

Cores with a tinned copper wire



Grade 1P3

l (mm)	L (mm)	D (mm)	catalog number
30 +4	30±0.5	4.00 -0.15	3122 997 70400
33 +4	28±0.5	4.95 -0.1	3122 108 70060
40 +4	22±0.5	4.95 -0.1	3122 108 70050

Screw cores

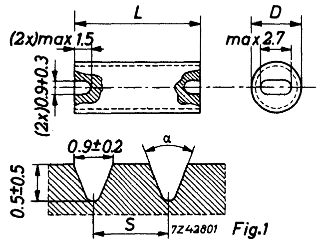


Fig.1

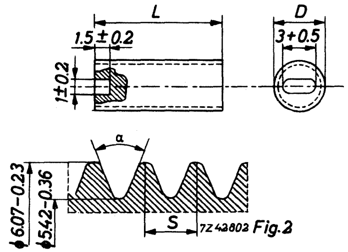


Fig.2

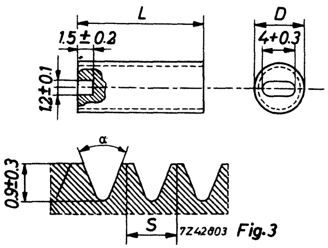


Fig.3

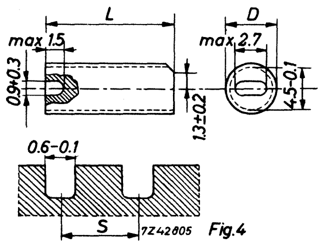


Fig.4

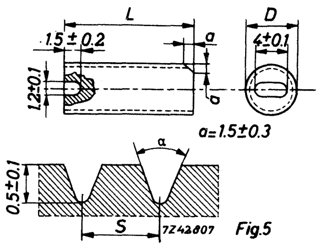
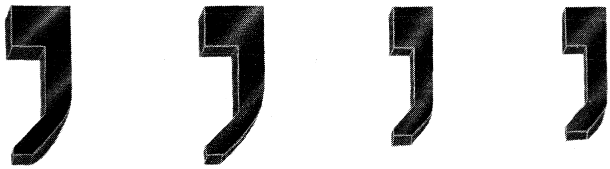


Fig.5

L (mm)	D (mm)	α	S (mm)	tol.[1] (mm)	n	grade	Fig.	catalog number
5±0.3	4.95 - 0.1	≤ 85°	1.5	0.1	1	1P1	1	3122 104 91580
6±0.5	6.07 - 0.23	60°	0.5			1P1	2	4322 020 69500
8±0.3	4.95 - 0.1	≤ 85°	1.5	0.2	4	1P2	1	3122 104 91610
10±0.3	7 - 0.1	60° ± 10°	1	0.1	1	1P2	3	3122 104 91590
12.25±0.3	4.95 - 0.1	≤ 85°	1.5	0.2	5	1P2	1	3122 104 91600
12.25±0.3	4.95 - 0.1	–	1.5	0.05	1	1P1	4	3122 104 93140
12.25±0.3	4.95 - 0.1	≤ 85°	1.5	0.2	5	1P1	1	3122 104 90970
13 - 1.5	6.07 - 0.23	60°	0.5	–	–	1P1	2	3122 104 90990
15±0.3	4.95 - 0.1	70° + 15°	1.5	–	–	1P1	1	3122 104 92970
16.5±0.3	7 - 0.1	60°	1.5	0.05	1	1P2	5	3122 104 91000
16.5±0.3	7 - 0.1	60° + 10°	1	0.1	1	1P2	3	3122 104 91660
20.25±0.4	4.95 - 0.1	≤ 85°	1.5	0.2	5	1P1	1	3122 104 90980

[1]) Tolerance on S in mm over n grooves

CORES FOR ERASING HEADS



10207

For good erasing of magnetic tape at a low noise level, a frequency is required that is several times higher than the maximum frequency to be recorded. That is why, for use in erasing heads a core material with low eddy current losses is recommended. Low eddy current losses imply low heat dissipation, and consequently less power for the erasing procedure.
Ferroxcube cores possess this property in a much higher degree than laminated metal cores, so that they are plainly indicated for this application.
Ferroxcube cores in the material grades 3C1, 3C2 and 3H1 are available.

MATERIAL PROPERTIES

Low eddy current losses at frequencies up to 500 kHz

Relative initial permeability is approximately 900 for 3C1 and 3C2, 2300 for 3H1.

Saturation flux density at 23 °C is
of ferroxcube 3C1 approximately 3300 gauss
of ferroxcube 3C2 approximately 3800 gauss
of ferroxcube 3H1 approximately 4400 gauss

AVAILABLE TYPES

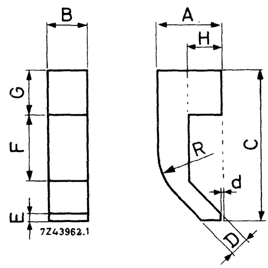


Fig. 1. Grade 3C1

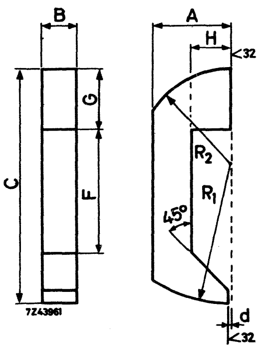


Fig. 2. Grade 3C2

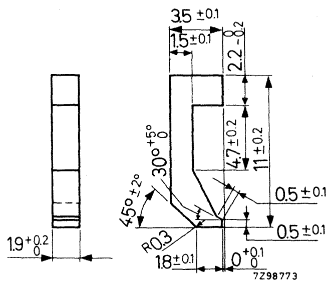


Fig. 3. Grade 3H1

Cores in ferroxcube grade 3C1 (See Fig. 1.)

catal. No.	dimensions (mm)										weight (g)
	A	B	C	D	d	E	F	G	H	R	
4322 020 30550	4.7-0.4	1.7-0.4	11 $\pm$ 0.2	1.4 $\pm$ 0.2	0	0.5 $\pm$ 0.1	4.8 $\pm$ 0.4	3.2-0.4	2.4+0.2	5 $\pm$ 0.2	0.23
3104 101 80230	4.7-0.4	3.6-0.2	11 $\pm$ 0.2	1.4 $\pm$ 0.2	0	0.5 $\pm$ 0.1	4.8 $\pm$ 0.4	3.2-0.4	2.4+0.2	5 $\pm$ 0.2	0.54
3922 860 20550	4.7-0.4	7.1-0.2	11 $\pm$ 0.2	1.4 $\pm$ 0.2	0	0.5 $\pm$ 0.1	4.8 $\pm$ 0.4	3.2-0.4	2.4+0.2	5 $\pm$ 0.2	1.02
4322 020 30560	4.7-0.4	1.2-0.4	11 $\pm$ 0.2	1.4 $\pm$ 0.2	0	0.5 $\pm$ 0.1	4.8 $\pm$ 0.4	3.2-0.4	2.4+0.2	5 $\pm$ 0.2	0.15
4322 020 30630	4.7-0.4	2.8-0.2	11 $\pm$ 0.2	1.4 $\pm$ 0.2	0+0.2	0.5 $\pm$ 0.1	4.8 $\pm$ 0.4	3.2-0.4	2.4+0.2	5 $\pm$ 0.2	0.44
3122 104 92540	4.7-0.3	1.4-0.2	11 $\pm$ 0.2	1.4 $\pm$ 0.2	0+0.2	0.5 $\pm$ 0.1	4.8 $\pm$ 0.4	3.2-0.4	2.4+0.2	5 $\pm$ 0.2	0.22
4322 020 30600	3.1-0.3	1.6-0.2	9.2 $\pm$ 0.2	1.4 $\pm$ 0.1	0+0.1	0.5 $\pm$ 0.1	3.8 $\pm$ 0.4	3.2-0.4	1.4+0.2	2 $\pm$ 0.2	0.12

Cores in ferroxcube grade 3C2 (See Fig. 2.)

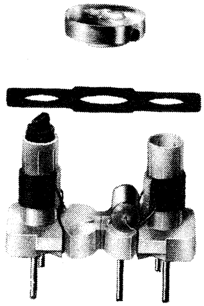
catal. No.	dimensions (mm)									weight (g)
	A	B	C	d	F	G	H	R_1	R_2	
4322 020 30580	5.8-0.4	3.6-0.2	18 $\pm$ 0.4	0.1 $\pm$ 0.05	9.4+0.4	4.5-0.4	3+0.2	11 $\pm$ 0.2	7 $\pm$ 0.2	1.22
4322 020 30590	5.8-0.4	1.6-0.2	18 $\pm$ 0.4	0.1 $\pm$ 0.05	9.4+0.4	4.5-0.4	3+0.2	11 $\pm$ 0.2	7 $\pm$ 0.2	0.52
4322 020 30610	5.8-0.4	2.6-0.2	18 $\pm$ 0.4	0.1 $\pm$ 0.05	9.4+0.4	4.5-0.4	3+0.2	11 $\pm$ 0.2	7 $\pm$ 0.2	0.87

Core in ferroxcube grade 3H1 (See Fig. 3.)

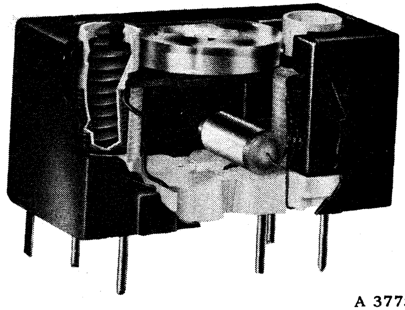
Catal. No.: 3104 101 80400. Completely machined type (no "firing skin") with relatively small tolerances.

Small coils, assemblies and assembling parts

PIECE PARTS AND MOUNTING PARTS
for small I.F. coils (lilliput type)



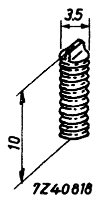
A 37755



A 37753

The complete range of piece parts comprises:

Screw cores (ferroxcube)

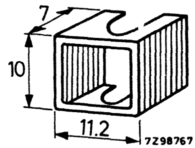


max. frequency (MHz)	grade	catal. No.
0.6	3B	3122 104 90550
2	4B1	3122 104 93020
12	4D1	3122 104 90590
100	powder iron	3122 104 91630

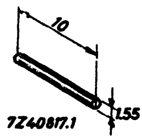
A version with a trimming grip on both sides is also avail-able

Ferroxcube frame (lacquered)

max. frequency (MHz)	colour	type	catal. No.
0.6	black	AP 3014/00/3B	3122 104 91460
2	green	AP 3014/01/4B1	3122 104 91470
12	light blue	AP 3014/02/4D1	3122 104 91480
ratio detector	light blue	AP 3014/03/4D1	3122 104 91490

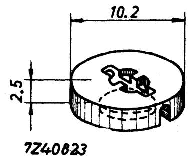


Coupling rod (3B)



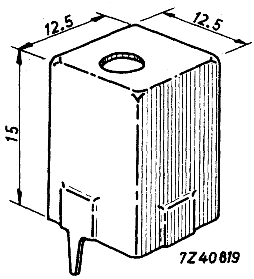
For coupling between primary and secondary windings, to be inserted in the coupling disc.
Catalog number:
3122 104 91130

Coupling disc



Catal. No. 3122 794 31200
(type AP3018)

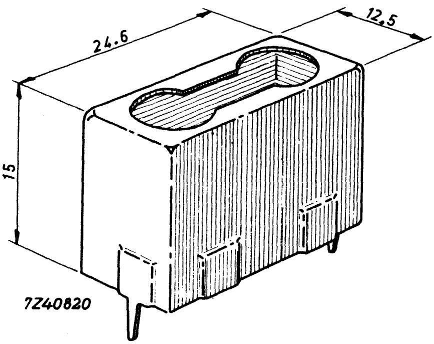
Cans for one coil



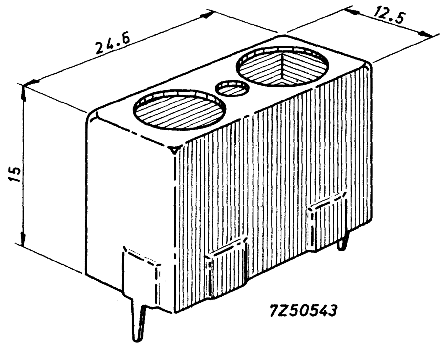
Polystyrene can for mechanical shielding, to be used when screening is not required. The Q-factor is not affected. Catal. No. 3122 104 03290 (type AP3015/00).

Copper can for mechanical and electrical shielding.
Hole centric: Catal. No. 3122 990 94120 (type AP3015/01)
Hole eccentric: Catal. No. 3122 990 94130
(type AP3015/02)

Cans for two coils

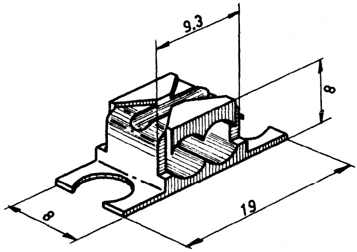


Tinned copper can
Catal. No. 3122 998 22260
(type AP3015/03)



Tinned copper can
Catal. No. 3122 991 91170
(type AP3015/04)

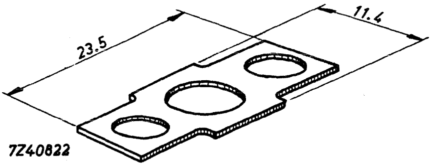
Block (for ratio detector only)



7Z40824

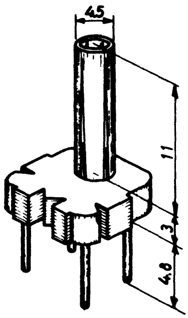
Catal. No. 4322 021 20700
(type number AP3019)

Spacer plate



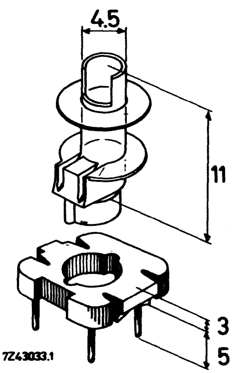
Catal. No. 3122 995 32070
(type number AP 3017)

Coil formers (polyethylene)



7Z40821.1

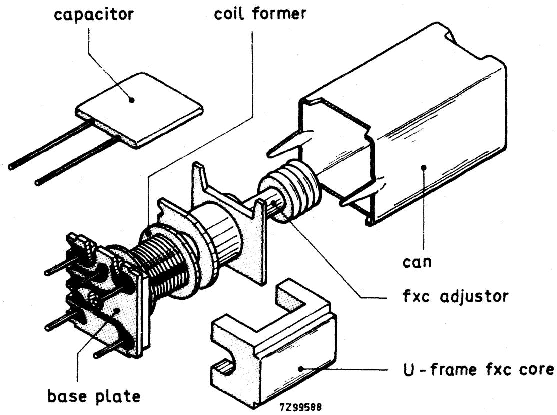
with base	version	catal. No.	type
symmetric for use without ferroxcube frame	4 pins 5 pins	3122 999 60230 3122 991 35830	AP 3016/00 AP 3016/01
asymmetric: for use with ferroxcube frame	4 pins 5 pins	3122 999 60430 3122 991 80420	AP 3016/02 AP 3016/03



Coil former (without base), asymmetric, for use with ferroxcube frame; catal. No. 3122 794 31430 (type AP3016/05)

Base with 4 pins for above coil former; catal. No. 3122 992 63220 (type AP3016/07)

COMPONENTS FOR 7×7 mm COIL ASSEMBLIES



7 x 7 mm coils are used as i.f. coils and band-pass filters, r.f. and oscillator circuits in radio and television receivers and as input and output coils in hybrid filters.

They were developed to complete the range of miniature LC circuits, manufactured in Europe, and suitable for mounting on printed-wiring boards made by the silk screen etching process.

Optimum design and arrangement of the magnetic circuits lead to high Q-factors and a widely adjustable inductance with a linear course of the trimming curve. Careful selection of the ferroxcube material and appropriate combination with built-in filter capacitors provide the desired minimum dependence of the frequency over a wide temperature range.

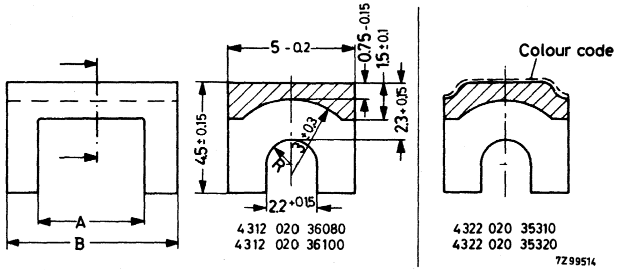
By means of inductive coupling provided by an additional winding on the head of the coil former it is possible to construct band-pass filters.

The polyamide coil former is supplied as one component ready fitted with a five-pin base plate made of synthetic resin bonded paper. Five printed conductors run from the pins to one edge of the base plate where flutes have been made to receive the wire terminals. The body of the coil former is positioned eccentrically on the base plate to provide the room necessary to house a miniature capacitor whose terminals can be soldered to the printed conductors.

The coils are designed to be wound on automatic winding machines as well as on the simplest type of hand operated winder. The beginnings and ends of the windings can easily be brought to their proper positions on the winding machine.

The components are separately available in different versions.

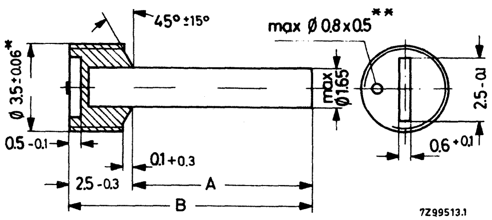
FRAME CORES



material	A (mm)	B (mm)	f_{max} (MHz)	colour code	catalogue number
FXC SP 4A4	4.4 + 0.2	7 - 0.3	2	-	4312 020 36080
FXC 4A4	4.4 + 0.2	7 - 0.3	2	green	4322 020 35310
FXC 4C6	4.4 + 0.2	7 - 0.3	20	dark blue	4322 020 35320
FXC SP 4A4	2.25 + 0.2	4.85 - 0.25	2	-	4312 020 36100[1]

1) To be used with type D coil former

ADJUSTORS



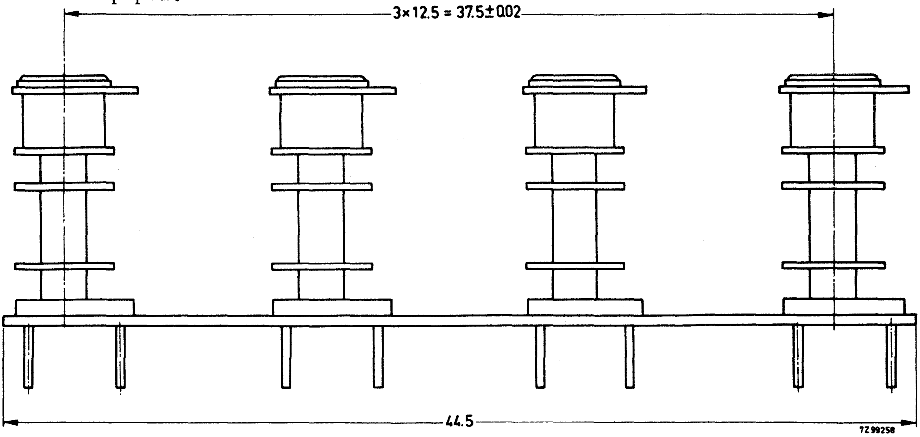
material	A_{min} (mm)	B_{max} (mm)	f_{max} (MHz)	colour code	catalogue number
3D3	7.1	9.6	2	red	4322 020 90510
4C6	7.1	9.6	20	black	4322 020 90500
3D3	5.6	8.1	2	orange	4322 020 90530

*) Not standard M 3.5: pitch = 0.5 mm.

**) Moulding stud.

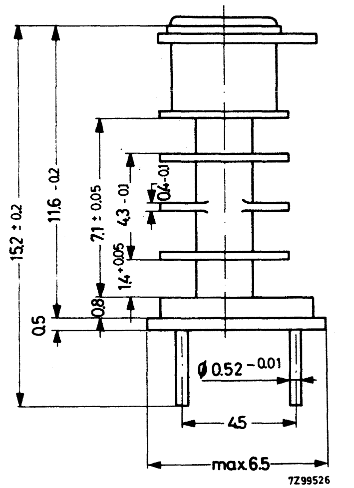
COIL FORMERS

Three types of coil former have been designed which are supplied in strips of four. The material of the coil is polyamide plastic, that of the base plate is synthetic resin bonded paper.

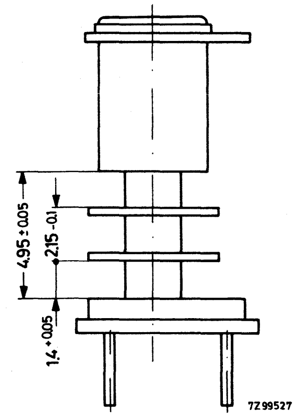


4 x type A

Type A is a single-section coil former. In the two-section coil former, type B, a central flange divides the coil chamber of type A into two equal parts. Type D is used for coils with wide trimming range and only suitable for frame core 4312 020 36100.



type B



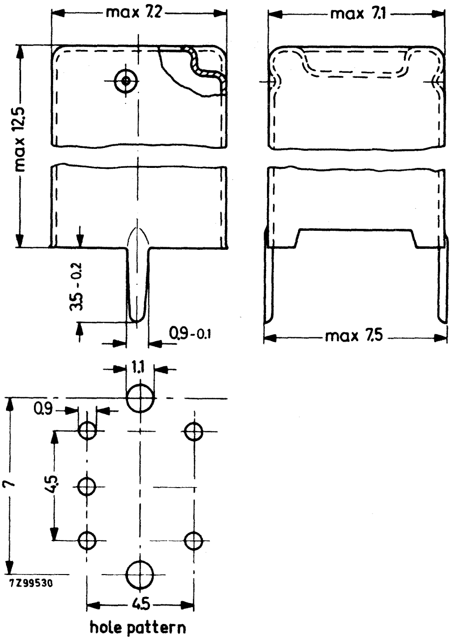
type D

4 x type A = 4312 021 29560

4 x type B = 4312 021 29570

4 x type D = 4312 021 29620

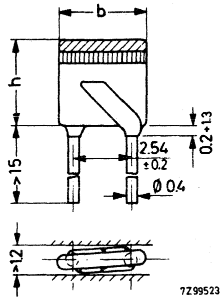
CAN



description	material	catalogue number
can	tinned copper	4312 021 29530
base screening cup	tinned copper	4312 021 29590 1)
insulating plate	triacetate foil	4312 021 29600 1)

1) Available to special order.

FILTER CAPACITORS



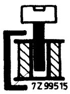
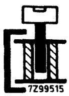
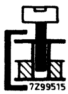
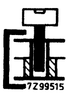
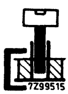
capacitance			dimensions		colour band		catalogue number
nom. (pF)	tol. ±(%)	temp. coeff. (ppm/degC)	b_{max} (mm)	h_{max} (mm)	upper	lower	
39	2	−150 ± 40	4.3	4.7	blue	brown	2222 632 96016
47	2		4.3	4.7	violet	brown	2222 632 96017
68	2		5.1	5.5	brown	red	2222 632 96021
82	2		5.5	5.9	orange	brown	2222 632 96013
100	2	−150 ± 40	5.5	6.6	red	brown	2222 632 96012
120	5	−150 ± 40	5.5	8.0	red	red	2222 632 96022
150	5	−330 ± 60	5.5	8.0	orange	red	2222 632 96023
180	5	−470 ± 90	5.5	8.0	yellow	red	2222 632 96024
220	5	−750 ±120	5.5	7.1	brown	brown	2222 632 96011

Loss factor, tan δ, at 1 MHz, 20 °C — $\leq 15.10^{-4}$

Insulation resistance at 20 °C — ≥ 1000 MΩ

Nominal voltage — 40 V d.c.

CALCULATION OF THE NUMBER OF TURNS

coil former	U-frame per core	adjustor	α with can	α without can	ΔL/L (%)	Δf/f (%)
Type A 4312 021 29500	grade 4A4 4322 020 35310	grade 3D3 4322 020 90510	255	250	±25	±12.5
	grade SP 4A4 4312 020 36080		255	250	±25	±12.5
Type A 4312 021 29500	grade 4C6 4322 020 35320	grade 4C6 4322 020 90500	300	295	±15	±7.5
						
Type B 4312 021 29510	grade 4A4 4322 020 35310	grade 3D3 4322 020 90510	255	250	±30	±15
	grade SP 4A4 4312 020 36080		255	250	±20	±15
Type B 4312 021 29510	grade 4C6 4322 020 35320	grade 4C6 4322 020 90500	300	295	±20	±10
						
Type D 4312 021 29610	grade SP 4A4 4312 020 36100	grade 3D3 (short) 4322 020 90530	-	280	±60	+58/-21
			-	330	+104/-41	±33

The meaning of the symbols is as follows:

α = winding factor; $N = \alpha\sqrt{L}$ (L in mH)

N = number of turns of the coil

L = nominal inductance of a 7 x 7 mm coil which at the nominal value of the capacitance involved (built-in capacitor + self-capacitance + additional capacitance) is tuned to resonance

$\Delta L/L$ = mean trimming range of the inductance

$\Delta f/f$ = mean trimming range of the frequency

Examples of single wires, stranded wires and winding data

number of strands	strand dia. (mm)	kind of insulation 1)	winding pitch 2) (mm)	max. number of turns 3)	turns per layer
5	0.03	CuLS	0.17	320	19
6	0.03	CuLS	0.17	270	19
8	0.03	CuLS	0.19	200	19
12	0.03	CuLS	0.22	140	16
16	0.03	CuLS	0.25	100	14
4	0.04	CuLS	0.19	290	19
5	0.04	CuLS	0.19	220	19
6	0.04	CuLS	0.22	170	16
8	0.04	CuLS	0.25	110	14
1	0.08	CuL	0.13	400	24
1	0.1	CuLS	0.17	240	19

1) CuL means lacquer-insulated copper wire, single or stranded; CuLS means silk-covered single or stranded CuL wire.

2) For special applications, e.g. bifilar windings, it is possible to use also a larger pitch.

3) Recommended for single section type A coil former.

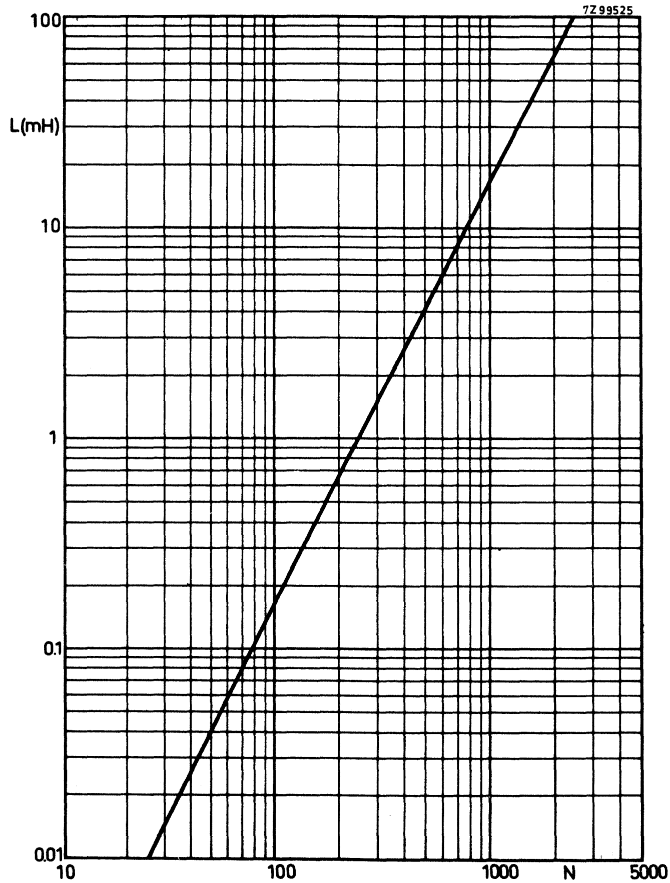
For windings on the head of the coil former it is recommended, irrespective of the other windings of the coil, to use 5 x 0.04 silk covered Litz wire with a pitch of the turns of 0.19 mm.

The winding always starts at the lower flange of the particular chamber of the coil former.

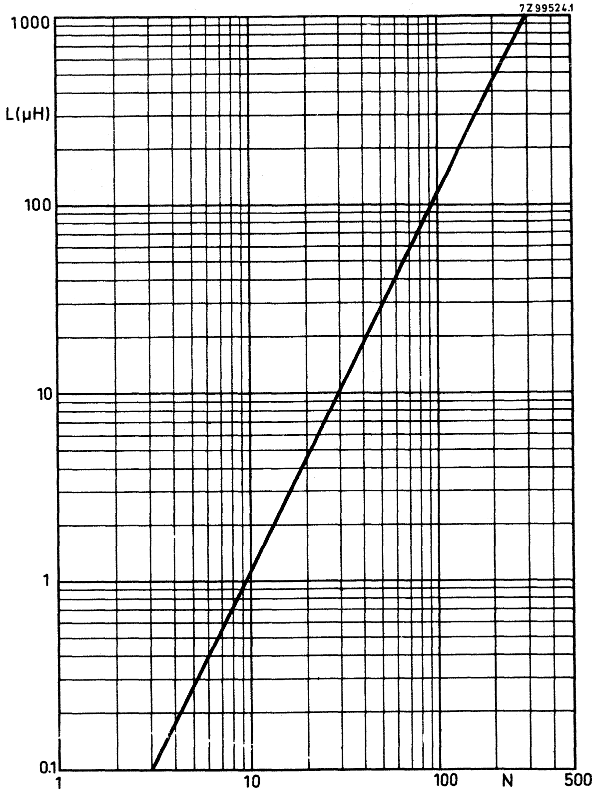
With multiple windings it is important to ensure, if necessary by means of three split windings, that the end of the winding reaches the flange of the particular chamber of the coil former.

The wires of a coil with a single layer is to be wound in the same direction as left hand screw thread.

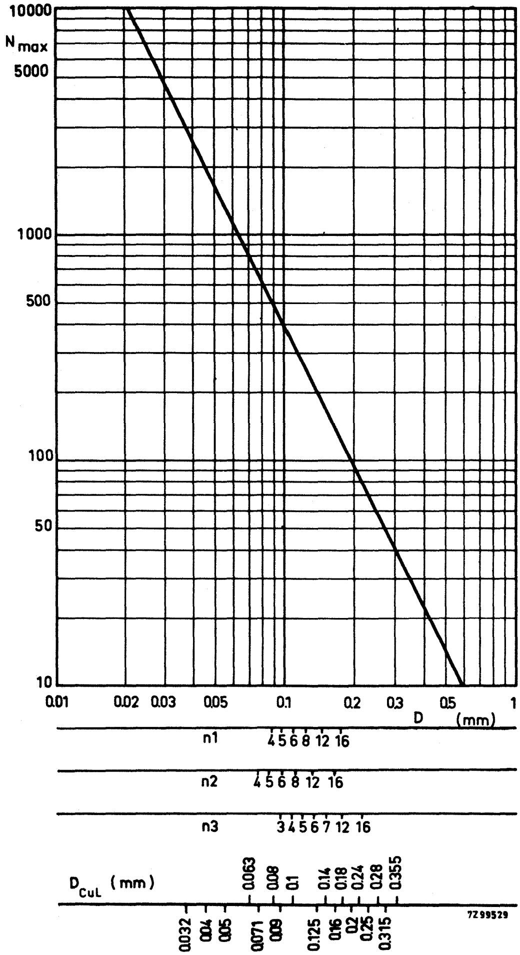
The number of turns is always an integer.



Inductance as a function of the number of turns for 4A4 U-frame core 4322 020 35310 with 3D3 adjustor 4322 020 90510.

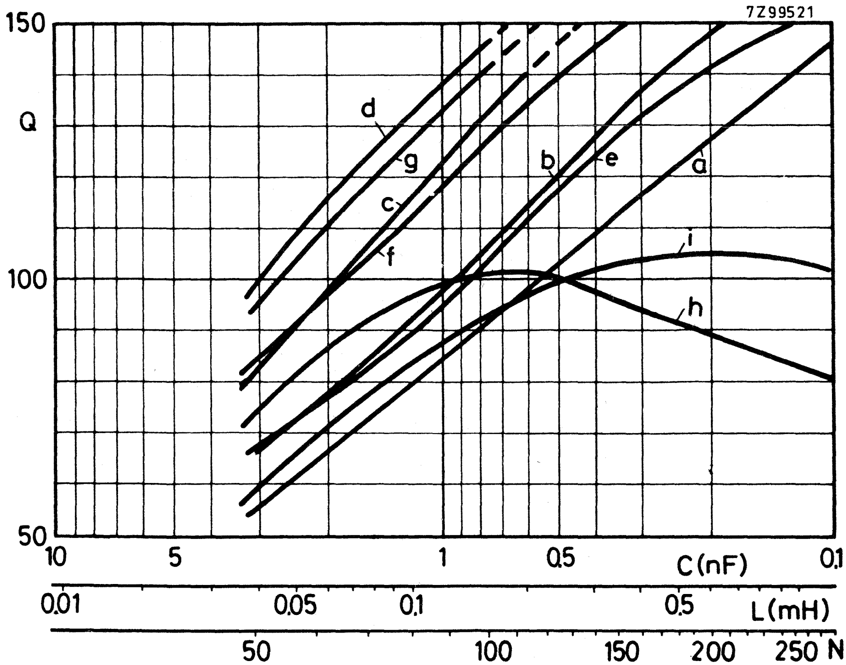


Inductance as a function of the number of turns for 4C6 U-frame core 4322 020 35320 with 4C6 adjustor 4322 020 90500.



Maximum number of turns as a function of the diameter of the wire for coil former type A.

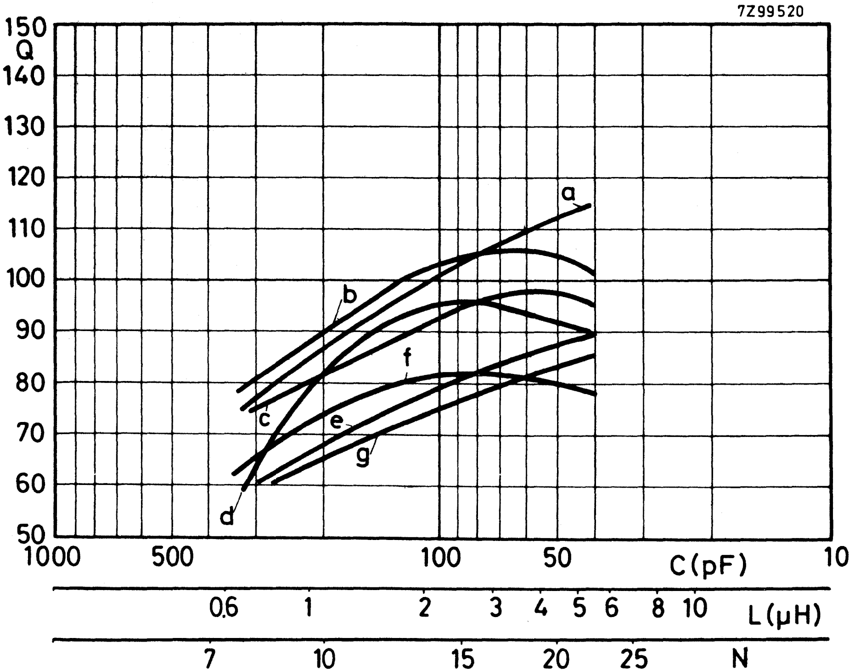
D = diameter of Litz wire
n_1 = number of strands, gauge 0.03 mm, silk covered
n_2 = number of strands, gauge 0.03 mm, without silk
n_3 = number of strands, gauge 0.04 mm, silk covered
D_{cul} = diameter of single or stranded, lacquer-insulated copper wire to German standard DIN46435.



Q versus filter capacitance, coil inductance and number of turns for a single a.m. bandpass filter at 460 kHz with 4A4 U-frame core 4322 020 35310 or 4312 020 36080 (SP), 3D3 adjustor 4322 020 90510, and coil former type A.
The following types of wire were used for these curves:

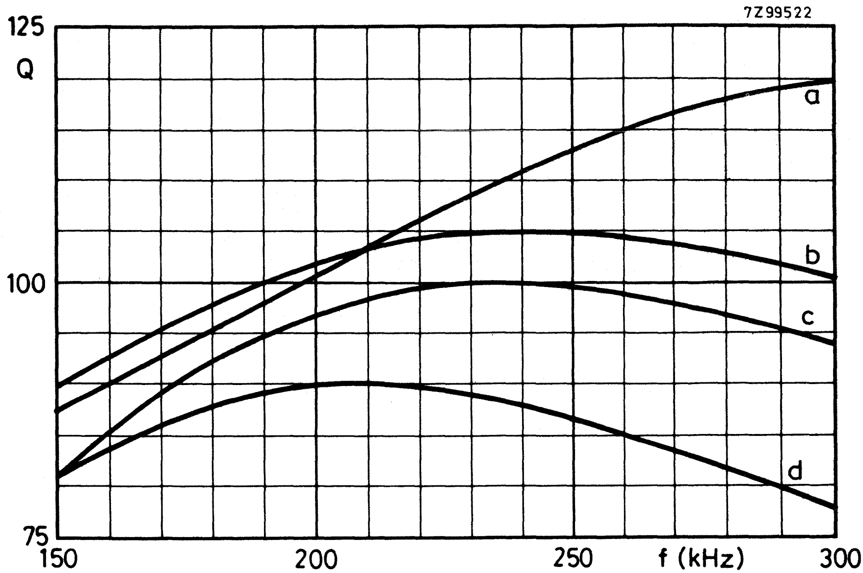
a: 6 x 0.03 CuLS
b: 8 x 0.03 CuLS
c: 12 x 0.03 CuLS
d: 16 x 0.03 CuLS
e: 4 x 0.04 CuLS
f: 6 x 0.04 CuLS
g: 8 x 0.04 CuLS
h: 1 x 0.1 CuLS
i: 1 x 0.08 CuLS

(6 x 0.03 CuLS means 6 strands of 0.03 mm copper wire, silk covered)



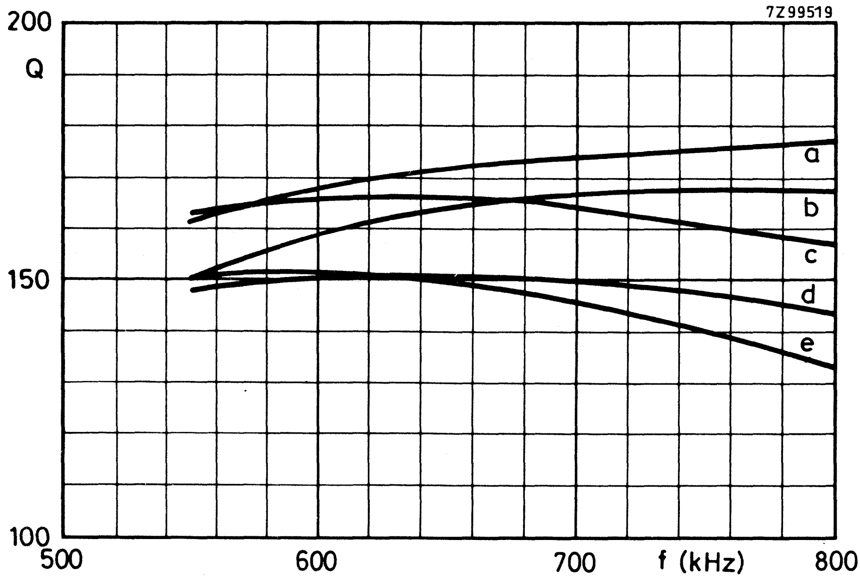
Q versus filter capacitance, coil inductance and number of turns for a single f.m. bandpass filter at 10.7 MHz with 4C6 U-frame core 4322 020 35320, 4C6 adjustor 4322 020 90500 and with coil former type A.
The following types of wire were used for the curves:

a: 8 x 0.03 CuLS
b: 16 x 0.03 CuLS
c: 5 x 0.04 CuLS
d: 8 x 0.04 CuLS
e: 1 x 0.07 CuLS
f: 1 x 0.1 CuLS
g: 1 x 0.08 CuLS



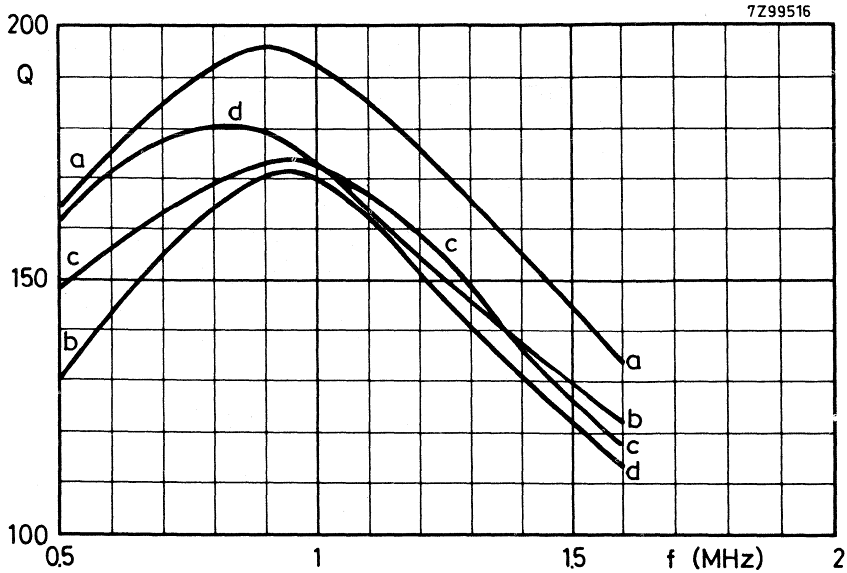
Q-curves measured on coils for r.f. bandpass filters for the l.w. band, with 4A4 U-frame core 4322 020 35310, 3D3 adjustor 4322 020 90510 and coil former type A.

curve a: L = 3.55 mH, 480 turns, 3 x 0.03 CuL
b: L = 4.0 mH, 510 turns, 1 x 0.07 CuL
c: L = 6.0 mH, 625 turns, 4 x 0.03 CuL
d: L = 6.0 mH, 625 turns, 1 x 0.06 CuL



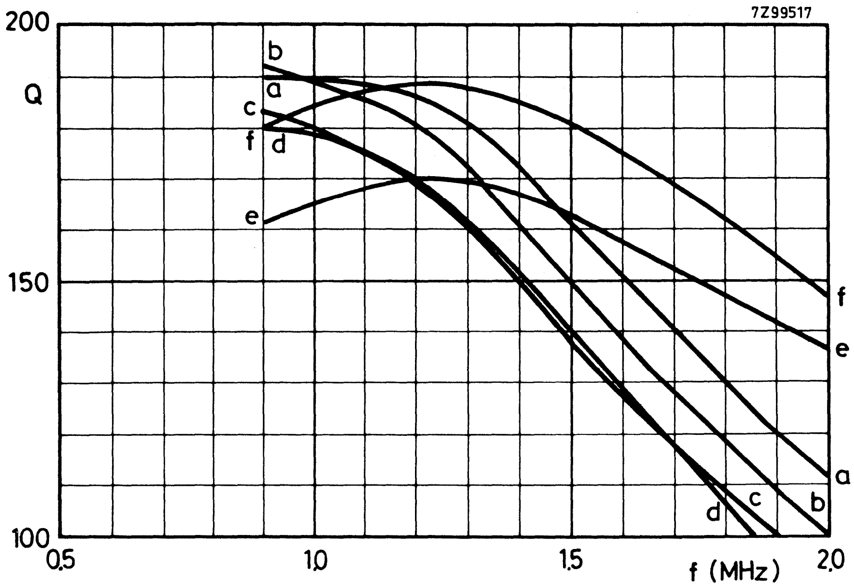
Q-curves measured on coils for l.w. oscillators, with 4A4 U-frame core 4322 020 35310, 3D3 adjustor 4322 020 90510 and coil former type A.

curve a:	L = 346 μH,	150 turns,	12 x 0.03 CuLS
b:	L = 346 μH,	150 turns,	6 x 0.04 CuLS
c:	L = 680 μH,	210 turns,	5 x 0.04 CuLS
d:	L = 915 μH,	244 turns,	6 x 0.03 CuLS
e:	L = 915 μH,	244 turns,	4 x 0.04 CuLS



Q-curves measured on coils for r.f. bandpass filters for the m.w. band, with 4A4 U-frame core 4322 020 35310, 3D3 adjustor 4322 020 90510 and coil former type A.

curve a:	L = 280 μH,	135 turns,	12 x 0.03 CuLS
b:	L = 346 μH,	150 turns,	8 x 0.03 CuLS
c:	L = 346 μH,	150 turns,	6 x 0.04 CuLS
d:	L = 400 μH,	161 turns,	6 x 0.04 CuLS

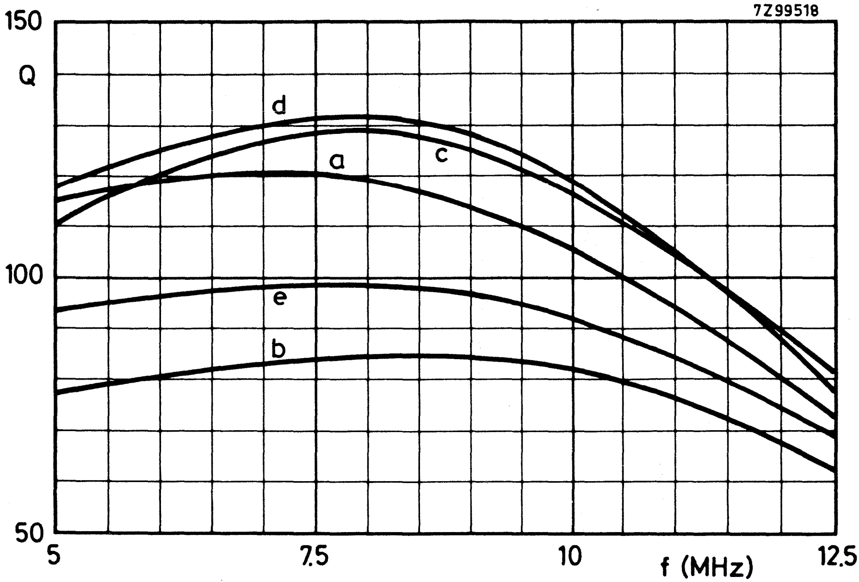


Q-curves measured on coils for m.w. oscillators.
With 4A4 U-frame core 4322 020 35310, 3D3 adjustor 4322 020 90510 and coil former type A:

curve a:	L = 142 μH,	96 turns,	16 x 0.03 CuLS
b:	L = 225 μH,	121 turns,	12 x 0.03 CuLS
c:	L = 225 μH,	121 turns,	8 x 0.04 CuLS
d:	L = 280 μH,	135 turns,	12 x 0.03 CuLS

With 4C6 U-frame core 4322 020 35320, 4C6 adjustor 4322 020 90500 and coil former type A:

curve e:	L = 142 μH,	113 turns,	8 x 0.04 CuLS
f:	L = 225 μH,	142 turns,	12 x 0.03 CuLS

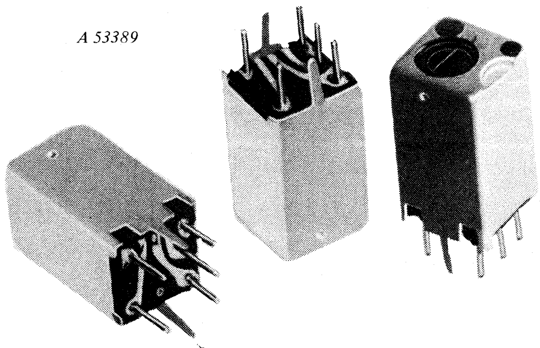


Q-curves measured on coils for r.f. bandpass filters for the s.w. band or for s.w. oscillators, with 4C6 U-frame core 4322 020 35320, 4C6 adjustor 4322 020 90500 and with coil former type A:

curve a:	L = 2.5 μH,	15 turns,	6 x 0.04 CuLS
b:	L = 2.5 μH,	15 turns,	1 x 0.14 CuL, 0.18 mm pitch
c:	L = 3.2 μH,	17 turns,	8 x 0.03 CuLS
d:	L = 4.0 μH,	19 turns,	6 x 0.03 CuLS
e:	L = 4.0 μH,	19 turns,	1 x 0.1 CuL, 0.13 mm pitch

7×7 mm COIL ASSEMBLIES

A 53389



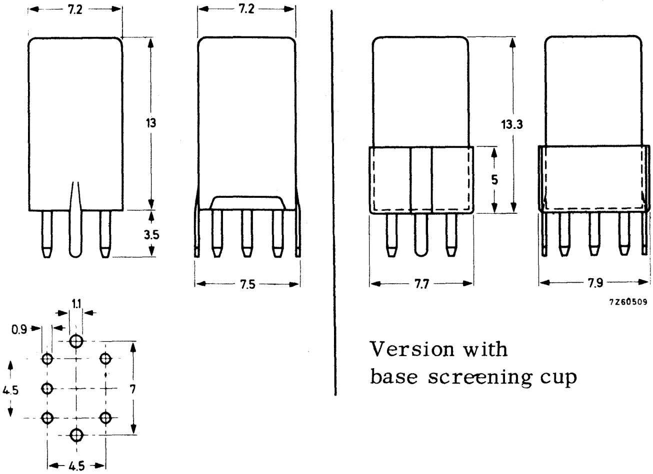
The 7 x 7 mm coil assemblies are intended for use in r.f. and oscillator circuits, in i.f. and band-pass filters of radio and television receivers and in hybrid filters. They can be mounted on silk screen etched printed-wiring boards with a grid pitch of 2.25 mm.
The coils have a high Q, a wide inductance trimming range and a linear trimming curve. A range of standard types, with and without built-in capacitor, is available. It is recommended to select coils from this range; if modifications are unvoidable they should be kept down to the bare minimum, e.g. by the omission or addition of a winding or a capacitor.
For loose components, data and graphs relating to number of turns and Q, we refer to the section "Components for 7 x 7 mm coil assemblies".

For manufacture of special coils to customer specifications, the following procedure applies.
We manufacture a few sample coils to a preliminary specification and deliver them to the customer for incorporation in development prototype. When the customer has trimmed these to his satisfaction, he returns a specimen coil to us as a manufacturing standard, with the position of the adjustor specified. All subsequent coils will be manufactured to conform to this standard.
(For production engineering reasons, we may make design modifications that affect neither the electrical performance nor the mechanical outline.)

MECHANICAL DATA

Dimensions in mm

Fig. 1



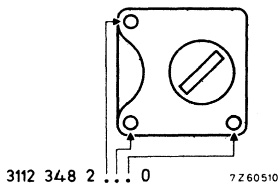
Colour code

The catalogue number of a coil is indicated by colour dots on the top of the can. The dots represent the 9th, 10th and 11th digit of the catalogue number (which are given in the type list).

The code, which is to be read in counterclockwise direction (see Fig. 2), is as follows:

Numeral	0	1	2	3	4	5	6	7	8	9
Colour	black	brown	red	orange	yellow	green	blue	violet	grey	white

Fig. 2



If the first digit is a zero the colour dot has been omitted.

ELECTRICAL DATA

	Coil former type *)								
	A (1 section) almost fully wound				B (2 small sections) lower section wound				D (1 small section)
U-frame core	4C6	4A4	4C6	4A4	4C6	4A4	4C6	4A4	4A4
Adjustor	4C6	3D3	4C6	3D3	4C6	3D3	4C6	3D3	3D3
Frequency (MHz)	2 to 20	≤ 2	2 to 20	≤ 2	2 to 20	≤ 2	2 to 20	≤ 2	≤ 2
Capacitor (pF)	built-in ≤ 120 N150		external		built-in ≤ 120 N150		external		external
Trimming range: $\frac{\Delta L}{L}$ (%)	±15	±25	±15	±25	±20	±30	±20	±30	±60
$\frac{\Delta f}{f}$ (%)	±3	±5.5	±4	±7	±5	±7	±6	±9.5	+58 −21
trimming slope $\frac{\Delta f}{f}$ per degree x 10^{-3}	0.2	0.3	0.2	0.3	0.25	0.35	0.25	0.35	0.25
Temp. coefficient (ppm/degC) Tamb = -20 to +20 °C	0 ±85		−75 ±70		−		0 ±85		+35 ±85
Tamb = +20 to +60 °C	0 ±85		−75 ±70		−		0 ±85		+35 ±85

*) See section "Components for 7 x 7 mm coil assemblies".

AVAILABLE TYPES

serial number	designation		f (MHz)	L (μH)	Q	number of turns			
						circuit winding		coupling winding	
01	i.f. circuit,	prim.	10.7	2.2	106		14	2	
02	i.f. circuit,	sec.	10.7	2.08	90		14	3	
03	i.f. coil,	prim.	10.7	1.05	90		10	2	
06	i.f. coil,	prim.	10.7	1.07	95		10	2	
07	i.f. circuit,	prim.	0.46	1150	125	185	95	3	
08	det. circuit,	a.m.	0.46	750	94	115	115	60	
09	i.f. circuit,	sec.	0.46	1180	125		280		
10	i.f. coil,	prim.	0.46	116	113		90		
11	i.f. circuit,	sec.	0.46	555	128		195	1	
12	det. coil,	a.m.	0.46	40.3	84		56	30	
14	i.f. circuit		10.7		108	11	10	1	
15	i.f. circuit		10.7	4.33	110	11	10		
16	det. circuit,	prim.	10.7	2.35	92		15	2	6
17	det. circuit,	sec.	10.7	5.1	95	11	11	2	
18	det. circuit,	a.m.	0.46	64	105	34	34	10	
19	i.f. coil,	prim.	0.46	126	118		90	2	
20	i.f. coil,	prim.	0.46	25	75		42	3	
21	i.f. circuit		0.46	35.5	90		50	3	
22	i.f. circuit		0.46	1170	120	180	100	3	
23	i.f. circuit		10.7	2	102		14	1	
24	i.f. circuit		10.7	2.03	104		14	1	
25	m.w.+l.w. osc. coil		1.2	162	103	98	4	12	
26	i.f. coil		10.7	2.73	74	5	12	10	
27	i.f. circuit		10.7	4.38	88	11	11	2	
28	i.f. circuit		10.7	5.32	116	12	11		
29	i.f. coil,	prim.	0.46	78	82		75	3	
30	det. coil		0.46	207	110		120	60	
31	i.f. circuit,	prim.	10.7	4.4	102		21	3	
32	i.f. circuit,	sec.	10.7	2.45	92		16	2	
33	i.f. circuit,	prim.	10.7	2.15	108		14	3	
34	i.f. circuit,	sec.	10.7	2.08	100		13	2	
35	i.f. circuit,	prim.	10.7	2.15	92	4	10	3	
36	i.f. circuit,	sec.	10.7	1.96	92		13	3	
37	i.f. circuit		0.46	750	116	115	115	27	
38	i.f. circuit		0.46	770	116	22	208		
40	i.f. circuit		0.46	770	116	162	68		

capacitor (pF)		circuit number, Fig. 3	version1)	usable as filter with serial number	colour code		catalogue number
built-in	external				tens	units	3112 348 .....
100	–	30	*	02	black	brown	20010
100	–	31		01,03,06,56	black	red	20020
–	200	10	*	02	black	orange	20030
–	200	10	*	02	black	blue	20060
100	–	32		09	black	violet	20070
150	–	32	≁		black	grey	20080
100	–	21		20,21,22, 29,63,64	black	white	20090
–	1000	1		11,19,71	brown	black	20100
220	–	31		10,19	brown	brown	20110
–	2900	10			brown	red	20120
47	–	32			brown	yellow	20140
47	–	23			brown	green	20150
82	–	35	o	17	brown	blue	20160
39	–	33	o	16	brown	violet	20170
–	1800	–	o		brown	grey	20180
–	1000	–		10	brown	white	20190
–	4700	–		09	red	black	20200
–	3300	10		09	red	brown	20210
100	–	32		09	red	red	20220
100	–	30			red	orange	20230
–	110	10			red	yellow	20240
–	105	11			red	green	20250
–	70	11			red	blue	20260
47	–	33			red	violet	20270
47	–	23			red	grey	20280
–	1500	10		09	red	white	20290
–	560	–			orange	black	20300
47	–	31	*	32	orange	brown	20310
82	–	31		31	orange	red	20320
100	–	30	*	34	orange	orange	20330
100	–	31		33	orange	yellow	20340
100	–	32	*	36	orange	green	20350
100	–	31		35	orange	blue	20360
150	–	32			orange	violet	20370
150	–	22			orange	grey	20380
150	–	22			yellow	black	20400

serial number	designation	f (MHz)	L (μH)	Q	number of turns circuit winding		coupling winding
41	osc. coil	26.66	1.67		17	7	
42	r.f. circuit coil I	27.12	1.63		17	7	
43	r.f. circuit coil II	27.12	1.4			22	21
44	det. circuit, prim.	10.7	2.03	84		14	11
45	det. circuit, sec.	10.7	5.3	114	11	11	4
46	det. circuit, prim.	10.7	2.03	84		14	11
47	det. circuit, sec.	10.7	5.3	114	11	11	4
48	i.f. coil	10.7	1.38	80		11	
49	i.f. circuit	10.7	4.65	65		21	2
50	i.f. circuit	10.7	2.51	77		15	1
51	i.f. circuit	10.7	2.5	77		15	
52	i.f. circuit	10.7	2.68	77		16	1
53	i f. circuit	10.7	2.6	77		15	
54	i.f. coil, prim.	0.46	74	105		70	8
55	i.f. coil, sec.	0.46	78	105		71	
56	i.f. coil, prim.	10.7	5.2	125		21	2
57	l.w. coil	0.46	105	102		82	
58	m.w. coil	1.2	20	145		41	
59	l.w. coil	0.46	408	95		185	
61	l.w. coil	0.46	470	94		199	
62	m.w. coil	1.2	8.5	95		27	
63	i.f. circuit, prim.	0.46	1160	125		280	3
64	i.f. coil, prim.	0.46	77.5	107		72	4
65	i.f. circuit, prim.	10.7	2.26	100	7	7	2
66	i.f. circuit, sec.	10.7	2.08	97		14	2
67	i.f. circuit	10.7	2.10	95		14	1
68	s.w. coil	6	3.2	105		16	4
69	s.w. coil	6	5	105		21	
70	det. coil	0.46	207	110		120	60
71	i.f. coil, prim.	0.46	126	118		90	2
72	i.f. coil	0.46	146	140		95	5
73	s.w. coil	6	6.67	95		25	4
74	l.w. coil	0.46	53	110		58	
75	l.w. coil	0.46	144	108		95	
76	l.w. coil	0.46	1138	145	135	135	
77	i.f. coil	0.46	118	105		90	3
79	i.f. coil	0.46	36	90		50	4
80	m.w. osc. coil	1.2	163	105	95	7	3

capacitor (pF) built-in	capacitor (pF) external	circuit number, Fig. 3	version[1])	usable as filter with serial number	colour code tens	colour code units	catalogue number 3112 348 .....
15	–	22			yellow	brown	20410
–	17	2			yellow	red	20420
15	–	30			yellow	orange	20430
82	–	31		45	yellow	yellow	20440
39	–	33	*	44	yellow	green	20450
82	–	31	⌿	47	yellow	blue	20460
39	–	33	⌿ *	46	yellow	violet	20470
–	160	–			yellow	grey	20480
47	–	31			yellow	white	20490
82	–	30			green	black	20500
82	–	–			green	brown	20510
82	–	–			green	red	20520
82	–	21			green	orange	20530
–	1500	10	*	55	green	yellow	20540
–	1500	1		54	green	green	20550
–	39	10	*	02	green	blue	20560
–	1100	1			green	violet	20570
–	860	1			green	grey	20580
–	290	1			green	white	20590
–	245	1			blue	brown	20610
–	2040	1			blue	red	20620
100	–	31		09	blue	orange	20630
–	1500	10		09	blue	yellow	20640
100	–	32	*	66	blue	green	20650
100	–	31		65	blue	blue	20660
100	–	31			blue	violet	20670
–	214	10			blue	grey	20680
–	137	1			blue	white	20690
–	560	10	⌿		violet	black	20700
–	950			10	violet	brown	20710
–	835	10			violet	red	20720
–	102	10			violet	orange	20730
–	2260	1			violet	yellow	20740
	845	1			violet	green	20750
–	106	2			violet	blue	20760
–	1025	10		09	violet	violet	20770
–	3300	10		09	violet	white	20790
–	105	11			grey	black	20800

serial number	designation	f (MHz)	L (μH)	Q	number of turns: circuit winding		number of turns: coupling winding	
81	i.f. coil	10.7	1.07	95		10	1	
82	det. coil	0.46	64.5	85	34	34	44	
83	i.f. coil	10.7	1.07	70		10		
84	m.w.+l.w.coil	1.2	36.3	142		53		
85	i.f. circuit, sec.	10.7	2.08	90		14	3	
86	i.f. circuit, prim.	10.7	2.26	100	7	7	2	
87	i.f. circuit, sec.	10.7	2.08	97		14	2	
88	i.f. coil	0.46	146	140		95	5	
89	i.f. coil	0.46	64	115		65	5	
90	i.f. circuit	0.46	570		158	65	3	

capacitor (pF) built-in	capacitor (pF) external	circuit number, Fig. 3	version[1])	usable as filter with serial number	colour code tens	colour code units	catalogue number 3112 348 .....
–	205	10			grey	brown	20810
–	1800	–	o		grey	red	20820
–		1			grey	orange	20830
–	475	1			grey	yellow	20840
100	–		a)		grey	green	20850
100	–	32	b) *	66, 87	grey	blue	20860
100	–	31	c)	65, 86	grey	violet	20870
–	835	10	d)		grey	grey	20880
–		10	o		grey	white	20890
150	–	–			white	black	20900

[1])

⌿ with base screening cup
* with coupling winding on head of coil former
o with insulating plate
a) as serial number 02, however, with insulating plate
b) as serial number 65, however, with insulating plate
c) as serial number 66, however, with insulating plate
d) as serial number 72, however, with insulating plate

Survey of standard circuits

If no coil with the required data can be found in the list of available types, we recommend that a choice be made from the following list of standard circuits. (Some of these circuits may not be found in the present list of coil types.)
As can be seen, the primary winding is always connected to pins 3-1, the secondary winding to pins 4-5, taps are connected to pin 2 and the capacitor to pins 3-1.
The start of the winding is marked ⊙ in the diagrams.

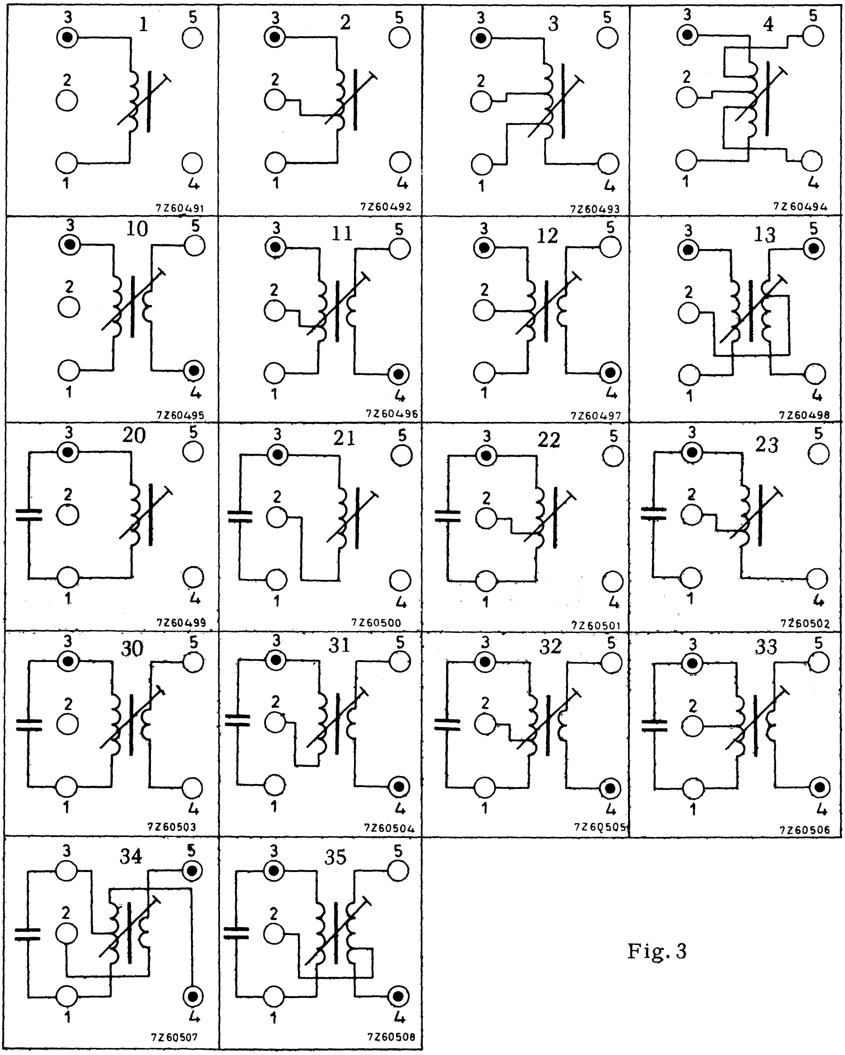
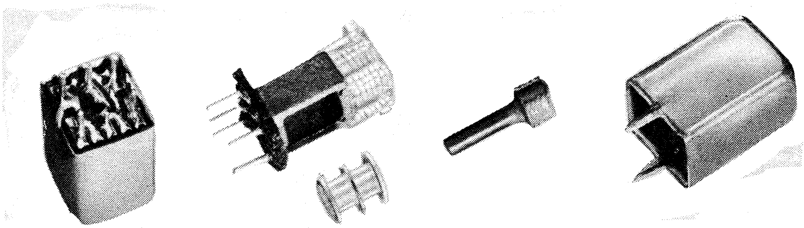


Fig. 3

COIL ASSEMBLIES
for transistorised radio receivers



RZ 16012-1

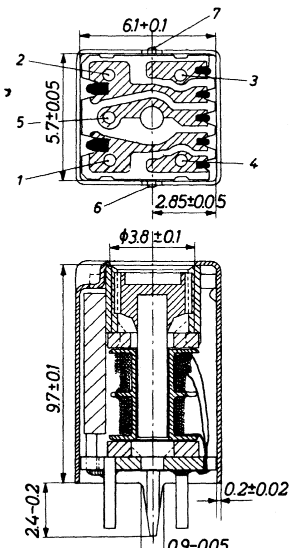
Inductance adjustment range	± 10%
Temperature coefficient	100.10^{-6} - 300.10^{-6}/deg C

GENERAL

These coils are designed for mounting in printed-wiring boards with an ϵ -grid ($\epsilon = \frac{e}{4} = 0.635$ mm).

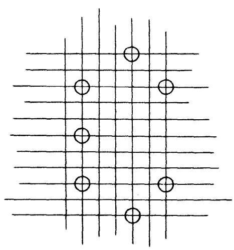
They can be supplied with a built-in capacitor (capacitance values 47, 82, 100 or 150 pF).

Dimensions in mm



7Z42541.1

Hole pattern

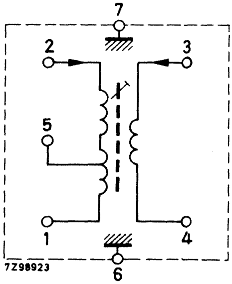


7Z42542

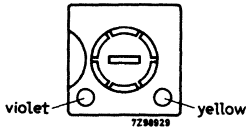
COIL ASSEMBLIES
for transistorised radio receivers

TYPES

Oscillator coil for m.w. and l.w. receivers AP1051/11

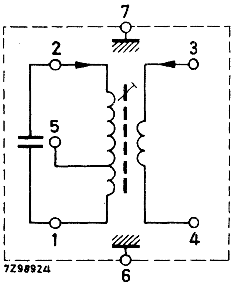


L_{1-2}	260 μH
Co_{1-2}	2.5 pF
Q_{1-2} (600 kHz)	125
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	1.5 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	8 %

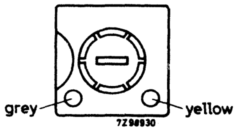


Marking

I.F. circuit for a.m. receivers AP1051/12

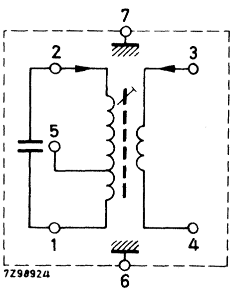


L_{1-2}	775 μH
C_{1-2}	150 pF
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	85
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	21.2 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	3.75 %
f_{1-2}	460 kHz

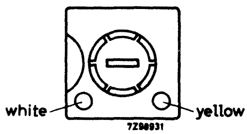


Marking

I.F. circuit for a.m. receivers AP1051/13

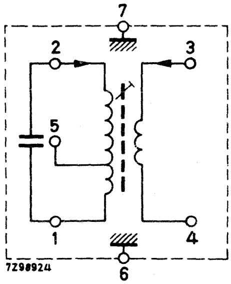


L_{1-2}	775 μH
C_{1-2}	150 pF
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	85
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	24 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	4.2 %
f_{1-2}	460 kHz

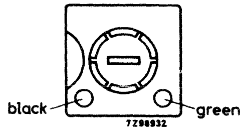


Marking

I.F. circuit for a.m. receivers AP1051/14

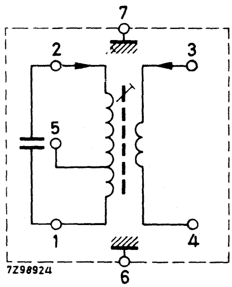


L_{1-2}	775 μH
C_{1-2}	150 pF
C_{o1-2}	6 pF
Q_{1-2} (460 kHz)	110
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	20.5 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	11.8 %
f_{1-2}	460 kHz

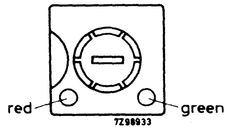


Marking

I.F. circuit for a.m. receivers AP1051/15

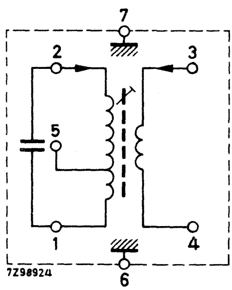


L_{1-2}	775 μH
C_{1-2}	150 pF
C_{o1-2}	6 pF
Q_{1-2} (460 kHz)	85
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	14.6 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	2.68 %
f_{1-2}	460 kHz

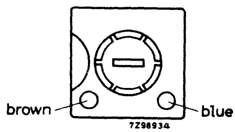


Marking

I.F. circuit for f.m. receivers AP1051/17

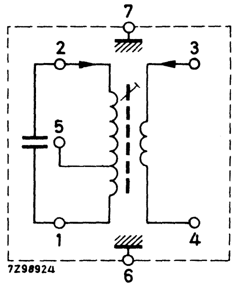


L_{1-2}	2.6 μH
C_{1-2}	82 pF
C_{o1-2}	3.5 pF
Q_{1-2} (10.7 MHz)	110
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	32 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	12.5 %
f_{1-2}	10.7 MHz

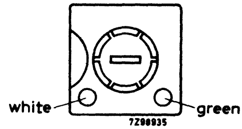


Marking

Detector circuit for f.m. receivers AP1051/18

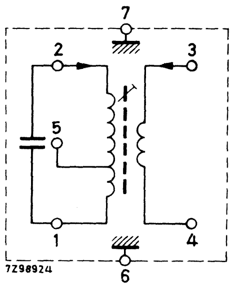


$L_{1\text{-}2}$	2.6 μH
$C_{1\text{-}2}$	82 pF
$C_{o1\text{-}2}$	3.5 pF
$Q_{1\text{-}2}$ (10.7 MHz)	105
$\frac{V_{1\text{-}5}}{V_{1\text{-}2}} \times 100\%$	50 %
$\frac{V_{3\text{-}4}}{V_{1\text{-}2}} \times 100\%$	32 %
$f_{1\text{-}2}$	10.7 MHz

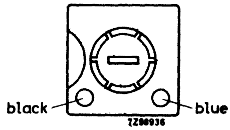


Marking

Detector circuit for f.m. receivers AP1051/19

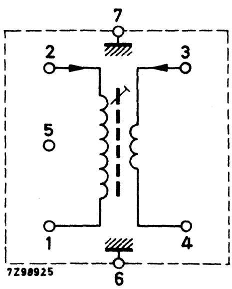


$L_{1\text{-}2}$	2.6 μH
$C_{1\text{-}2}$	82 pF
$C_{o1\text{-}2}$	3.5 pF
$Q_{1\text{-}2}$ (10.7 MHz)	110
$\frac{V_{1\text{-}5}}{V_{1\text{-}2}} \times 100\%$	50 %
$\frac{V_{3\text{-}4}}{V_{1\text{-}2}} \times 100\%$	12.5 %
$f_{1\text{-}2}$	10.7 MHz

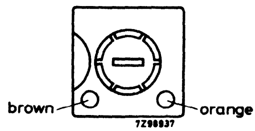


Marking

I.F. coil for a.m. receivers AP1051/20

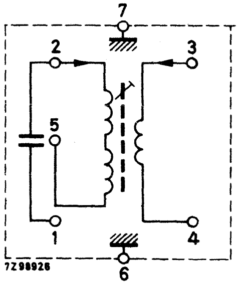


$L_{1\text{-}2}$	33 μH
$C_{o1\text{-}2}$	7 pF
$Q_{1\text{-}2}$ (460 kHz)	100
$\frac{V_{3\text{-}4}}{V_{1\text{-}2}} \times 100\%$	6.2 %
$f_{1\text{-}2}$	450-470 kHz

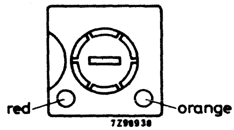


Marking

I.F. circuit for a.m. receivers AP1051/21

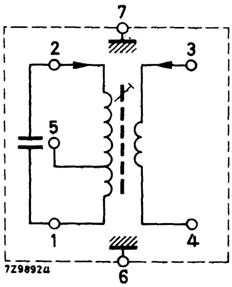


L_{2-5}	1300 μH
C_{1-2}	82 pF
$C_{o\,2-5}$	7.5 pF
$Q_{1/5-2}$ (460 kHz)	110
$\frac{V_{3-4}}{V_{2-5}} \times 100\%$	1.9 %
$f_{1/5-2}$	460 kHz

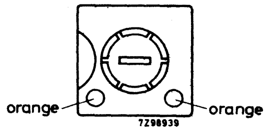


Marking

I.F. circuit for a.m. receivers AP1051/22

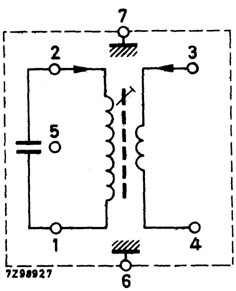


L_{1-2}	775 μH
C_{1-2}	150 pF
$C_{o\,1-2}$	7.5 pF
Q_{1-2} (460 kHz)	110
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	22.2 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	1.3 %
f_{1-2}	460 kHz

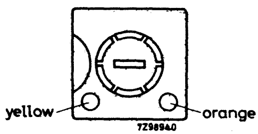


Marking

Detector circuit for a.m. receivers AP1051/23

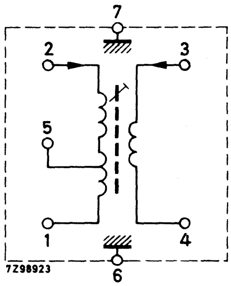


L_{1-2}	945 μH
C_{1-2}	100 pF
$C_{o\,1-2}$	7.5 pF
Q_{1-2} (460 kHz)	80
$\frac{V_{3-4}}{V_{1-2}} = 100\%$	66.6 %
f_{1-2}	460 kHz

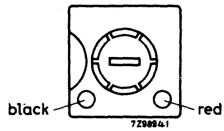


Marking

I.F. coil for a.m. receivers AP1051/24

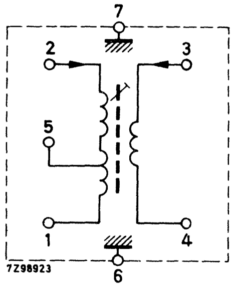


L_{1-2}	775 μH
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	140
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	34.4 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	2.6 %
f_{1-2}	450-470 kHz

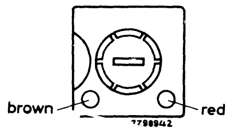


Marking

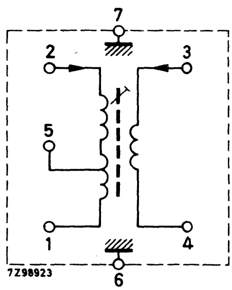
Detector coil for a.m. receivers AP1051/25



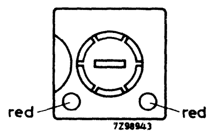
L_{1-2}	775 μH
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	125
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	33.3 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	21.3 %
f_{1-2}	450-470 kHz



Oscillator coil for m.w. and l.w. receivers AP1051/26

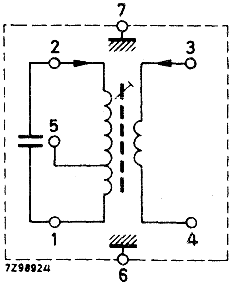


L_{1-2}	200 μH
Co_{1-2}	2.5 pF
Q_{1-2} (600 kHz)	125
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	1.6 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	9 %

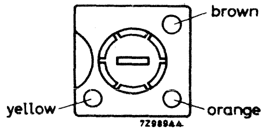


Marking

I.F. circuit for a.m. receivers AP1051/27

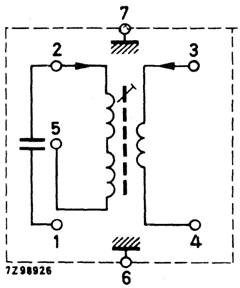


L_{1-2}	800 μH
C_{1-2}	150 pF
$C_{o\,1-2}$	6 pF
Q_{1-2} (460 kHz)	125
$\frac{V_{1-5}}{V_{1-2}}$ x 100%	47 %
$\frac{V_{3-4}}{V_{1-2}}$ x 100%	1.3 %
f_{1-2}	460 kHz

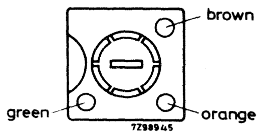


Marking

I.F. circuit for a.m. receivers AP1051/28

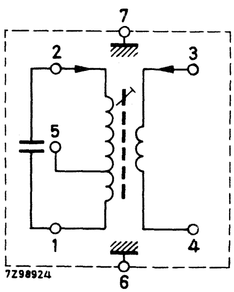


L_{2-5}	1180 μH
C_{1-2}	100 pF
$C_{o\,2-5}$	6 pF
$Q_{1/5-2}$ (460 kHz)	120
$\frac{V_{3-4}}{V_{2-5}}$ x 100%	2.2 %
$f_{1/5-2}$	460 kHz

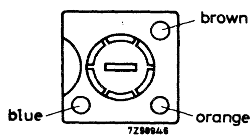


Marking

I.F. circuit for f.m. receivers AP1051/29

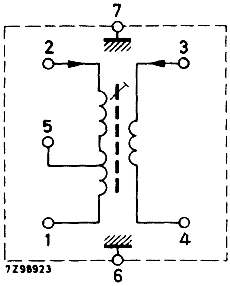


L_{1-2}	2.6 μH
C_{1-2}	82 pF
$C_{o\,1-2}$	3 pF
Q_{1-2} (10.7 MHz)	68
$\frac{V_{1-5}}{V_{1-2}}$ x 100%	60 %
$\frac{V_{3-4}}{V_{1-2}}$ x 100%	13.3 %
f_{1-2}	10.7 MHz

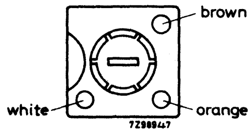


Marking

Oscillator coil for m.w. and l.w. receivers AP1051/30

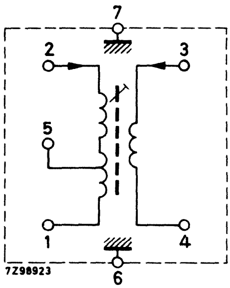


L_{1-2}	135 μH
Co_{1-2}	2.8 pF
Q_{1-2} (1200 kHz)	145
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	2 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	9.3 %

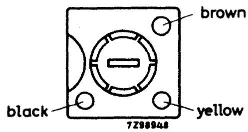


Marking

Oscillator coil for m.w. and l.w. receivers AP1051/31

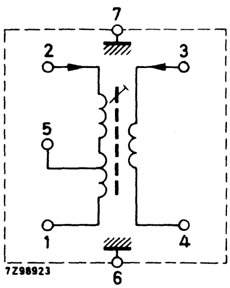


L_{1-2}	200 μH
Co_{1-2}	2.5 pF
Q_{1-2} (1200 kHz)	145
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	1.6 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	8.2 %

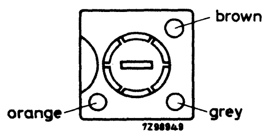


Marking

I.F. coil for f.m. receivers AP1051/32

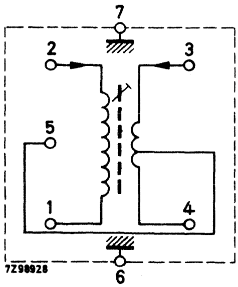


L_{1-2}	2.6 μH
Co_{1-2}	3 pF
Q_{1-2} (10.7 MHz)	70
$\frac{V_{1-5}}{V_{1-2}} \times 100\%$	60 %
$\frac{V_{3-4}}{V_{1-2}} \times 100\%$	13.3 %
f_{1-2}	10.7 MHz

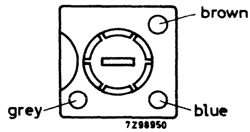


Marking

I.F. coil assembly for a.m. receivers AP 1051/33

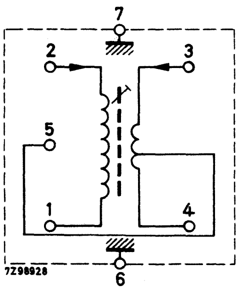


L_{1-2}	40 μH
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	130
$\frac{V_{3-4}}{V_{1-2}}$ x 100%	19.8 %
$\frac{V_{3-5}}{V_{1-2}}$ x 100%	11.6 %
f_{1-2}	450-470 kHz

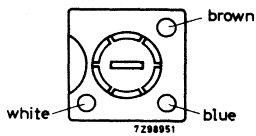


Marking

I.F. coil assembly for a.m. receivers AP1051/34

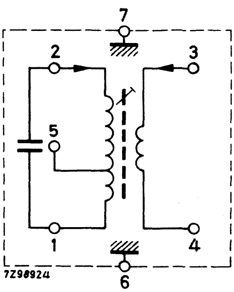


L_{1-2}	120 μH
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	135
$\frac{V_{3-4}}{V_{1-2}}$ x 100%	6.66 %
$\frac{V_{3-5}}{V_{1-2}}$ x 100%	5.56 %
f_{1-2}	450-470 kHz

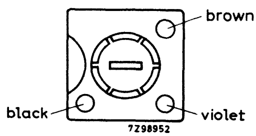


Marking

I.F. circuit for a.m. receivers AP1051/35



L_{1-2}	775 μH
C_{1-2}	150 pF
Co_{1-2}	6 pF
Q_{1-2} (460 kHz)	112
$\frac{V_{1-5}}{V_{1-2}}$ x 100%	36.1 %
$\frac{V_{3-4}}{V_{1-5}}$ x 100%	59 %
f_{1-2}	460 kHz

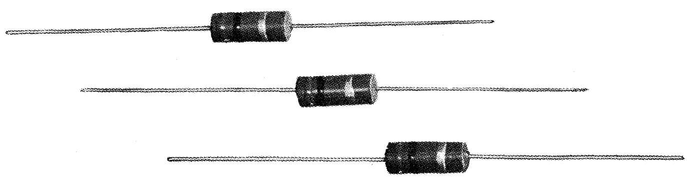


Marking

CATALOGUE NUMBERS (for ordering)

type number	catalogue number
AP1051/11	3122 107 30940
AP1051/12	30950
AP1051/13	30960
AP1051/14	30970
AP1051/15	30980
AP1051/17	3122 108 20570
AP1051/18	20550
AP1051/19	20560
AP1051/20	3122 994 93890
AP1051/21	93900
AP1051/22	93910
AP1051/23	93920
AP1051/24	3122 107 30990
AP1051/25	31000
AP1051/26	31010
AP1051/27	31020
AP1051/28	31030
AP1051/29	31040
AP1051/30	31050
AP1051/31	31060
AP1051/32	31700
AP1051/33	3122 108 91490
AP1051/34	91500
AP1051/35	91510

MICROCHOKES



RZ 24762-3

Inductances (at 100 kHz)	0.1 μH to 100 mH (E6 series)
Quality factor	25 to 50
Low d.c. resistance	
Very weak stray field	

APPLICATION

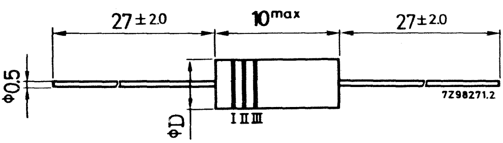
In coupling and decoupling circuits, equalising networks, interference suppression filters etc.

DESCRIPTION

The microchokes consist of a winding which is wound on a ferroxcube tube, magnetically shielded by a second ferroxcube tube and terminates in two axial leads of tinned copper. The microchokes are encapsulated.
The inductance value is indicated on the body by means of three coloured bands.

MECHANICAL DATA

Dimensions (in mm) and weight



inductance	D	weight
0.1-1000 μH	4 mm	0.4 g
1.5- 100 mH	6.5 mm	1 g

Terminal strength (pull)	23 N (2.3 kg)
Bending of terminals	not less than 1.5 mm from inductor body

Colour code

The colour code indicates the nominal value of the inductance in μH.

colour	band I first digit	band II second digit	band III multiplier
silver			10^{-2}
gold			10^{-1}
black	0	0	1
brown	1	1	10^{1}
red	2	2	10^{2}
orange	3	3	10^{3}
yellow	4	4	10^{4}
green	5	5	10^{5}
blue	6	6	10^{6}
violet	7	7	
grey	8	8	
white	9	9	

Examples:
brown-black-silver = 0.1 μH
red-red-black = 22 μH

ELECTRICAL DATA

→ The specification of the microchokes is based primarily on MIL specification C-15305C, style 4LT4, Family K.

The electrical values are valid at 25 ± 10 °C and a relative humidity of 45 to 75%.

Inductance tolerance at 1.2 V_{rms} and 100 kHz	±25%
Maximum voltage between a lead and the body	500 V_{rms}, 50 Hz
Insulation resistance between a lead and the body at 500 V_{dc}	> 10^3 MΩ
Crosstalk attenuation between two chokes touching each other over the full length	60 dB
Operating temperature range	−20 to +85 °C

Table 1. Microchokes of 0.1 to 1000 μH

Diameter = 4 mm, max. C_0 = 1 pF

nominal inductance 1) (μH)	quality factor Q	at freq. (MHz)	max. d.c. resistance (Ω)	d.c. current 2) (mA)	catalogue number
0.10	45	25	0.10	2900	2422 535 00107
0.15	45	25	0.12	2800	00157
0.22	45	25	0.14	2700	00227
0.33	45	25	0.17	2600	00337
0.47	45	25	0.21	1700	00477
0.68	45	25	0.25	1600	00687
1.0	45	25	0.31	1500	2422 535 00108
1.5	40	8	0.38	1200	00158
2.2	40	8	0.45	1100	00228
3.3	40	8	0.53	900	00338
4.7	40	8	0.63	650	00478
6.8	40	8	1.00	500	00688
10	40	8	1.70	300	2422 535 00109
15	40	2	0.55	250	00159
22	40	2	0.70	150	00229
33	40	2	0.90	120	00339
47	40	2	1.35	110	00479
68	40	2	1.6	100	00689
100	40	2	1.9	60	2422 535 00101
150	45	0.8	3.5	60	00151
220	45	0.8	6.5	50	00221
330	45	0.8	11	40	00331
470	50	0.8	20	35	00471
680	50	0.8	41	35	00681
1000	50	0.8	48	25	2422 535 00102

1) Chokes with inductance values between 0.1 μH and 100 mH and differing from those given in the table can be supplied at quantities of 10 000 or more.

2) Direct current at which the inductance decrease is 5% or less.

Table 2. Microchokes of 1.5 to 100 mH

Diameter = 6.5 mm

nominal inductance 1) (mH)	quality factor Q	at freq. (MHz)	max. d.c. resistance (Ω)	max. C_o (pF)	d.c. current 2) (mA)	catalogue number
1.5	50	0.25	25	4	100	2422 535 01152
2.2	50	0.25	30	4	100	01222
3.3	45	0.25	50	4.5	70	01332
4.7	45	0.25	60	5	60	01472
6.8	40	0.25	75	4.5	50	01682
10	40	0.1	90	4	40	2422 535 01103
15	40	0.1	110	3.5	20	01153
22	40	0.1	130	3	15	01223
33	35	0.1	275	3	12	01333
47	35	0.1	400	3.5	10	01473
68	30	0.1	470	3.5	9	01683
100	25	0.1	720	3.5	8	2422 535 01104

PACKAGING

A basic package contains 25 microchokes with the same inductance value, so please order in multiples of this quantity.

1) Chokes with inductance values between 0.1 μH and 100 mH and differing from those given in the table can be supplied at quantities of 10 000 or more.

2) Direct current at which the inductance decrease is 5% or less.

WIDE-BAND H.F. CHOKES

APPLICATION

See section "Beads for screening and damping and wide-band h.f.chokes" of chapter B "Ferrites for radio, audio and television".

TECHNICAL DATA

The chokes are supplied with six axial holes through which 1.5, 2.5 or 2 x 1.5 turns of tinned copper wire are threaded.
The table gives the types of choke that are currently available.

Dimensions in mm

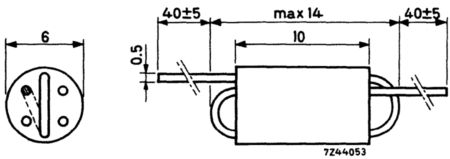


Fig. 1

number of turns	Z_{max} (kΩ)	f at Z_{max} (MHz)	decrease of impedance in the freq. range (MHz)	dB	grade	catalog number
1.5	0.35 ± 20%	120	10-300	≤7	3B	4312 020 36630
1.5	0.45 ± 20%	250	80-300	≤3	4B1	4312 020 36690
2.5	0.75 ± 20%	50	10-220, 30-100	≤7, ≤3	3B	4312 020 36640
2.5	0.85 ± 20%	180	50-300, 80-220	≤6, ≤3	4B1	4312 020 36700
2 x 1.5	0.90 ± 20%	50	10-220, 30-100	≤7, ≤3	3B	4312 020 36650
2 x 1.5	1.00 ± 20%	110	50-300, 80-220	≤7, ≤3	4B1	4312 020 36710

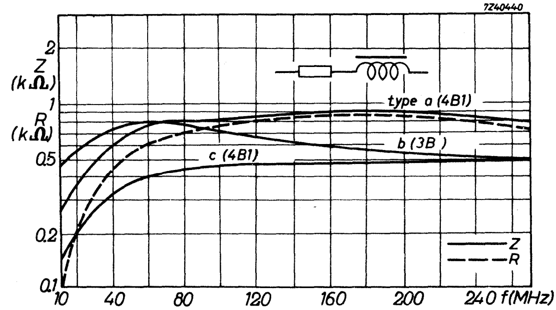


Fig. 2. Performance of three single chokes

Type a = 4312 020 36700
b = 4312 020 36640
c = 4312 020 36690

Fig. 2 shows some performance details of three single chokes. It will be noted that above approx. 80 MHz the impedance is substantially resistive and tends to be constant. Double chokes are used for twin leads, in which case the advantages of mutual inductance can be utilized.
Fig. 3 compares the typical obtainable performance.

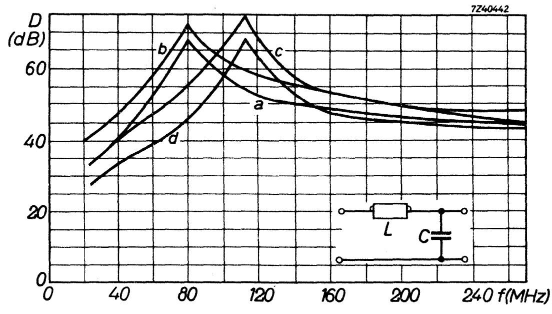


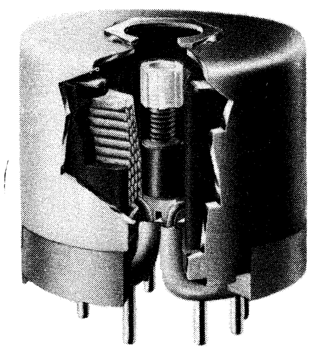
Fig. 3. Damping in an LC circuit consisting of a ferroxcube choke and a ceramic disc capacitor.

a. L = 4312 020 36690, C = 1500 pF
b. L = 4312 020 36700, C = 1500 pF
c. L = 4312 020 36700, C = 550 pF
d. L = 4312 020 36690, C = 550 pF

Ferroxcube potcores and square cores

GENERAL

INTRODUCTION



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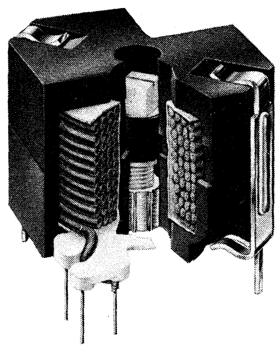


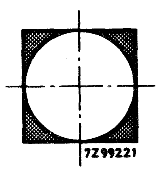
RZ 25252

Ferroxcube potcores and square cores have been developed for stable low loss filters, coils and transformers. Due to their closed shape they combine a low weight with a small volume.

The principal properties of potcores and square cores are the inductance, the quality factor Q, the temperature coefficient T.F., the disaccommodation factor D.F. and. if the core is used on higher induction values, the generation of third harmonics.

Our preferred types of potcore are called P-potcores; they are standardized in accordance with the international I.E.C., the German D.I.N. and the French C.C.T.U. specifications.

Our preferred types of square core are called RM cores, the I.E.C. and several national standardization committees are preparing standardization.



Square cores have the advantage over conventional (round) potcores that, if mounted on a printed wiring board, the space of the corners (see the adjoining sketch) is used.

SURVEY OF SYMBOLS

l_e	effective length of the magnetic path in cm
A_e	cross-section of a homogeneous part of the core in cm^2
μ_i	relative initial permeability, defined by: $$\mu_i = \frac{1}{\mu_0} \lim_{H \to 0} \frac{B}{H}$$
μ_e	relative effective permeability, defined by $$\mu_e = \frac{1}{\mu_0} \frac{\sum \frac{l_e}{A_e}}{\sum \frac{l_e}{\mu_i A_e}}$$
μ_{dif}	relative differential permeability, defined by $$\mu_{dif} = \frac{1}{\mu_0} \frac{dB}{dH}$$
V_e	effective volume of a core in cm^3 = volume of an ideal toroid in the same material grade and with the same magnetic properties as the core. V_e is calculated from: $$V_e = \frac{\left(\sum \frac{l_e}{A_e}\right)^3}{\left(\sum \frac{l_e}{A_e^2}\right)^2} cm^3$$
Δ	length of the air gap in mm
α	turns factor = number of turns for 1 mH
A_L	inductance factor in nanohenry per turn^2 (1 nH = 10^{-9} H)
$\hat{H}$	peak field strength in oersted
$\hat{B}$	peak induction in gauss
AT	amperes x turns
N	number of turns

$T.F. = \frac{1}{\mu_i^2} \cdot \frac{d\mu}{dT}$ — temperature factor = permeability variation per deg C over a certain temperature range.

$D.F. = \frac{\mu_1 - \mu_2}{\mu_1^2 \log \frac{t_2}{t_1}}$ — disaccommodation factor, which gives the permeability variation of the core, measured between 10 and 100 minutes after demagnetisation.

So $D = D.F. \times \mu_e \log \frac{t_2}{t_1}$

Curie point — critical temperature in $^{\circ}C$ above which the ferromagnetic body is paramagnetic.

$\frac{\tan \delta}{\mu_i}$ — constant for eddy current and residual losses together at a certain frequency, determined at $\hat{B} \leq 1$ gauss through the coil. The resulting R/L value for eddy current and residual losses is:

$$\frac{R}{L} = \frac{\tan \delta}{\mu_i} \times \mu_e \times 2 \pi f \ \Omega/H \qquad \text{(f in Hz)}$$

$q_{2-24-100}$ — constant for hysteresis losses standardized for an effective volume of 24 cm^3, $\mu_e = 100$ and measured between two currents, corresponding with two specified B_{max} values.

At 800 Hz for a given volume V_e and for an effective permeability μ_e, we obtain:

$$q_{2-V-\mu} = q_{2-24-100} \times \left\{\frac{\mu_e}{100}\right\}^{3/2} \times \sqrt{\frac{24}{V_e}} \ \Omega mA/H^{3/2}$$

$$\frac{R_h}{L} = q_{2-V-\mu} \times \sqrt{L} \times i \times \frac{f}{800} \ \Omega/H$$

(L in henry, f in Hz and i in mA)

ρ — specific resistance in Ω.cm measured with d.c. current.

$1 \text{ Gs} = 0.1 \text{ mT } (= 10^{-4} \text{ Wb/m}^2 = 10^{-4} \text{ Vs/m}^2)$

$1 \text{ Oe} = \frac{10^3}{4\pi} \text{ A/m} \approx 0.08 \text{ A/mm}$

$\mu_0 = 1 \text{ Gs/Oe} = 4 . 10^{-7} \text{ H/m}$

PRE-ADJUSTED CORES

In principle potcores and square cores with any μ_e value and A_L-factor can be manufactured. However, in practice the ranges are limited to the μ_e-values and A_L-factors required for the most important fields of application.

Recommended are the pre-adjusted cores which are provided with a nut for an adjustor. However, for those users who prefer to insert the nut themselves, some information is given under Mounting Data in this general part and under Mounting Parts in the data sheets.

For most μ_e-values and A_L-factors of the pre-adjusted cores a continuously variable adjustor mechanism can be delivered. These continuously variable adjustors are specially recommended if the coils are employed as filter coils. The maximum adjustment varies from 8 - 14 %, depending on the type.
For the potcores P26/16 and larger a step-by-step adjustor can be delivered, specially recommended if the coils are employed as loading coils. For detailed data see the relevant sections Inductance Adjustment in the data sheets.

When the aforementioned adjustors are used, coils with a higher μ_e value can be designed in order to obtain a maximum quality factor with a minimum volume, maintaining a small inductance tolerance field.

α AND A_L FACTORS

α is the number of turns for an inductance of 1 mH for a given core shape. For other inductance values the number of turns is $N = \alpha \sqrt{L}$ (L in millihenrys).

A_L is the inductance per turn^2 in nanohenrys (10^{-9} H) for a given core shape. For a given number of turns the total inductance is $L = N^2 A_L$ (L in nanohenrys).

The α and A_L values mentioned under "Pre-adjusted cores" in the data sheets are valid for cores without inductance adjustor. The adjustors give an increase in inductance of the potcores as given under "Inductance adjustment".

Measurement

The α and A_L factors given in the data sheets are guaranteed by means of a tolerance on the inductance, which is valid when the ten following measuring conditions are met:

1. The core should be magnetically conditioned (demagnetised). The α or A_L value should not be measured less than 24 hours after the conditioning (demagnetisation).

2. The mating surfaces should be carefully cleaned.

3. A standard coil as indicated in the following table should be used.

for series	catalog number of standard coil	number of turns			number of layers	diam. of copper (mm)
		total	per layer	upper layer		
P 9/5	7622 301 00101	65	11	10	6	0.20
P 11/7	7622 301 00301	71	12	11	6	0.25
P 14/8	7622 301 00501	90	13	12	7	0.30
P 18/11	7622 301 00701	83	12	11	7	0.45
P 22/13	7622 301 00901	71	12	11	6	0.60
P 26/16	7622 301 01101	71	12	11	6	0.70
P 30/19	7622 301 01301	104	15	14	7	0.70
P 36/22	7622 301 01501	135	17	16	8	0.70
P 42/29	7622 301 01701	199	20	19	10	0.80
P 66/56	7622 301 01901	231	29	28	8	1.20

4. The axial lines of the potcore halves should coincide.

5. The silver reference lines (if any) on the circumference of the potcore halves should coincide. If no reference lines are given, the halves may be positioned arbitrarily.

6. A force is applied to the flat sides of the core by means of rings. The inner diameter of these rings should be equal to the average value of the inner diameter of the core.

7. The force mentioned above should be as given in the relevant data sheets.

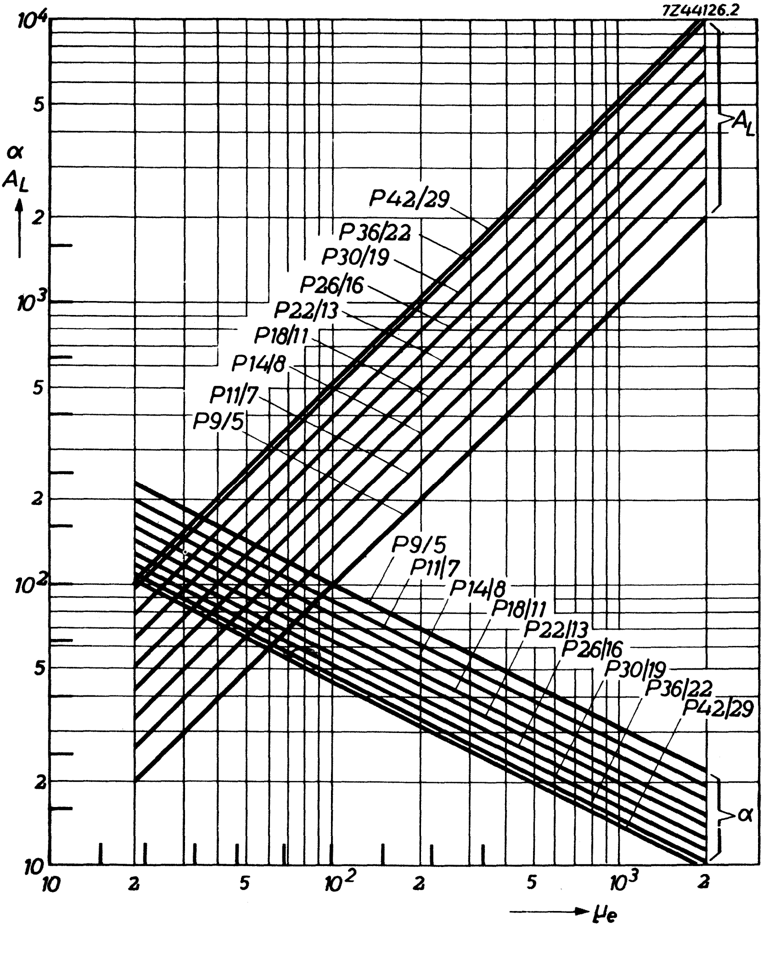
8. The temperature should be $23 \pm 2\ ^{o}C$.

9. The frequency should be 4 kHz.

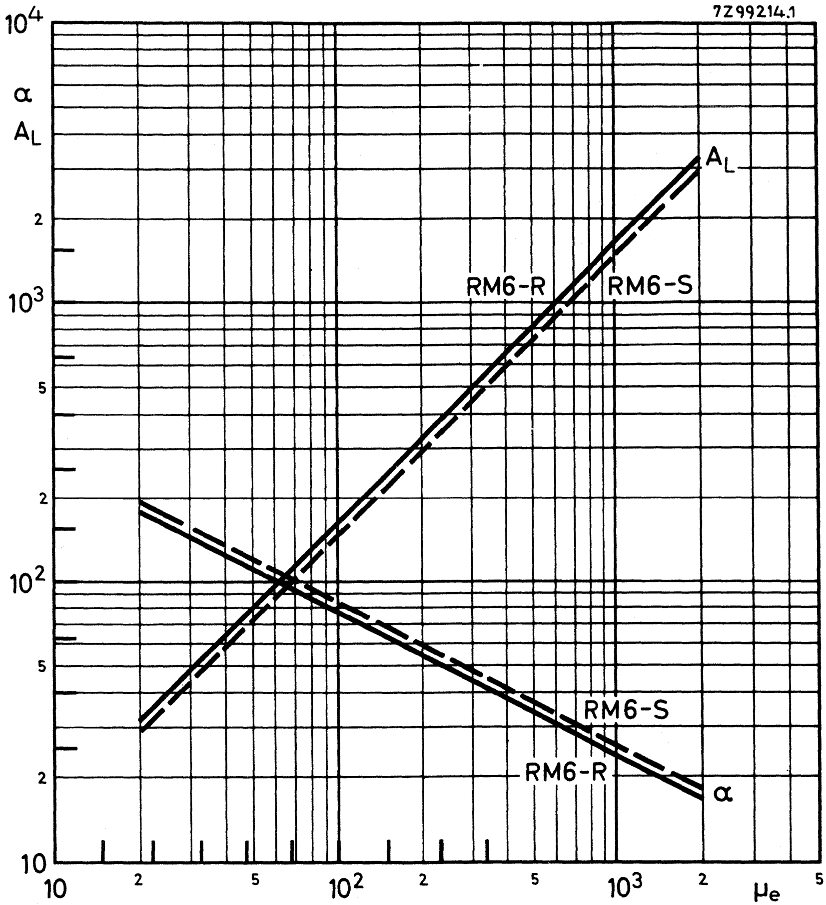
10. The current through or the voltage over the coil should correspond to a peak flux density ($\hat{B}$) in the core of ≤ 1 Gs.

Conversion of μ_e-values into α and A_L values

Potcores



Square cores



Q-CURVES

As so many assumptions have to be made in calculating filter cores, an accuracy in Q-factor of better than ± 15% is difficult to obtain. Because of this, the proper value of μ_e or A_L for a given core is best arrived at by comparing Q-curves for various values of μ_e.

Several curves are included for most potcores and square cores. To simplify comparison, the curves for a given core have been made using identical coil windings.

Consequently curves for different μ_e values and the same core size can be compared, as well as curves for the same μ_e value and different core sizes.

The Q-factors for inductances other than given in the curves may be found be interpolation or extrapolation, as necessary.

MEASUREMENT OF HYSTERESIS, EDDY CURRENT AND RESIDUAL LOSSES

The hysteresis constant for calculating the hysteresis losses is $q_{2-24-100}$, see the section Survey of Symbols. For the relation between the several hysteresis constants see the section Hysteresis Constants. For the guaranteed values, measuring frequencies and induction values see the relevant data sheets.

The eddy current and the residual losses are measured at an induction $\hat{B} \leq 1$ Gs and are expressed in a $\frac{\tan \delta}{\mu_i}$ value. For guaranteed values and measuring frequencies see the relevant data sheets.

The windings used for the measurement of the above mentioned quantities are indicated in the following table. The winding data refer to a single-section bobbin.

potcore	FXC grade	4 kHz	100 kHz	0.5 - 1 MHz	2 MHz	5 MHz	10 MHz
P 9/5	3B7/3H1	–	35 t/0.2 E	–	–	–	–
	4C6	–	–	–	17 t/40 x 0.04 E	8 t/0.30 E	6 t/0.30 E
P 11/7	3B7/3H1	–	42 turns 0.18 E	–	–	–	–
	3D3	–	42 turns 0.18 E	22 turns 0.10 E	–	–	–
	4C6	–	–	–	16 turns 45 x 0.04 E	6 turns 40 x 0.04 E.S.	3 turns 1 x 1.55 Cu
P 14/8	3B7/3H1	53 turns 0.25 E	37 turns 0.10 E	–	–	–	–
	3D3	–	37 turns 0.10 E	19 turns 8 x 0.04 E.S.	–	–	–
	4C6	176 turns 0.14 E	–	–	14 turns 0.40 E	6 turns 0.5 x 1.9 Cu	3 turns 0.7 x 1.9 Cu
P 18/11	3B7/3H1	42 turns 0.50 E	35 turns 0.14 E	–	–	–	–
	3D3	–	35 turns 0.14 E	16 turns 12 x 0.04 E.S.	–	–	–
	4C6	150 turns 0.25 E	–	–	12 turns 0.60 E	5 turns 0.7 x 2.75 Cu	2 turns 2.2 x 2.75 Cu
P 22/13	3B7/3H1	37 turns 0.60 E	29 turns 0.20 E	–	–	–	–
	3D3	–	29 turns 0.20 E	16 turns 40 x 0.04 E.S.	–	–	–
	4C6	140 turns 0.25 E	–	–	11 turns 0.70 E	4 turns 1.2 x 3.5 Cu	2 turns 2.8 x 3.5 Cu
P 26/16	3B7/3H1	34 turns 0.70 E	28 turns 0.28 E	–	–	–	–
	3D3	–	28 turns 0.28 E	14 turns 40 x 0.04 E.S.	–	–	–
	4C6	125 turns 0.40 E	–	–	10 turns 0.90 E	4 turns 2.0 x 4.0 Cu	2 turns 3.5 x 4.0 Cu

core	FXC grade	4 kHz	100 kHz	0.5 - 1 MHz	2 MHz	5 MHz	10 MHz
P 30/19	3B7/3H1	30 turns 1.0 E	23 turns 0.40 E	-	-	-	-
	3D3	-	23 turns 0.40 E	8 turns 2 x (100 x 0.04)E.S.	-	-	-
P 36/22	3B7/3H1	27 turns 1.2 E	22 turns 0.50 E	-	-	-	-
	3D3	-	22 turns 0.50 E	7 turns 2 x (100 x 0.04)E.S.	-	-	-
P 42/29	3B7/3H1	26 turns 1.8 E	20 turns 0.45 E	-	-	-	-
	3B5	33 turns 1.4 E	32 turns 0.45 E	-	-	-	-
P 66/56	3H1/3B5	21 turns 1.5 E	18 turns 1.5 E	-	-	-	-
RM6-R/ RM6-S	3B7/3H1	66 turns 0.35 E	20 turns 0.55 E				

CALCULATIONS

LOSSES IN A COIL

The losses can be divided into two groups:

Losses in the winding	Losses in the core
- d.c. copper losses	- hysteresis losses
- eddy current losses	- residual and eddy current losses
- dielectric losses	

The screening losses may be neglected when using ferroxcube potcores and square cores. So we can say:

$$\frac{R_t}{L} = \frac{R_o}{L} + \frac{R_{ec}}{L} + \frac{R_d}{L} + \frac{R_h}{L} + \frac{R_{e+r}}{L} \qquad \Omega/H \qquad \text{Eq. (1)}$$

For filter coils as a rule the maximum Q can be obtained if the sum of the copper losses is made equal to the sum of the core losses.

D.C. copper losses

D.C. losses are given with the formula:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times \text{constant } ^{*)} \qquad \Omega/H \qquad (2)$$

In this formula μ_e is the effective permeability of the magnetic circuit. f_{cu} is the space factor, which depends on the diameter and insulation of the wire in question, and the method of winding.

Eddy current losses in the winding

$$\frac{R_{ec}}{L} = \frac{C_{wcu}}{\mu_e} \times V_{cu} \times f^2 \times d^2 \qquad \Omega/H \qquad (3)$$

C_{wcu} is the eddy current copper factor, depending on the dimensions of the coil former and the core.

V_{cu} is the copper volume in cm^3
f is the frequency in Hz
d is the diameter of a single wire in cm

*) For this constant see the coil former data.

Dielectric losses

The capacitances of the coil are not loss-free. These capacitances have a loss angle tan δ_c which increases the a.c. resistance of a coil.

$$\frac{R_d}{L} = \left(\frac{2}{Q} + \tan\delta_c\right) \times \omega^3 \times L \times C \qquad \Omega/H \qquad (4)$$

in which Q is the quality factor of the coil.

ω = 2 x π x f
f in Hz
L in henry
C in farad

Hysteresis losses

These losses depend on the $q_{2-24-100}$ value of the ferroxcube grade concerned, the μ_e value, effective volume of the potcore, inductance and current.

$$\frac{R_h}{L} = q_{2\text{-}V\text{-}\mu} \times \sqrt{L} \times i \times \frac{f}{800} \qquad \Omega/H \qquad (5)$$

For $q_{2\text{-}V\text{-}\mu}$ see Survey of symbols.

Eddy current and residual losses

In the core data $\frac{\tan\delta_e}{\mu_1}$ is given as the sum of eddy current and residual losses.
We obtain:

$$\frac{\tan\delta_{e+r}}{\mu_i} = \frac{\tan\delta_e}{\mu_i} + \frac{\tan\delta_r}{\mu_i} = \frac{\tan\delta_r}{\mu_i} + K_1 f \qquad (6)$$

EXAMPLES OF CALCULATION

Example 1:

A filter coil has to be calculated for 2.75 mH with a maximum permissible temperature coefficient of +8.5 x 10^{-3} between +5 and +55 °C. The Q factor has to be at least 950 at 100 kHz, the alternating current through the coil is 1 mA.

For a positive temperature coefficient and because of the high frequency take ferroxcube grade 3H1.
The maximum μ_e value is calculated from the maximum temperature coefficient.

$$\text{t.c.} = \left(\frac{\Delta\mu}{\mu_i^2} \times \mu_e + C\right) \times \Delta T$$ (See T.F. in Survey of symbols) 1)

1) See also Product Information No.9: Relative Effective Permeability and Inductance Factor of Coils with Ferroxcube Core.

Assume $C = +20 \times 10^{-6}$, then:

$$\mu_e = \frac{t.c. - C \times \Delta T}{\frac{\Delta\mu}{\mu_i^2} \times \Delta T} = \frac{max.\ 8.5 \times 10^{-3} - 1000 \times 10^{-6}}{1 \times 10^{-6} \times 50} = max.\ 150$$

A comparison of different Q curves for grade 3H1 and $\mu_e = 150$ indicates that potcore P 18/11 is suitable. The pre-adjusted potcore with nut has cat. No. 4322 022 24270, the inductance adjustor to be used is 4322 021 30730.
To allow for ±5% inductance adjustment by the adjustor, the required inductance should be decreased by 5%, thus down to $0.95 \times 2.75 = 2.62$ mH without the adjustor.

The number of turns is $N = \alpha\sqrt{L} = 56.3\sqrt{2.62} = 91$.
The wire diameter can be found on the Ferroxcube Slide Rule: 63 x 0.04 E.S.
The coil formers 4322 021 3027 and 4322 021 30090 can be used.

Calculation of the losses

Eq. (2): $\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 16.4 \times 10^3$ Ω/H (see data P 18/11)

Say $f_{cu} = 0.38$ for this type of wire

$$\frac{R_o}{L} = \frac{1}{150} \times \frac{1}{0.38} \times 16.4 \times 10^3 = 286\ \Omega/H$$

Eq. (3): $\frac{R_{ec}}{L} = \frac{C_{wcu}}{\mu_e} \times V_{cu} \times f^2 \times d^2$ Ω/H

Assume $C_{wcu} = 100 \times 10^{-6}$

$$\frac{R_{ec}}{L} = \frac{100 \times 10^{-6}}{150} \times 0.28 \times 10^{10} \times 0.04^2 = 3\ \Omega/H$$

Eq. (4): $\frac{R_d}{L} = \frac{2}{Q} + \tan\delta_c\ \omega^3 \times L \times C$ Ω/H

Assume $\tan\delta_c = 0.01$ and $C = 8$ pF

$$\frac{R_d}{L} = \frac{2}{950} + 0.01 \times (2 \times \pi \times 10^5)^3 \times 2.62 \times 10^{-3} \times 8 \times 10^{-12} = 63\ \Omega/H$$

Eq. (5): $\frac{R_h}{L} = q_{2-V-\mu} \times \sqrt{L} \times i \times \frac{f}{800}$ Ω/H

$$q_{2-V-\mu} = q_{2-24-100} \times \left\{\frac{\mu_e}{100}\right\}^{3/2} \times \sqrt{\frac{24}{V_e}} \quad \Omega/H^{3/2}\ mA$$

Take $q_{2-24-100} = 0.8\ \Omega/H^{3/2}$ mA for grade 3H1 as an average value.

So $q_{2-V-\mu} = 0.8 \times \left(\frac{150}{100}\right)^3 \times \frac{\sqrt{24}}{1.12} = 6.72\ \Omega/H^{3/2}$ mA

Then $\frac{R_h}{L} = 6.72\sqrt{2.62 \times 10^{-3}} \times 1 \times \frac{10^5}{800} = 43\ \Omega/H$

Eq. (7): $\frac{R_{r+e}}{L} = \left\{\frac{\tan\delta_{e+r}}{\mu_i} - K_1 f\right\} \times \mu_e \times 2\pi f\ \Omega/H$

Take $\frac{\tan\delta_{e+r}}{\mu_i}$ at 100 kHz of grade 3H1 = 3.0×10^{-6} as an average value and

$K_1 = 0.3 \times 10^{-11}$

$\frac{R_{r+e}}{L} = (3 \times 10^{-6} - 0.3 \times 10^{-11} \times 10^5) \times 150 \times 6.28 \times 10^5 = 247\ \Omega/H$

Eq. (1): $\frac{R_t}{L} = \frac{R_o}{L} + \frac{R_{ec}}{L} + \frac{R_d}{L} + \frac{R_h}{L} + \frac{R_{r+e}}{L}\quad \Omega/H$

$= 286 + 3 + 63 + 43 + 247 = 642\quad \Omega/H$

Quality factor $Q = \frac{2\pi f}{R_t/L} = \frac{6.28 \times 10^5}{642} = 975$

The measured value was 980, according to the relevant Q curve. An accuracy within ±15% for coil calculations is generally regarded as very good, in view of the great number of variables to be taken into account.

Example 2

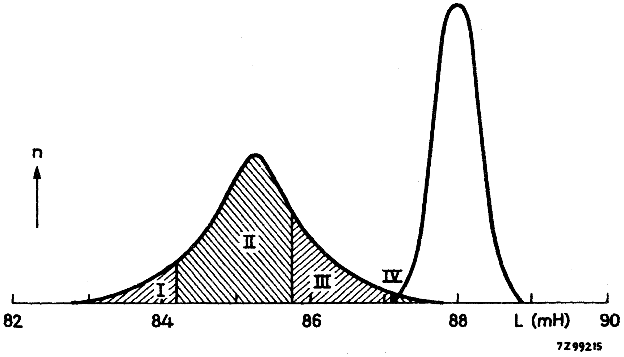
An 88 mH loading coil has to be calculated with optimum results in the smallest possible volume. The requirements are:

Tolerance on inductance	±1 %
D.C. resistance	≤ 4.8 Ω (thus $\frac{R_o}{L} \leq \frac{4.8}{0.088} \leq 53.5\ \Omega/H$)
A.C. resistance at 1800 Hz and 1 mA	≤ 5.8 Ω
Capacitance between the two line windings (C_{a-b})	≤ 200 pF
Inductance unbalance between the two line windings	≤ 0.1%
Resistance unbalance between the two line windings (ΔR_o)	≤ 0.1 Ω

In order to fulfil the requirement for the D.C. resistance we can take for instance potcore P 30/19, made 3H1, with A_L = 630 or P 26/16, grade 3H1, with A_L = 1000 (μ_e = 318). We choose the latter one because it is smaller.
The published inductance tolerance of ±3% (cores without adjustor) can be reduced to ±1% by using step-by-step adjustors; at the same time the number of turns can be made divisible by 4, as follows:
We choose an average inductance for the coils without adjustor lying more than 2% below the required 88 mH (88×10^6 nH).

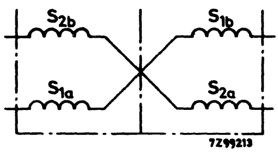
$$N \leq \sqrt{\frac{L}{A_L}} \leq \sqrt{\frac{88 \times 10^6 \times 0.98}{1000}} \leq 294 \text{ turns}$$

We take 292 turns because this number is divisible by 4; the corresponding inductance is 85.25 mH and it will have a tolerance of ±3%, which means values lying between 82.8 and 87.8 mH, see distribution curve.



Distribution curves of coils without (left curve) and with step-by-step adjustor

To shift the inductances to within ±1% distance from 88 mH (i.e. between 87.12 and 88.88 mH), we provide all coils of 82.8 to 84.2 mH (region I) with step-by-step adjustor No. 11, which gives a shift of 5.3% (4.4 mH).
For the coils falling in region II we use adjustor No. 8, for region III No. 4 and no adjustor for the remaining coils (IV).
In order to fulfil the requirements for capacitance and unbalance of inductance and resistance, we divide the 292 turns into four windings of 73 turns, to be wound on a two-section coil former as in the figure below.



Four-winding loading coil on a two-section coil former

The lowest value for R_0/L will be obtained when the available space on the coil former is completely filled with copper wire. Calculations indicate that copper wire with a diameter of 0.28 mm and double polyvinylformal insulation will do very well.

Calculation of the d.c. resistance

Eq. (2): $\frac{R_0}{L} = \frac{1}{318} \times \frac{1}{0.49} \times 7.79 \times 10^3 = 49.9\ \Omega/H$

Calculation of the a.c. resistance

Eq. (3): $\frac{R_{ec}}{L} \times \frac{C_{wcu}}{\mu_e} \times V_{cu} \times f^2 \times d^2 \quad \Omega/H$

Assume $C_{wcu} = 100 \times 10^{-6}$

then $\frac{R_{ec}}{L} = \frac{100 \times 10^{-6}}{318} \times 1 \times 3.24 \times 10^6 \times 0.28^2 = 0.8\ \Omega/H$

Eq. (4): $\frac{R_d}{L} = (\frac{2}{Q} + \tan\delta_c)\omega^3 \times L \times C_o \quad \Omega/H$

Assume Q at 1800 Hz = 200, C_o = 60 pF and $\tan\delta_c = 0.01$, then

$$\frac{R_d}{L} = (\frac{2}{200} + 0.01) \times (2\pi \times 1800)^3 \times 88 \times 10^{-3} \times 60 \times 10^{-12} = \text{negligible.}$$

Eq. (5): $\frac{R_h}{L} = q_{2\text{-}V\text{-}\mu} \times \sqrt{L} \times i \times \frac{f}{800} \quad \Omega/H$

$$q_{2\text{-}V\text{-}\mu} = q_{2\text{-}24\text{-}100} \times \left\{\frac{\mu_e}{100}\right\}^{3/2} \times \sqrt{\frac{24}{V_e}} \quad \Omega mA/H^{3/2}$$

Assume $q_{2\text{-}24\text{-}100} = 0.8$, then

$$q_{2\text{-}V\text{-}\mu} = 0.8 \times \frac{318\sqrt{318}}{1000} \times \sqrt{\frac{24}{3.53}} = 11.9\ \Omega mA/H^{3/2}$$

$$\frac{R_h}{L} = 11.9 \times \sqrt{0.088} \times 1 \times \frac{1800}{800} = 6.4\ \Omega/H$$

Eq. (7): $\frac{R_r}{L} = \left\{\frac{\tan\delta_{e+r}}{\mu_i} - K_1 f\right\} \times \mu_e \times 2\pi f \quad \Omega/H$

Take $\frac{\tan\delta_{e+r}}{\mu_i}$ at 1800 Hz = 0.5×10^{-6} as an average value and

$K_1 = 0.2 \times 10^{-11}$

$$\frac{R_{r+e}}{L} = (0.5 \times 10^{-6} - 0.2 \times 10^{-11} \times 1.8 \times 10^3) \times 318 \times 2\pi \times 1.8 \times 10^3 = 1.8\ \Omega/H$$

Eq. (1): $\frac{R_t}{L} = \frac{R_o}{L} + \frac{R_{ec}}{L} + \frac{R_d}{L} + \frac{R_h}{L} + \frac{R_{r+e}}{L} \quad \Omega/H$

$= 49.9 + 0.8 + 0 + 6.4 + 1.8 = 58.9\ \Omega/H$

or R_t at 1800 Hz and 1 mA = 5.18 Ω

So we see that the requirement for R_t at 1800 Hz - 1 mA is amply fulfilled and we also notice that the increase of resistance due to the a.c. losses is very low for ferroxcube 3H1.

HYSTERESIS CONSTANTS

The contribution of the hysteresis losses to the core losses is:

$$\frac{R_h}{L} \left(\frac{\text{ohm}}{\text{henry}}\right).$$

These losses can be calculated with the aid of several formulas with different constants:

Table I

	R	L	B	H	I	V	l_e	f
	units							
$\frac{R_h}{L} = q_{2-24-100} \sqrt{\frac{24}{V_e}} \sqrt{(\frac{\mu_e}{100})^3} \sqrt{L} \cdot I_{rms} \cdot \frac{f}{800}$	Ω	H			mA	cm^3		Hz
$\frac{R_h}{L} = a.\mu.\hat{B}.f$	Ω	H	G					Hz
$\frac{R_h}{L} = \frac{16}{3} \cdot \frac{\nu}{\mu^3} \cdot \mu^2 \cdot \hat{H}.f$	Ω	H		Oe				Hz
$\frac{R_h}{L} = \frac{h}{\mu^2} \cdot \mu^2 \cdot \frac{N I_{eff}}{l_{eff}} \cdot \frac{f}{800}$	Ω	H			A		cm	Hz
$\frac{R_h}{L} = \frac{h'}{\mu^2} \cdot \mu^2 \cdot H_{eff} \cdot f$	Ω	H		$\frac{A}{cm}$				kHz
$\frac{R_h}{L} = \eta_B \cdot \mu \cdot \hat{B} \cdot \omega \; (\omega = 2\pi f)$	Ω	H	T					Hz

Table II shows the conversion factors for the hysteresis constants given in Table I.

Table II

	$q_{2\text{-}24\text{-}100}$ x	a x	$\frac{\nu}{\mu^3}$ x	$\frac{h}{\mu^2}$ x	$\frac{h'}{\mu^2}$ x	η_B x
$q_{2\text{-}24\text{-}100}$ =	1	2.59×10^6	13.8×10^6	1.82×10^3	1.46×10^3	1.63×10^3
a =	0.386×10^{-6}	1	5.33	0.703×10^{-3}	0.563×10^{-3}	0.628×10^{-3}
$\frac{\nu}{\mu^3}$ =	72.4×10^{-9}	0.188	1	0.132×10^{-3}	0.106×10^{-3}	0.118×10^{-3}
$\frac{h}{\mu^2}$ =	0.549×10^{-3}	1.42×10^3	7.58×10^3	1	0.8	0.893
$\frac{h'}{\mu^2}$ =	0.686×10^{-3}	1.78×10^3	9.48×10^3	1.25	1	1.12
η_B =	0.615×10^{-3}	1.59×10^3	8.49×10^3	1.12	0.896	1

Example: $q_{2\text{-}24\text{-}100} = 1.46 \times 10^3 \times \frac{h'}{\mu^2}$

MARKING

MARKING OF POTCORES

Type of piece part	Type description	Position of description	Example
Separate halves without air gap diam. > 15 mm	dimensions, material, date and manufacturer	on the base	18/11 3H1 B9A
diam. ≤ 15 mm	material	on the base	3H1
	type, material, date and manufacturer	on the primary pack	P 14/8 3H1 - B9A
Separate halves with an air gap diam. > 15 mm	dimensions, material, date and manufacturer, air gap	on the base	26/16 3H1 B9A 0.5
diam. ≤ 15 mm	material, air gap	on the base	
	type, material, date and manufacturer, air gap	on the primary pack	P 14/8 - 3 B7 B9A - 0.3
Pre-adjusted potcores diam. > 15 mm	dimensions, material, date and manufacturer, μ_e or A_L	on the base	26/16 3B7 B9A μ33

Type of piece part	Type description	Position of description	Example
Pre-adjusted potcores (continued)	material μ_e or A_L	on the base	
diam. ≤ 15 mm with an air gap	type, material, date and manufacturer, μ_e or A_L	on the primary pack	P 14/8 - 3B7 B9A - μ33
diam. ≤ 15 mm without air gap	material, zero air gap	on the base	
	type, material, date and manufacturer, μ_e or A_L	on the primary pack	P 14/8 - 3B7 B9A - μ1400

MARKING OF SQUARE CORES

To be established.

MOUNTING DATA

ASSEMBLING

To obtain a stable inductance it is advisable to glue the coil former to the inside of one core half.
When the cores are assembled with the accessories, as stated in the relevant data sheets, they fulfil the normal requirements of temperature stability and stability against shock and vibration. However, if the requirements are extremely severe it is advisable to glue also the core halves to each other.

As the difference between the outer diameter of the adjustor of P-potcores and the diameter of the hole in the potcore is very small the potcore halves must be accurately centred. For small quantity production, assembly plugs are useful aids to this end. These assembly plugs are not supplied, however drawings are shown below.

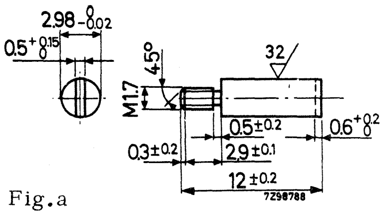


Fig.a

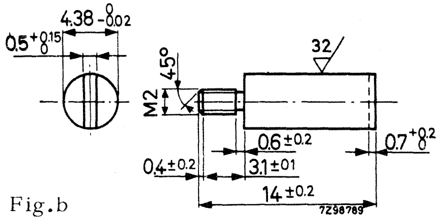


Fig.b

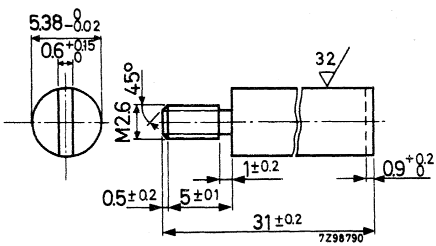


Fig.c

Assembly plugs for centring (a) for P 14/8 and P 18/11, (b) for P 22/13, (c) for P 26/16 to P 42/29. Recommended material is brass.

The centring must be done before any mounting parts are fitted.

The assembly plugs mentioned above can also be used during the impregnation process with wax or other compounds.
After impregnation the plugs must be removed and the inductance adjustors must be inserted; see pages "Inductance adjustment" of the potcore concerned.

For large quantity production special tools have been designed, which first centre the potcore halves and afterwards bend the lips of the containers.
These tools are not supplied, however drawings of the tools are sent on request, see table below.

core type	drawing number of tool
P 11/7	4322 058 00070
P 14/8	4322 058 00000
P 18/11	4322 058 00010
P 22/13	4322 058 00020
P 26/16	4322 058 00030
P 30/19	4322 058 00040
P 36/22	4322 058 00050
P 42/29	4322 058 00060

See also the section Mounting Parts in the data sheets.

INSERTING THE NUT FOR THE ADJUSTOR

The pre-adjusted cores can be supplied with a nut for the inductance adjustor, cemented into the hole of one of the potcore halves.

For those manufacturers however, who prefer to insert the nut themselves, the following remarks are given.
Push the nut into the centre hole of one of the core halves from the flat side. The recommended distance between the nut and the mating surface of the core is given under "Inductance adjustment".

Cement the nut in the hole of the core half. A suitable adhesive composition is:

1 weight part	Araldit	DY023	curing time 2 hours at 80 °C
5 weight parts	Araldit	CY230	
2.6 weight parts	Versamid	140	

The tools recommended for insertion of the nut are not supplied, but drawings are sent on request.

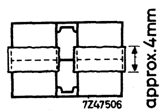
core type	drawing number of insertion tool
P 14/8 and P 18/11	7V48160
P 22/13	7V48161
P 26/16 - P 42/29	7V48198

Also for the dosating devices, recommended for wetting the insides of the centre hole with Araldit, are drawings available:

core type	drawing number of dosating tool
P 14/8 and P 18/11	7V12356
P 22/13	7V12353
P 26/16 - P 42/29	7V12341

CEMENTING

1. Remove all dust from the inside and outside of the core with a dry brush or with a rotating brushing machine.
2. Expose the core to a trichlore vapor bath of at least 10 seconds to remove all grease.
   After cleaning and degreasing, the core must be protected against dust and the joint surfaces must not be touched by hand.
3. Mix Araldit AY18 with hardener HZ18 in a weight ratio of 4:3. If desired, add chalk to the mixture in a maximum ratio of 1:1. The pot life is about two weeks, depending on temperature.
4. Place the coil in the core; if desired, cement the coil former to one of the core halves.
5. Centre the halves and put the core under pressure; the recommended pressure on the contact surface is 0.2 N/mm^2 (0.02 kg/mm^2).
6. Heat the core to about 35 °C to drive off any moisture.
7. Brush the adhesive onto the cylindrical surface of the core, to approximately 2 mm on each side of the parting line (see figure below).



With the core still under pressure (see 5 above) put it in a kiln for 1 hour at 70 °C followed by $1\frac{1}{2}$ hour at 100 °C to cure the adhesive. Cool the core to room temperature before releasing the applied pressure.

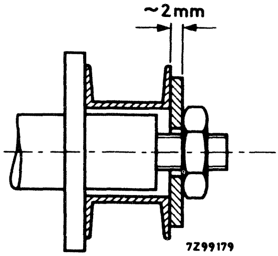
NOTES

1. In order to obtain coils which are very stable with temperature variations, it is recommended to subject the complete coil to about five temperature cycles from room temperature to 70 °C.
2. A suitable trimming device for potcores P 14/8 up to and including P 42/29 is the screwdriver available under catalog number 4322 021 31660.

COIL WINDING RECOMMENDATIONS

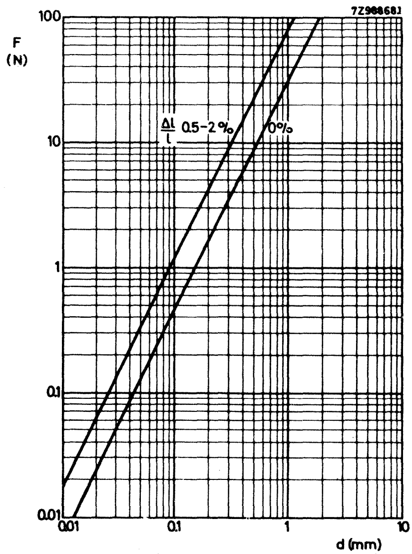
PROTECTION OF THE COIL FORMER

Because the flanges of coil formers are thin (down to 0.2 mm), it is necessary to protect them during winding, for instance, with a metal flange of 2 mm thickness, see figure:



WIRE TENSION

The following graph may be used to find the tension necessary in the wire during winding:



Wire tension (F) as a function of the wire diameter (d) with the occurring stretch ($\frac{\Delta l}{l}$) as parameter (1 N = 100 g)

POTCORES

POTCORES

INTRODUCTION

Three types of core can be supplied:

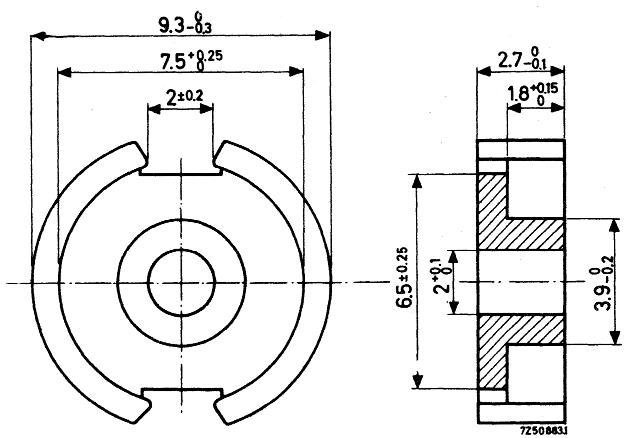
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E6 range of values or an inductance factor (A_L) in the R5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Gr. Britain).

Potcores and associated parts are ordered by their 12-digit catalog number.
Quantity: a primary pack contains 40 potcore halves or 20 pre-adjusted potcores, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 20970
3H1	4322 020 20980
4C6	4322 020 20940
3D3	4322 020 20900

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I

	temp. (^{o}C)	grade 3B7	3H1	3D3	4C6
T.F. x 10^6	+5 to +23	-	+0.5 to +1.5	-	-2 to +4
	+23 to +55	-	+0.5 to +1.5	-	0 to +6
	+23 to +70	-0.6 to +0.6	+0.5 to +1.5 1)	0 to +2	-
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 6	≤ 6	≤ 10	≤ 20

For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 25 Newton, the values in Table II are guaranteed at 25±10 ^{o}C.

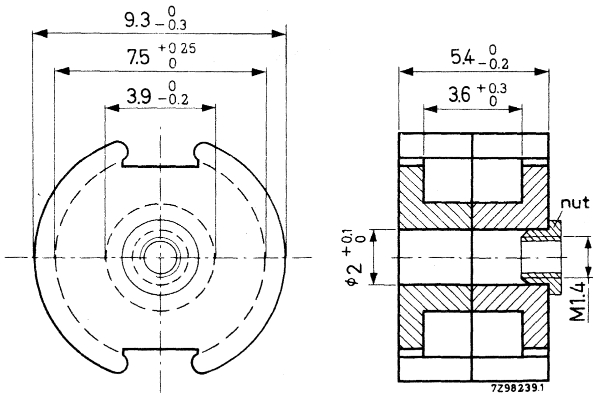
Table II

	$\hat{B}$ (Gs)	freq. (MHz)	grade 3B7	3H1	3D3	4C6
μ_e	≤ 1	0.1	≥ 915	≥ 915	≥ 475	≥ 93
α	≤ 1	0.1	32.7	32.7	≤ 45.5	≤ 103
$\frac{\tan \delta}{\mu_i} \times 10^6$	≤ 1	0.1	≤ 6	≤ 6	≤ 10	-
	≤ 1	0.5	-	-	≤ 14	-
	≤ 1	1	-	-	≤ 30	-
$q_{2-24-100}$	3-12	0.1			≤ 4	≤ 10
	15-30	0.004	≤ 2.0	≤ 1.8		

1) For orientation only.

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 6....
Without nut, catalog number = 4322 022 4.... — suffix, see table

Weight 1.3 g

Mean length of lines of force l_e = 1.25 cm

$\Sigma \frac{l_e}{A_e}$ = 12.4 cm^{-1}

Effective volume V_e = 0.126 cm^3

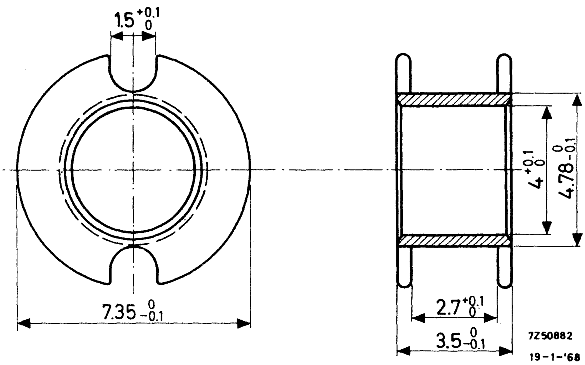
Potcores with standard A_L factors

The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.

A_L	corresponding μ_e-value	tolerance on inductance	Catal. No.: 4322 022 6.... with nut / 4322 022 4.... without nut		
			3B7	3H1	4C6
16	16	± 1%	–	–	1800
25	25	± 1	–	–	1810
40		± 1	–	–	1820 ←
63	63	± 1	1030	1230	–
100	100	± 1.5	1040	1240	–
160	160	± 2	1050	1250	–

Inductance $L = N^2 A_L$ (in 10^{-9} H)

COIL FORMER



Dimensions in mm

Type number	4322 021 31700
Material	polycarbonate K486
Window area	3.4 mm^2
Mean length of turn	1.9 cm
Maximum temperature	130 °C
D.C. losses	$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 69.5 \times 10^3 \; \Omega/H$
Weight	0.07 g

INDUCTANCE ADJUSTMENT

ADJUSTORS

The tolerances on inductance of the pre-adjusted potcores (without adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03% by means of a continuous inductance adjustor. Such an ădjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the lips of the adjustor head. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negigible.
The maximum permissible temperature is 110 °C.
Table II shows the type of adjustor recommended for different potcores.

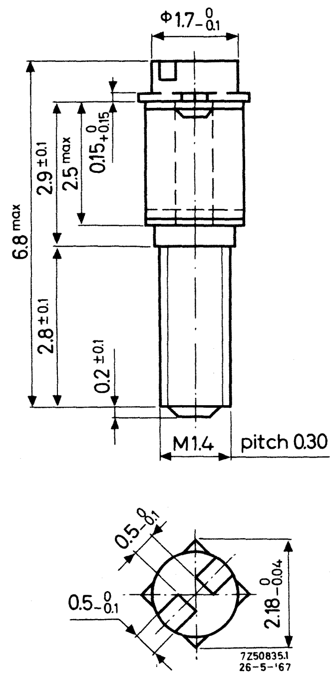


Table I, available types

colour	catalog number
green	4322 021 31250
yellow	4322 021 31270
brown	4322 021 31540

Table II, recommended application

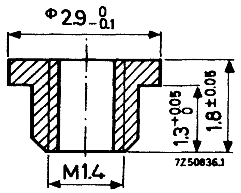
A_L	3B7/3H1/3D3
63	4322 021 31250
100	4322 021 31270
160	4322 021 31540

The adjustors are packed in bags of 100, so please order in multiples of 100.

Dimensions in mm

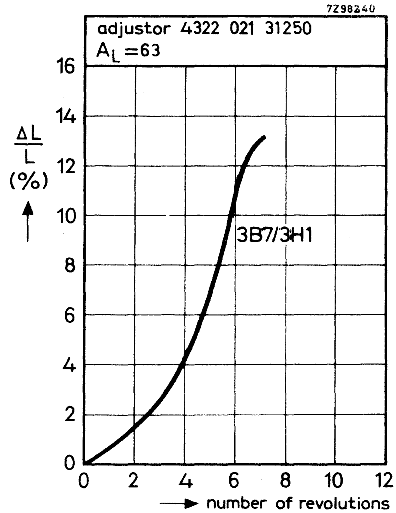
NUT FOR ADJUSTOR

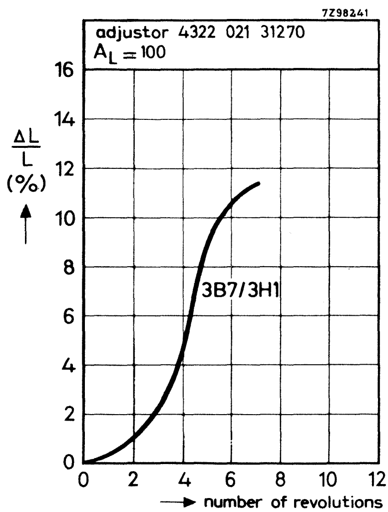
Material: brass,
nickel plated

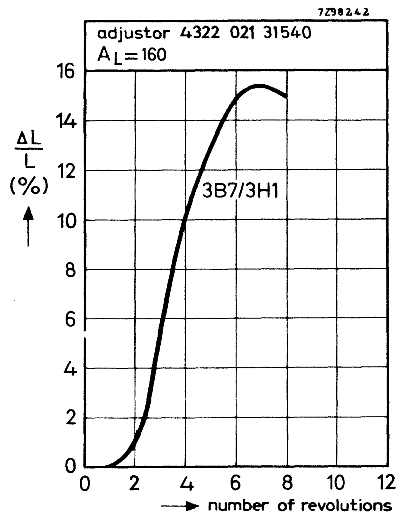


Loose nuts are not delivered.

ADJUSTMENT CURVES







POTCORES

INTRODUCTION

Three types of core can be supplied:

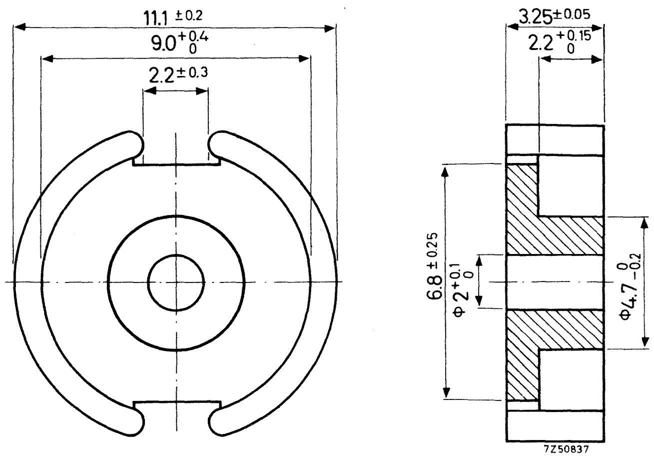
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E_6 range of values or an inductance factor (A_L) in the R_5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: **I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).**

Potcores and associated parts are ordered by their 12-digit catalog number.
Quantity: a primary pack contains 40 potcore halves or 20 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 21000
3H1	4322 020 21010
3D3	4322 020 21020
4C6	4322 020 21140

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (^{o}C)	grade				
		3B7	3H1	3D3		4C6
T.F. x 10^6	+5 to +23	-	+0.5 to +1.5	-		−2 to +4
	+5 to +55	-	-	-		-
	+23 to +55	-	+0.5 to +1.5	-		0 to +6
	+23 to +70	-0.6 to +0.6	1)	0 to 2		-
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 15		≤ 10

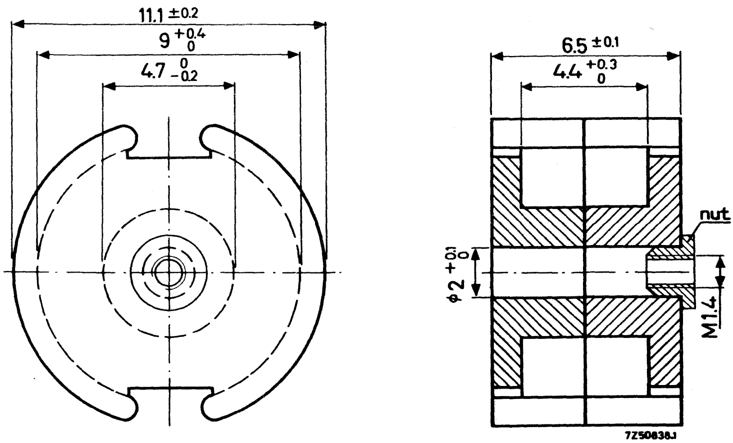
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 35 Newton, the values in Table II are guaranteed at 25+ 10 ^{o}C.

Table II	$\hat{B}$ (Gs)	freq. (MHz)	grade				
			3B7	3H1	3D3		4C6
μ_e	≤ 1	0.1	≥ 975	≥ 975	≥ 495		≥ 93
α	≤ 1	0.1	≤ 27.9	≤ 27.9	≤ 39.2		≤ 90.5
$\frac{\tan \delta}{\mu_i} \times 10^6$	≤ 1	0.1	≤ 5	≤ 5	≤ 8		
	≤ 1	0.5			≤ 14		
	≤ 1	1			≤ 30		
		2					≤ 40
		5					
		10					≤ 100
q2-24-100	3-12	0.1			≤ 3.0		≤ 10
	15-30	0.004	≤ 2.0	≤ 1.8			

1) For orientation: +0.5 to +1.5

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 2....
Without nut, catalog number = 4322 022 0....

Weight			1.8	g
Mean length of lines of force	l_e	=	1.55	cm
	$\Sigma \frac{l_e}{A_e}$	=	9.56	cm^{-1}
Effective volume	V_e	=	0.251	cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 15, grade 4C6, potcore with nut, catalog number = 4322 022 20810
   A_L = 100, grade 3B7, potcore without nut, catalog number = 4322 022 01040
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

Potcores with standard μ_e values [1])

μ_e	α	tolerance on inductance (%)	catal. No.: 4322 022 2.... with nut / 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
15	225	± 1	-	-	-	0810
22	186	± 1	-	-	-	0820
33	152	± 1	-	-	0430	0830
47	127	± 1	-	-	0440	-
68	105.8	± 1	0050	0250	0450	-
100	87.2	± 1.5	0060	0260	-	-
150	71.2	± 2	0070	0270	-	-
220	58.8	± 5	0080	0280	-	-
660	33.9	± 25	-	-	0400*	-
1300	24.2	± 25	0000*	0200*	-	-

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

Potcores with standard A_L factors [1])

A_L	corresponding μ_e-value	tolerance on inductance (%)	catal. No.: 4322 022 2.... with nut / 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
16	12.2	± 1	-	-	-	1800
25	19.0	± 1	-	-	-	1810
40	30.5	± 1	-	-	1420	1820
63	48	± 1	-	-	1430	-
100	76	± 1	1040	1240	1440	-
160	122	± 1.5	1050	1250	-	-
250	190	± 3	1060	1260	-	-

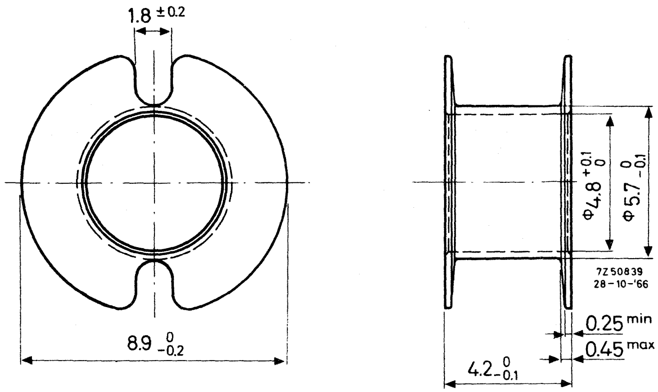
Inductance $L = N^2 A_L$ (in 10^{-9} H)

1) See Notes on the previous page.

* Only available without nut.

COIL FORMER

Dimensions in mm



Catalog number	4322 021 30240
Material	glassfibre-reinforced polyacetal ←
Window area	5.5 mm^2
Mean length of turn	2.3 cm
Max. temperature	130 °C
D.C. losses	$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 58.1 \times 10^3\ \Omega/H$
Weight	0.1 g

The dimensions conform with the following specifications: I.E.C.133 (international), and D.I.N.41 294 (Germany).

INDUCTANCE ADJUSTMENT

ADJUSTORS

The tolerances on inductance of the pre-adjusted potcores (without adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy $< 0.03\%$ by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.

The adjustor is screwed through the potcore into the nut and is held in position by the lips of the adjustor head. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.

The influence of the adjustors on the variability of the inductance is negligible.

The maximum permissible temperature is 110 ^{o}C.

Table II shows the type of adjustor recommended for different potcores.

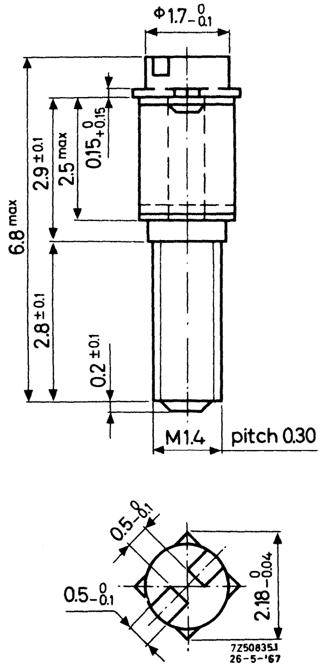


Table I, available types

colour	catalog number
green	4322 021 31250
red	4322 021 31260
yellow	4322 021 31270
grey	4322 021 31280
brown	4322 021 31540

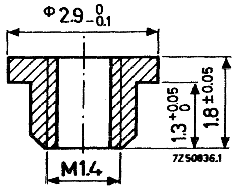
Table II, recommended application

μ_e	A_L	3B7/3H1/3D3
	40	4322 021 31250
33		4322 021 31250
	63	4322 021 31260
47		4322 021 31260
68		4322 021 31270
	100	4322 021 31270
100		4322 021 31540
150	160	4322 021 31540
	250	4322 021 31280
220		4322 021 31280

Dimensions in mm

The adjustors are packed in bags of 100, so please order in multiples of 100.

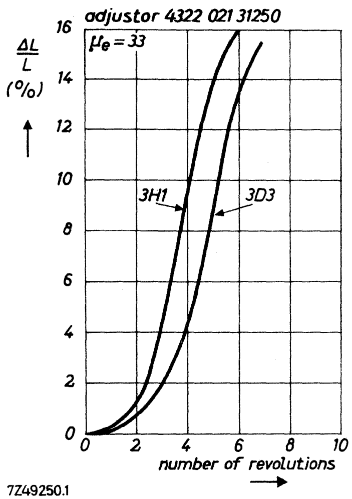
NUT FOR ADJUSTOR

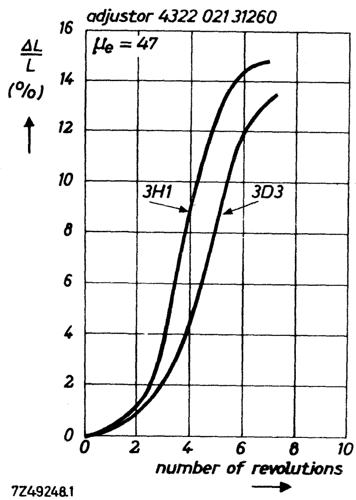


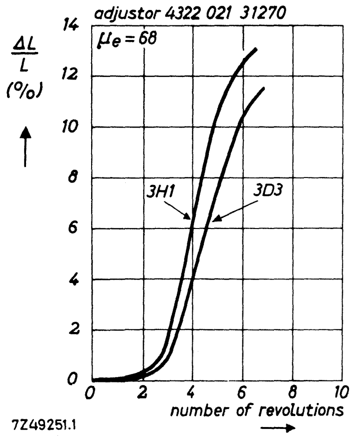
Material brass, nickel plated

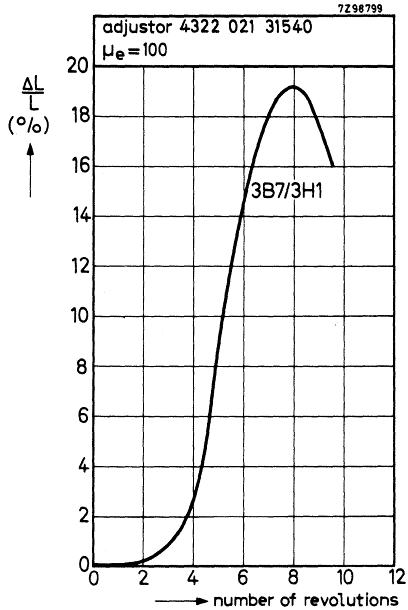
Loose nuts are not delivered.

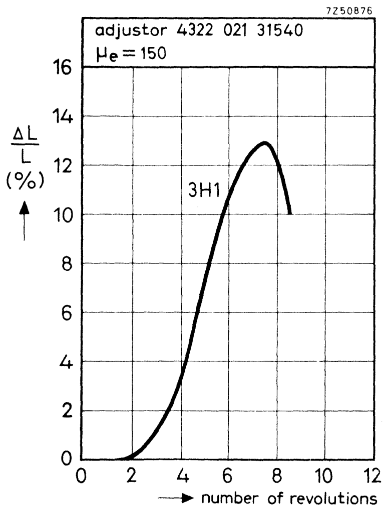
ADJUSTMENT CURVES

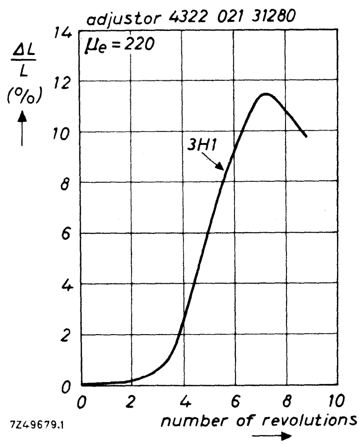





adjustor 4322 021 31270
$\mu_e = 68$
ΔL/L (%)
3H1
3D3
number of revolutions
7Z49251.1

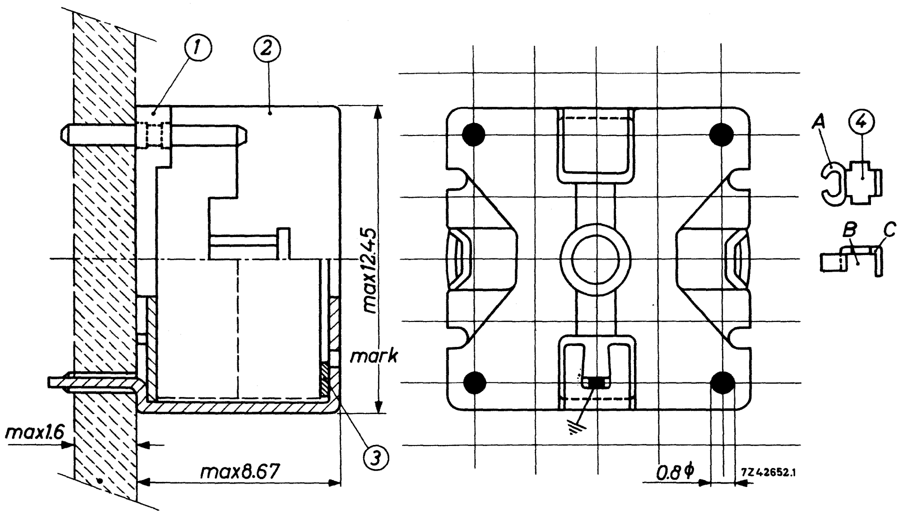

7Z98799
adjustor 4322 021 31540
$\mu_e = 100$
ΔL/L (%)
3B7/3H1
number of revolutions


7Z50876
adjustor 4322 021 31540
$\mu_e = 150$
ΔL/L (%)
3H1
number of revolutions


adjustor 4322 021 31280
$\mu_e = 220$
ΔL/L (%)
3H1
number of revolutions
7Z49679.1

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30180
(2) brass container	4322 021 30510
(3) spring	4322 021 30620
(4) soldering spring	4322 021 30700 (4x)

The core is suitable for mounting on printed-wiring boards.

The four soldering pins and the earth tag are arranged so as to fit a grid of 2.52 mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 1.6 mm. The board should be provided with holes of 1.3 $\pm$ 0.1 mm diameter.

If stranded wire is applied the use of a soldering spring (4) is recommended. Part A of this spring is put over the pin, then the wire is put in B and lip C is bent over. For solid wire the soldering spring is not strictly necessary.

The container is provided with an earth tag.

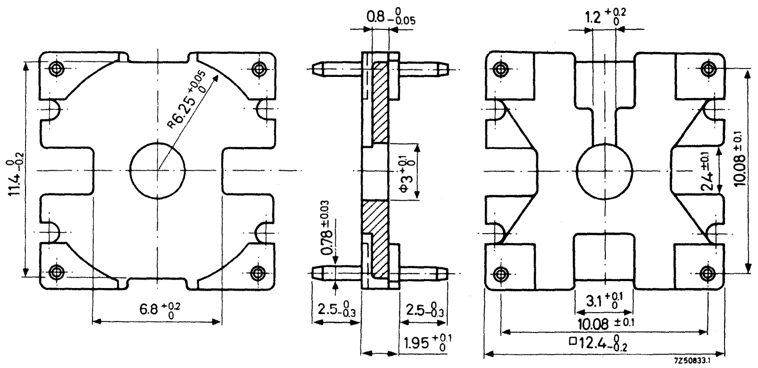
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 35 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

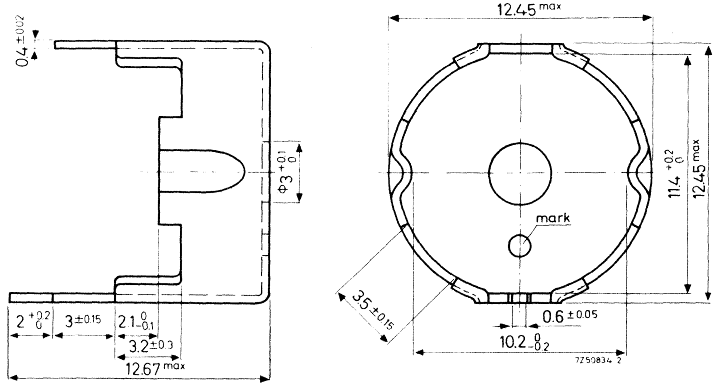
(1) Tag plate 4322 021 30180

Plate : reinforced polyester
Pins : phosphorbronze, dipsoldered



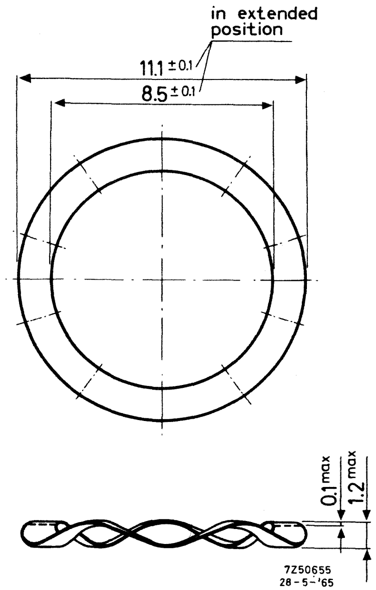
(2) Container 4322 021 30510

Material : brass, nickel plated



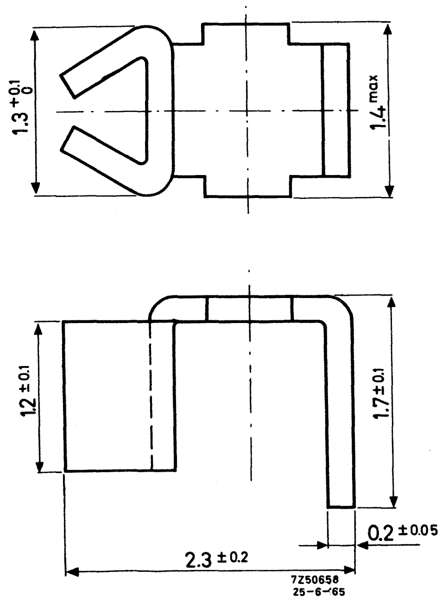
(3) Spring 4322 021 30620

Material : chrome-nickelsteel



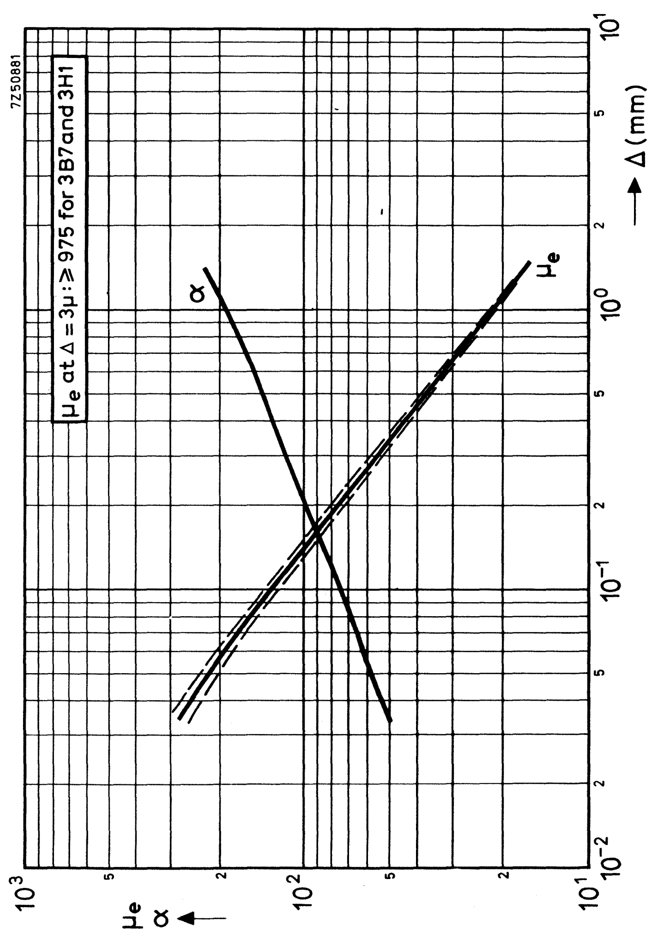
(4) Soldering spring 4322 021 30700

Material : brass, dipsoldered



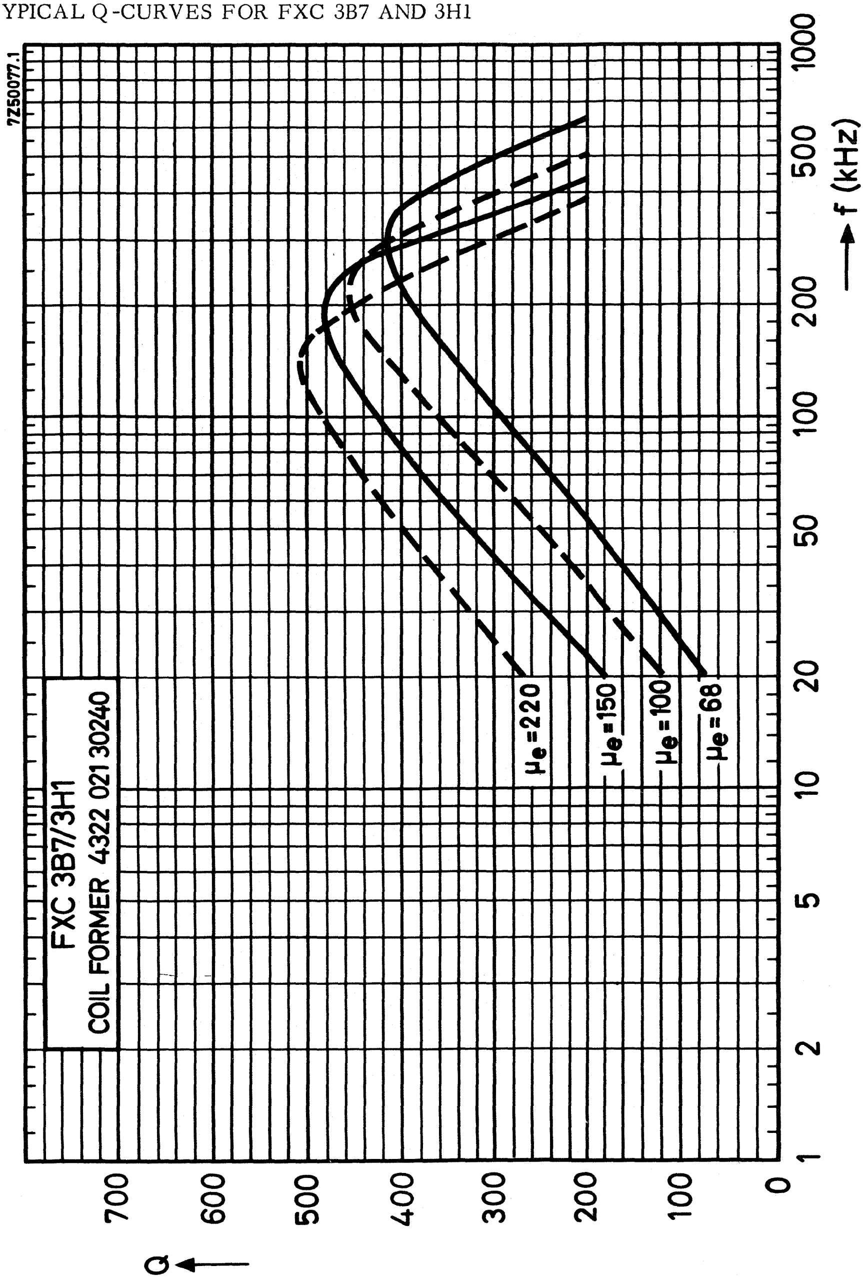
CHARACTERISTIC CURVES

μ_e - α values

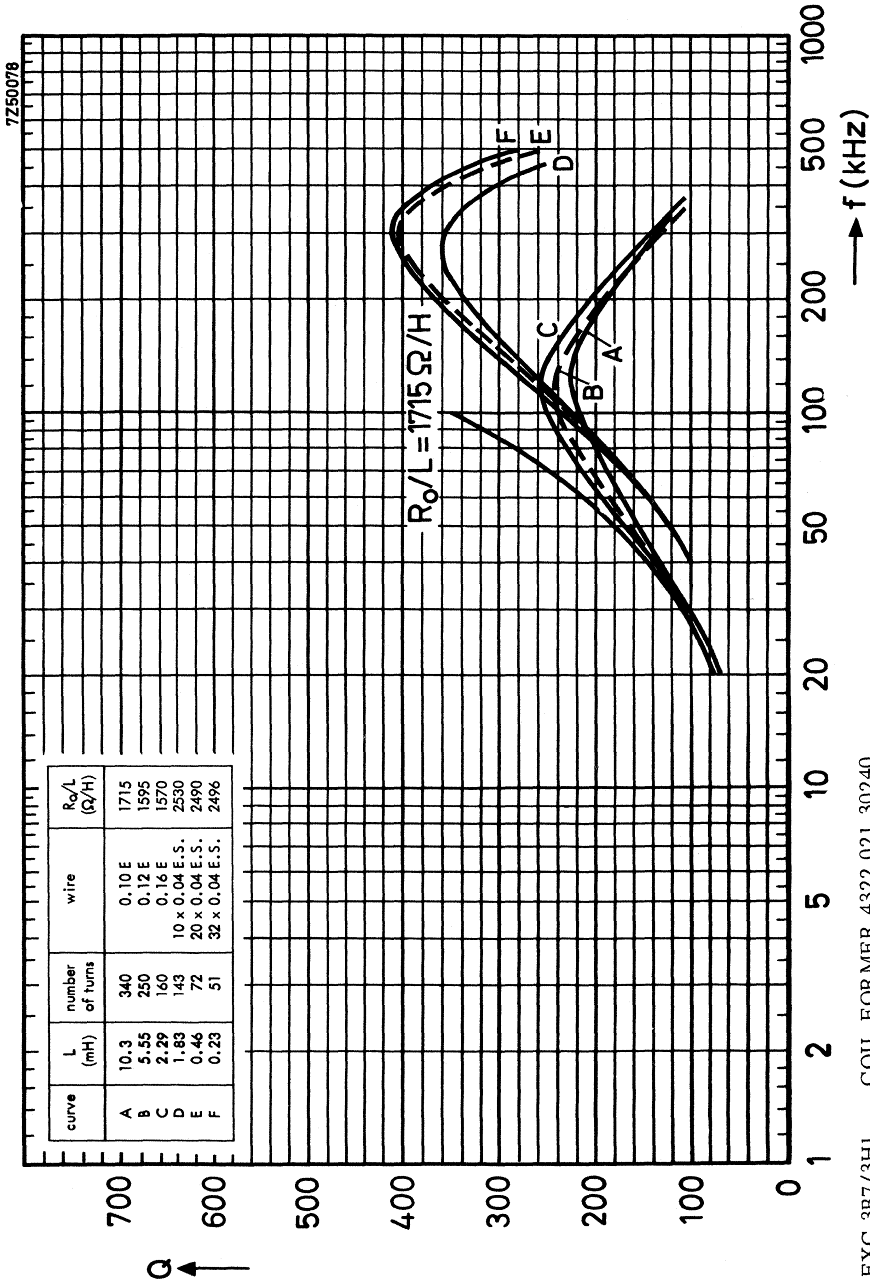


Relative effective permeability and turn factor for 1 mH as a function of the air gap length

TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1



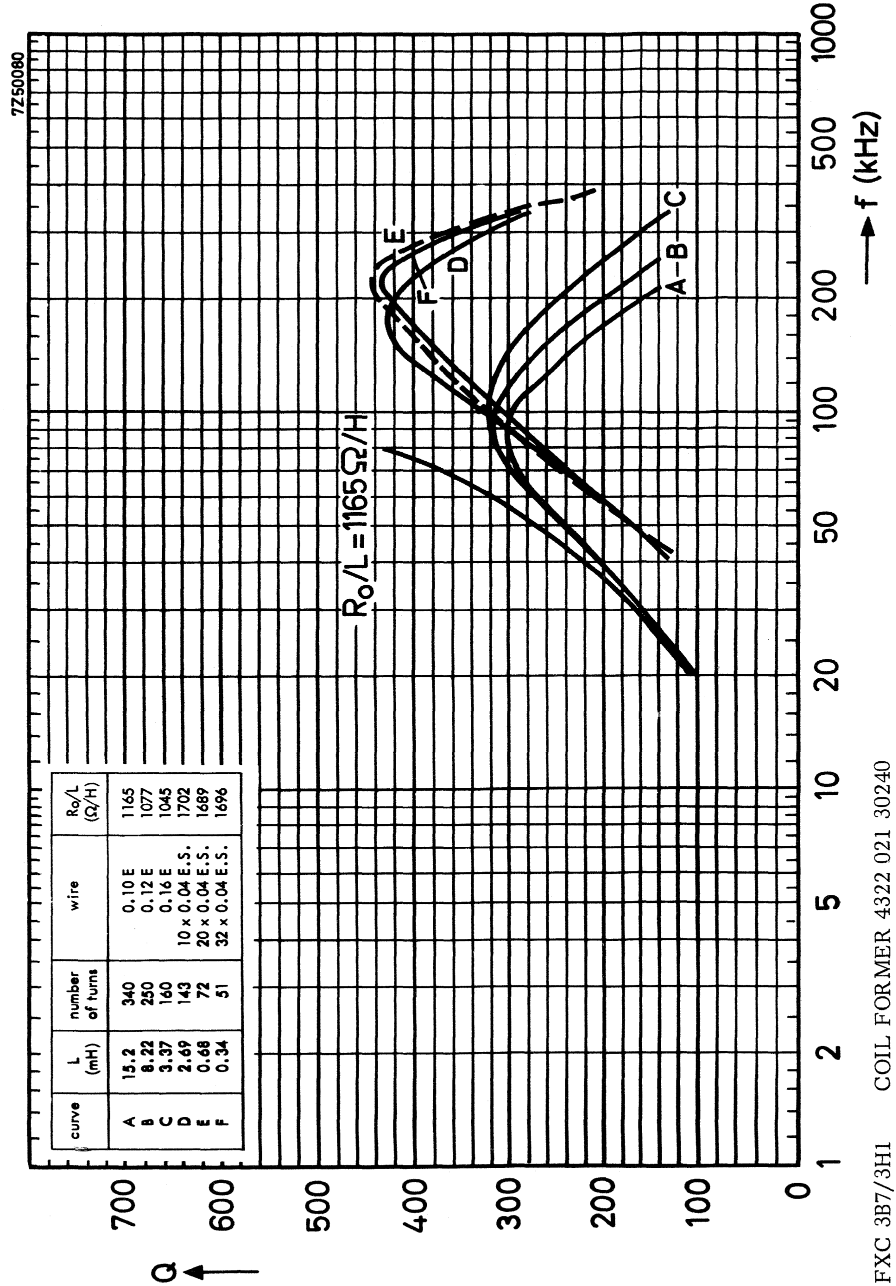
Enveloping curves



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	10.3	340	0.10 E	1715
B	5.55	250	0.12 E	1595
C	2.29	160	0.16 E	1570
D	1.83	143	10 x 0.04 E.S.	2530
E	0.46	72	20 x 0.04 E.S.	2490
F	0.23	51	32 x 0.04 E.S.	2496

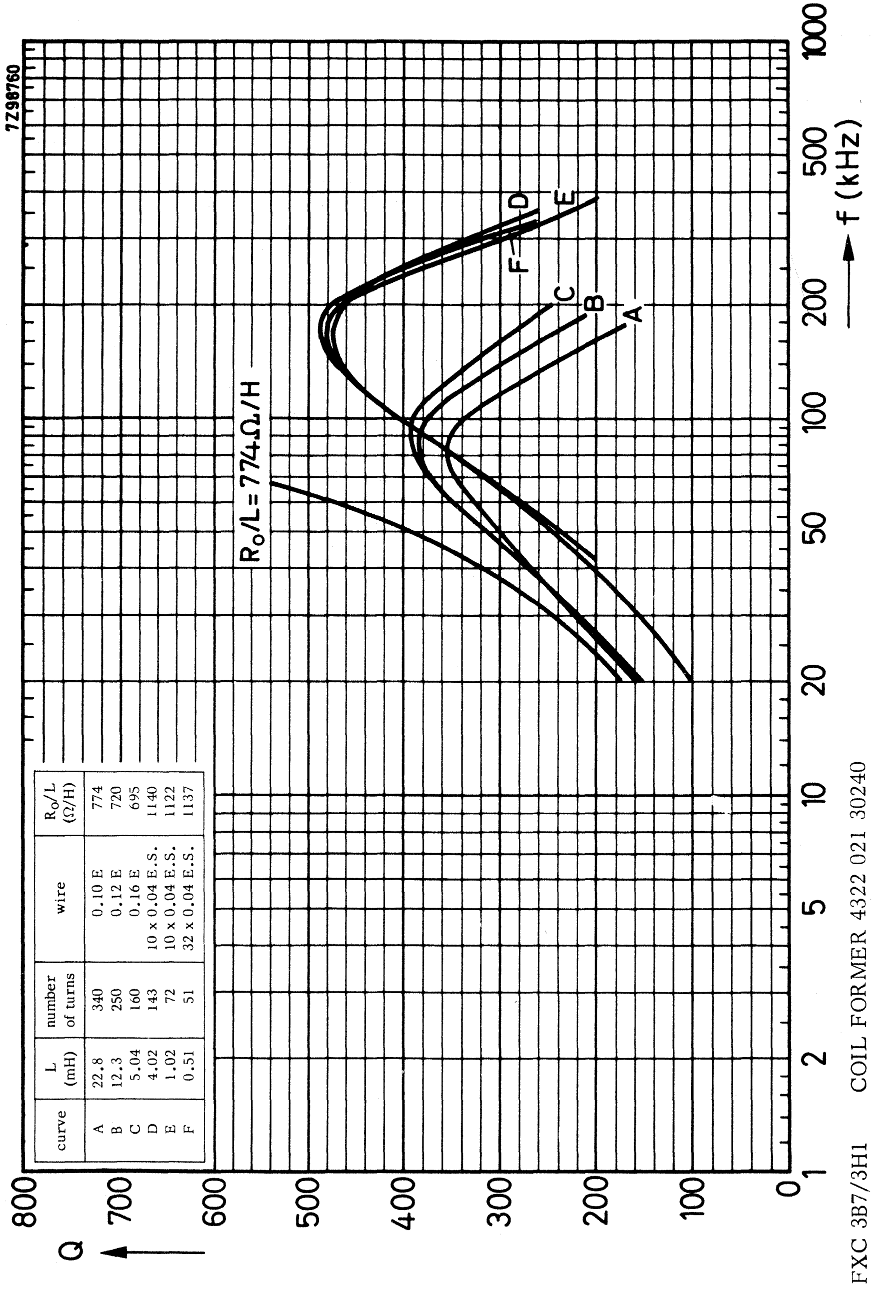
FXC 3B7/3H1 COIL FORMER 4322 021 30240

$\mu_e = 68$



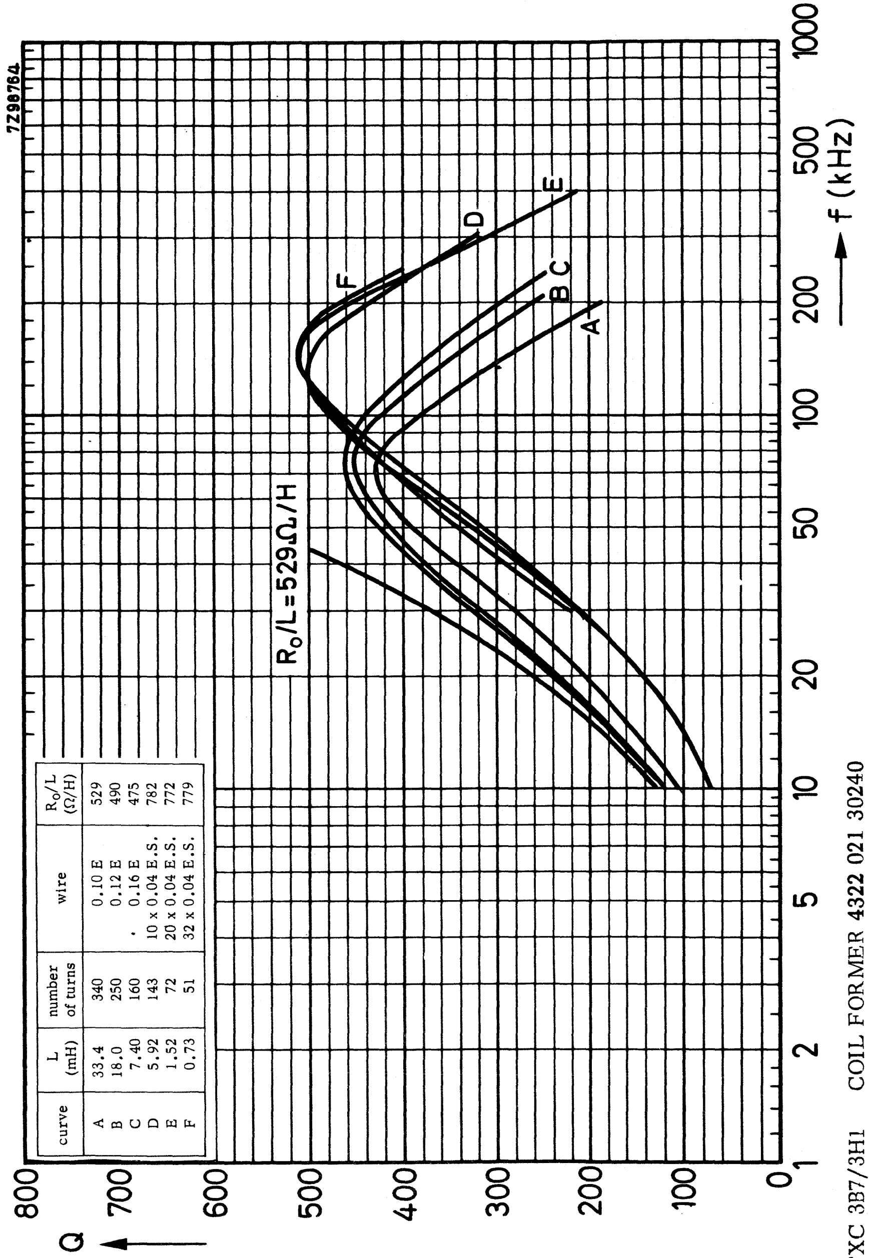
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	15.2	340	0.10 E	1165
B	8.22	250	0.12 E	1077
C	3.37	160	0.16 E	1045
D	2.69	143	10 x 0.04 E.S.	1702
E	0.68	72	20 x 0.04 E.S.	1689
F	0.34	51	32 x 0.04 E.S.	1696

FXC 3B7/3H1 COIL FORMER 4322 021 30240
$\mu_e = 100$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	22.8	340	0.10 E	774
B	12.3	250	0.12 E	720
C	5.04	160	0.16 E	695
D	4.02	143	10 x 0.04 E.S.	1140
E	1.02	72	10 x 0.04 E.S.	1122
F	0.51	51	32 x 0.04 E.S.	1137

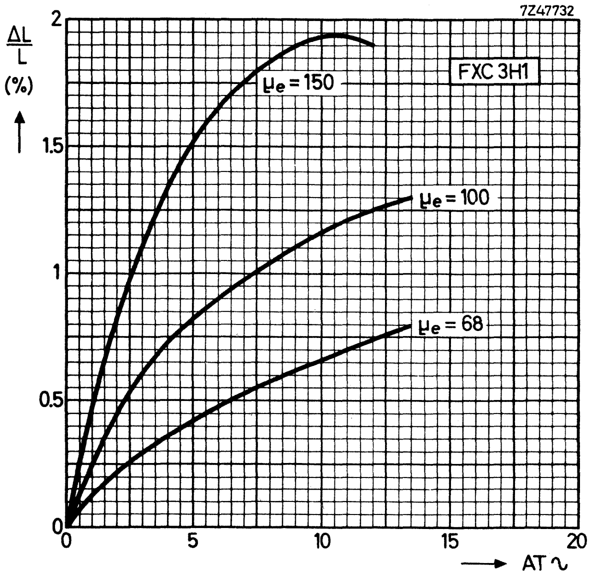
FXC 3B7/3H1 COIL FORMER 4322 021 30240
$\mu_e = 150$

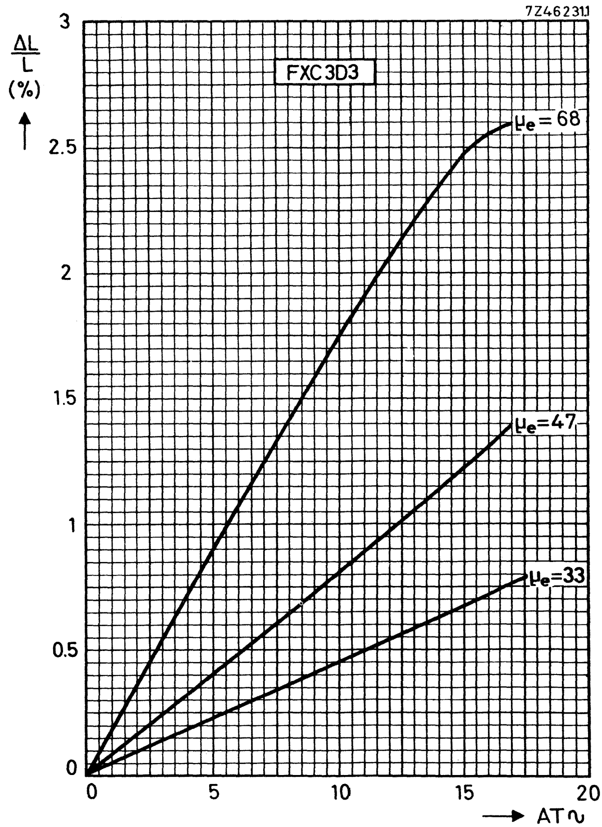


curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	33.4	340	0.10 E	529
B	18.0	250	0.12 E	490
C	7.40	160	0.16 E	475
D	5.92	143	10 x 0.04 E.S.	782
E	1.52	72	20 x 0.04 E.S.	772
F	0.73	51	32 x 0.04 E.S.	779

FXC 3B7/3H1 COIL FORMER 4322 021 30240
$\mu_e = 220$

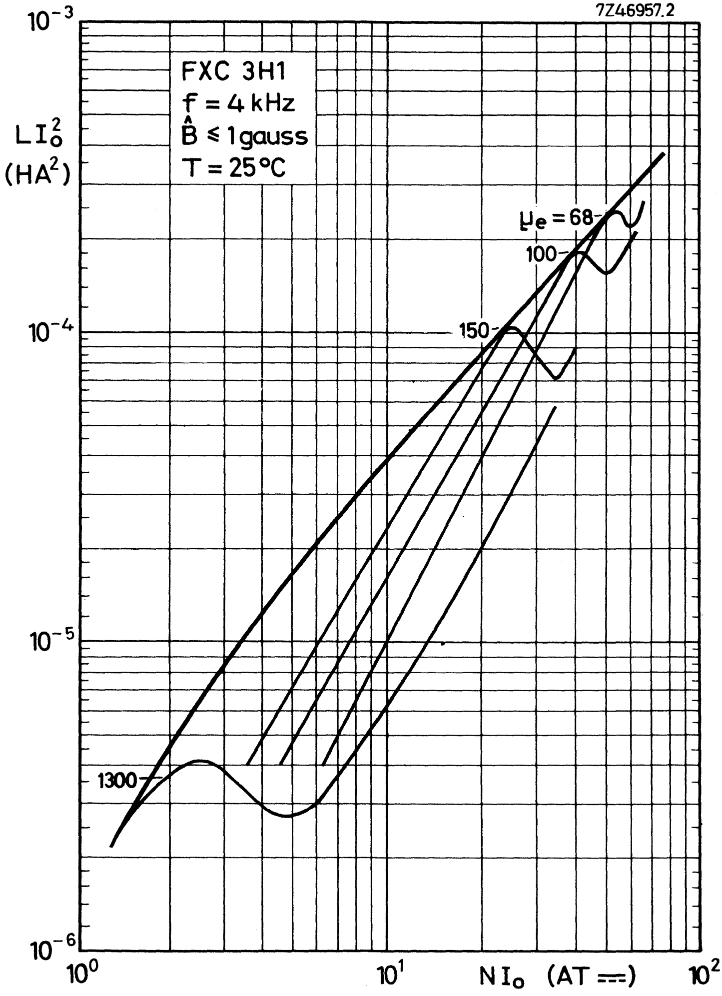
INDUCTANCE VARIATION AS A FUNCTION OF AT ~



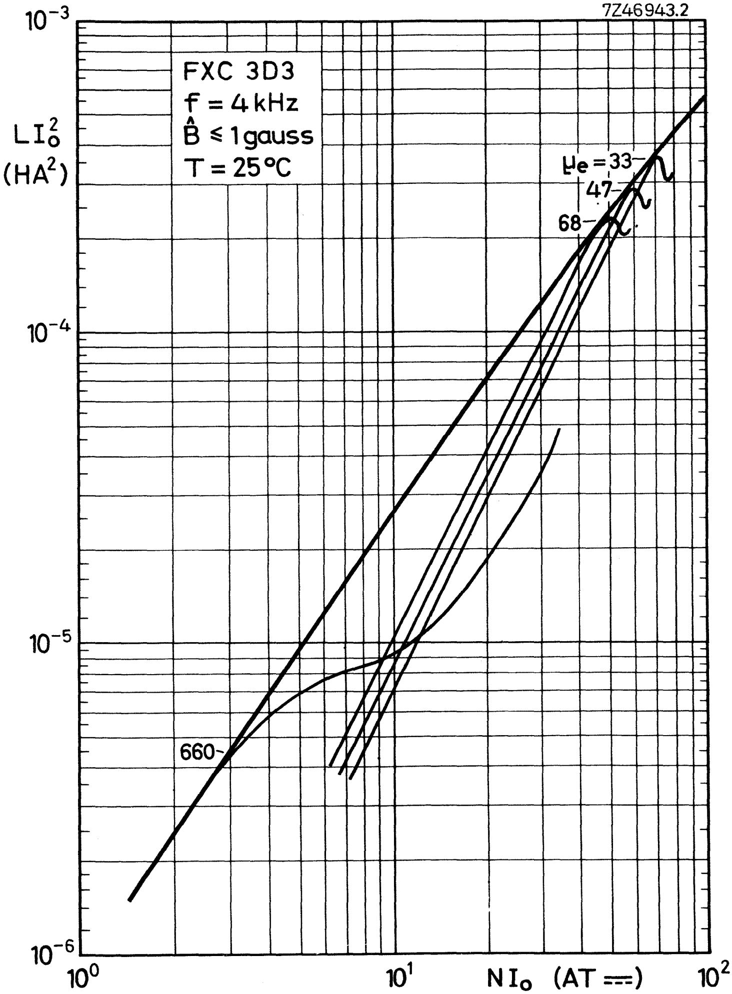

7Z4623.1
FXC 3D3
ΔL/L (%)
3
2.5
2
1.5
1
0.5
0
$\mu_e = 68$
$\mu_e = 47$
$\mu_e = 33$
0
5
10
15
20
AT∿

HANNA CURVES

Indicating the optimum inductance for a certain μ_e-value and direct current.
Typical values.



Typical values



POTCORES

INTRODUCTION

Three types of core can be supplied:

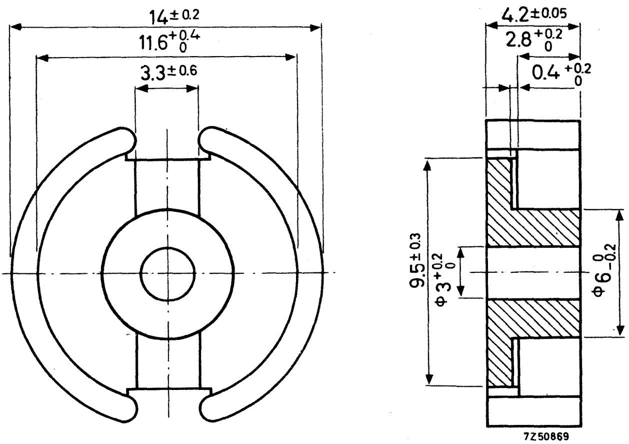
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E6 range of values or an inductance factor (A_L) in the R5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany), B.S. 4061 (Gr. Britain).

Potcores and associated parts are ordered by their 12-digit catalog number. Quantity: a primary pack contains 30 potcore halves or 15 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 21250
3H1	4322 020 21260
3D3	4322 020 21270
improved 3E1	4322 020 21360
4C6	4322 020 21350

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (°C)	grade				
		3B7	3H1	3D3		4C6
T.F. x 10^6	+ 5 to +23	-	+0.5 to +1.5	-		-2 to +4
	+ 5 to +55	-	-	-		-
	+23 to +55	-	+0.5 to +1.5	-		0 to +6
	+23 to +70	-0.6 to +0.6	1)	0 to 2		-
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 12		≤ 10

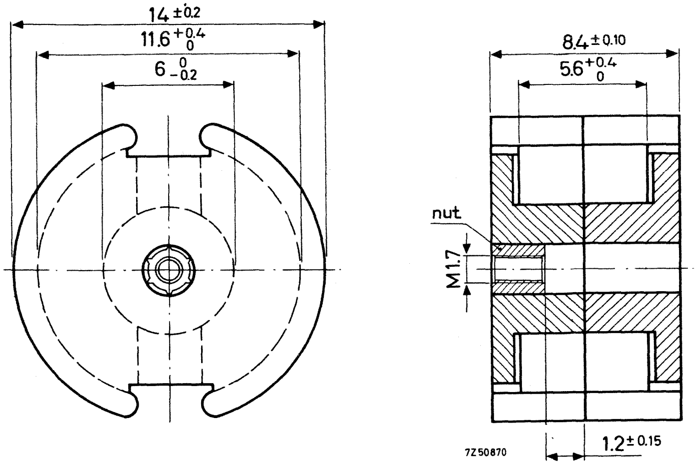
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 60 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II	$\hat{B}$ (Gs)	freq. (MHz)	grade				
			3B7	3H1	3D3	impr. 3E1	4C6
μ_e	≤ 1	0.004				1800-3000	
	≤ 1	0.1	≥ 1050	≥ 1050	≥ 510		≥ 93
A_L	≤ 1	0.004				2875-4775	
	≤ 1	0.1	≤ 24.4	≤ 24.4	≤ 35.1		≤ 81.8
$\frac{\tan\delta}{\mu_i}$ x 10^6	≤ 1	0.004			–	≤ 2.5	
	≤ 1	0.1	≤ 5	≤ 5	≤ 8	≤ 20	
	≤ 1	0.5			≤ 14	≤ 200	
	≤ 1	1			≤ 30		
		2					≤ 40
		10					≤ 100
$q_{2-24-100}$	3-12	0.1			≤ 3.0		≤ 10
	15-30	0.004	≤ 1.8	≤ 1.4		≤ 3	

1) For orientation: +0.5 to +1.5.

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 2....
Without nut, catalog number = 4322 022 0....

Weight		3.2	g
Mean length of lines of force	l_e =	1.98	cm
	$\Sigma \frac{l_e}{A_e}$ =	7.89	cm^{-1}
Effective volume	V_e =	0.495	cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 15, grade 4C6, potcore with nut, catalog number = 4322 022 22810
   A_L = 100, grade 3B7, potcore without nut, catalog number = 4322 022 03040
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

Potcores with standard μ_e values [1])

μ_e	α	tolerance on inductance (%)	catal. No.: 4322 022 2.... with nut 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
15	205	± 1	–	–	–	2810
22	169	± 1	–	–	–	2820
33	137.9	± 1	2030	2230	2430	2830
47	115.5	± 1	2040	2240	2440	–
68	96.1	± 1	2050	2250	2450	–
100	79.2	± 1.5	2060	2260	–	–
150	64.6	± 2	2070	2270	–	–
220	53.3	± 3	2080	2280	–	–
680	30.3	± 25	–	–	2400*	–
1400	21.2	± 25	2000*	2200*	–	–

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

Potcores with standard A_L factors [1])

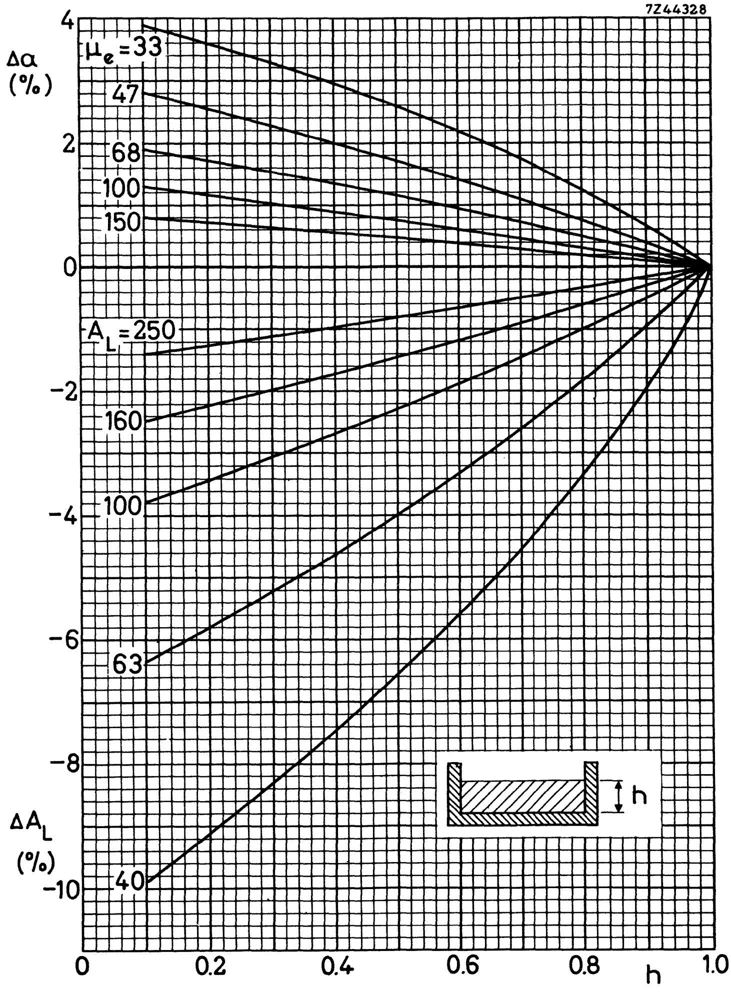
A_L (nH)	corresponding μ_e-value	tolerance on inductance (%)	catal. No.: 4322 022 2.... with nut 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
25	15.7	± 1	–	–	–	3810
40	25	± 1	–	–	3420	3820
63	39.5	± 1	–	–	3430	3830
100	63	± 1	3040	3240	3440	–
160	100.5	± 1.5	3050	3250	–	–
250	157	± 2	3060	3260	–	–
315	198	± 2	3070	3270	–	–
400	252	± 2		3280	–	–

Inductance $L = N^2 A_L$ (in 10^{-9} H)

1) See Notes on the previous page.

* Only available without nut.

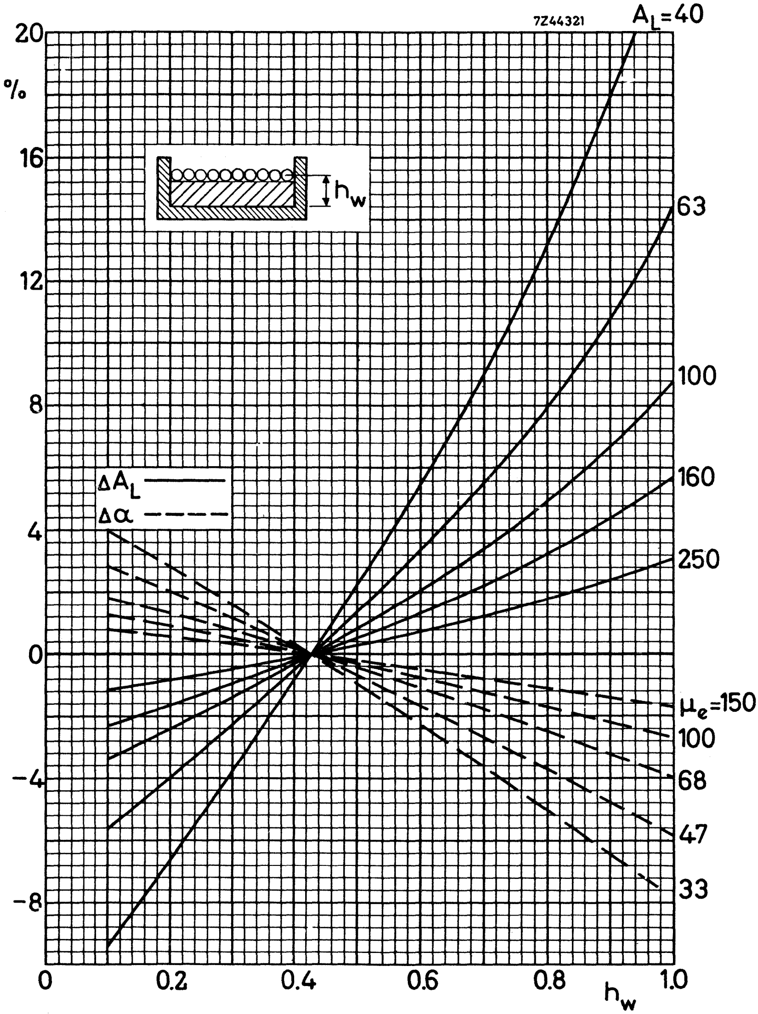
DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former only 0.4 part of the available height is used. A potcore with μ_e = 68 in that case obtains an α factor of 96.1 + 1.3 %.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_w on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 68 obtains for that winding an α factor of 96.1 - 1.7 %.

COIL FORMERS

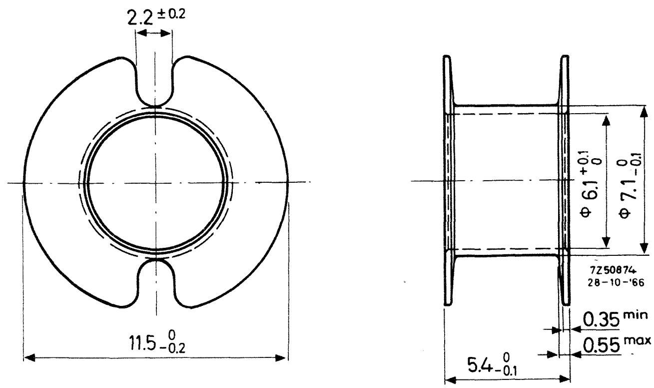
GENERAL

Three types of coil former can be supplied:

- with one section
- with two sections
- with one section and with soldering pins to fit 0.1" and 2.50 mm grid.

The dimensions conform with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-02 (France) and D.I.N. 41 294 (Germany).
The dimensions in the drawings are in mm.

SINGLE-SECTION COIL FORMER



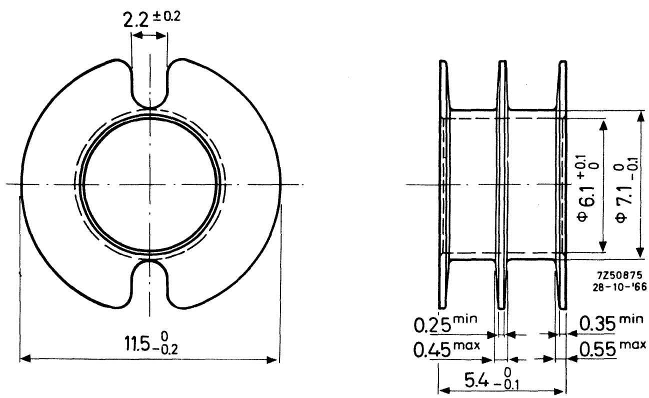
Catalog number	4322 021 30250
Material	glassfibre-reinforced polyacetal
Window area	9.7 mm^2
Mean length of turn	2.9 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 32.3 \times 10^3 \ \Omega/H$$

Weight	0.15 g

TWO-SECTION COIL FORMER



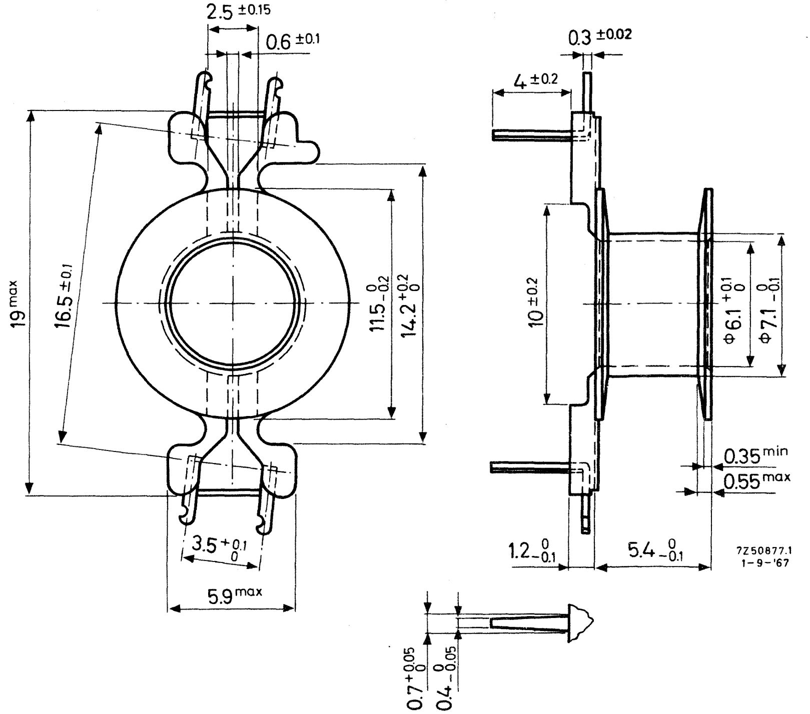
Catalog number	4322 021 30260
→ Material	glassfibre-reinforced polyacetal
Window area	2 x 4.5 mm^2
Mean length of turn	2.9 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 35.1 \times 10^3 \ \Omega/H$$

Weight 0.2 g

SINGLE-SECTION COIL FORMER WITH SOLDERING PINS



Catalog number 4322 021 30070

Material: reinforced polyester with brass dipsoldered pins

Window area 9.7 mm^2

Mean length of turn 2.9 cm

Max. temperature 180 °C

Solderability according to I.E.C.68-2-20, part 2, test T

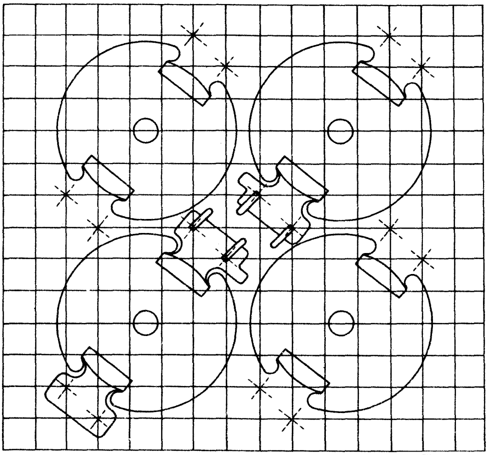
D.C. losses:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 32.3 \times 10^3 \quad \Omega/H$$

Weight 0.25 g

The coil formers are packed in boxes containing 5 layers of 140 coil formers, so please order in multiples of 140.

The soldering pins are so arranged as to fit a grid of 2.52 mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes 1.3 ± 0.1 mm diameter. For this coil former the potcore halves must be cemented together, and it is recommended to cement the coil former to the lower potcore half.



INDUCTANCE ADJUSTORS

ADJUSTORS

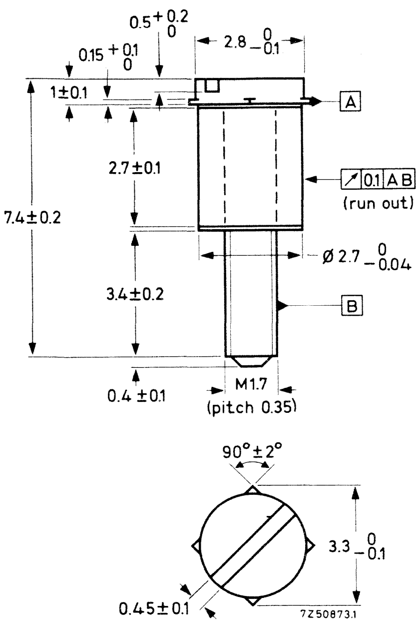


Fig. A

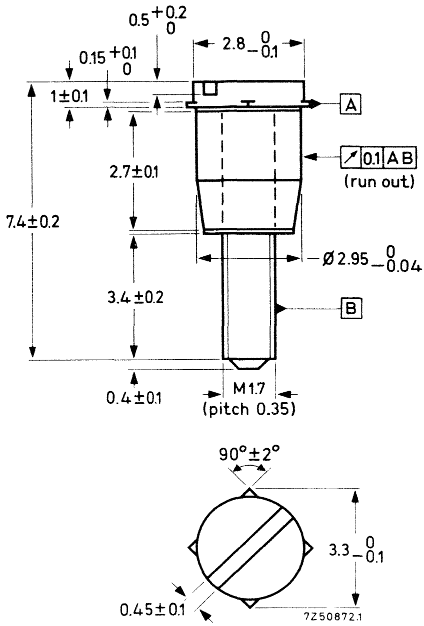


Fig. B

The tolerances on inductance of the pre-adjusted potcores (with adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03% by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.
Table II shows the type of adjustor recommended for different potcores.

Table I, available types

Fig.	colour	catalogue number
A	red	4322 021 30740
A	green	4322 021 30750
B	yellow	4322 021 30940
B	white	4322 021 30950
A	brown	4322 021 31070
B	grey	4322 021 31130

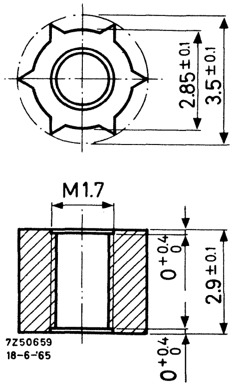
Table II, recommended application

μ_e	A_L	3B7/3H1/3D3	4C6
		cat. number 4322 021	
15		–	30740
	25	–	30740
22		–	30740
	40	30750	30940
33		30750	30950
	63	30740	30940
47		30740	–
	100	30940	–
68		30940	–
100		30950	–
	160	30950	–
150		31070	–
	250	31070	–
220		31130	–
	315	31130	–
	400	31130	–

The adjustors are packed in bags of 100, so please order in multiples of 100.

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

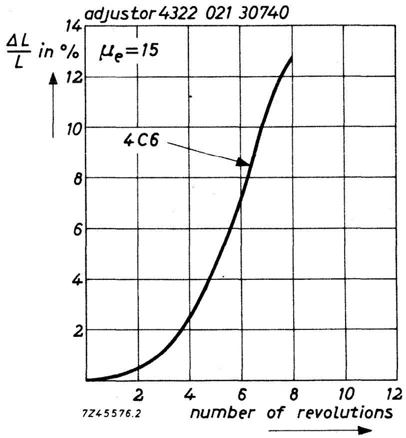


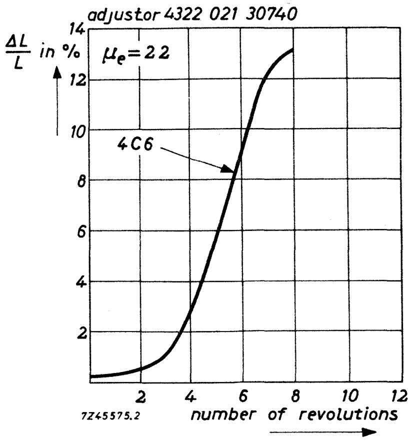
Catalogue number	4322 021 30140
Material	polycarbonate
Max. impregnation temperature during 24 hours	120 °C
Recommended distance from mating surface to nut	1.2 ± 0.15 mm

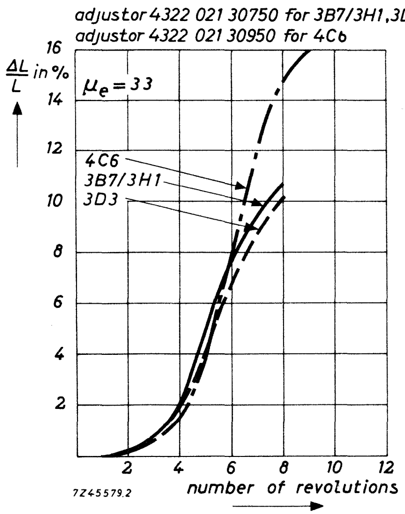
For more information see Potcores General, Mounting data.

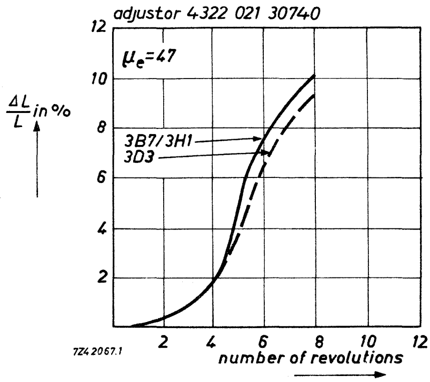
The nuts are packed in bags of 100, so please order in multiples of 100.

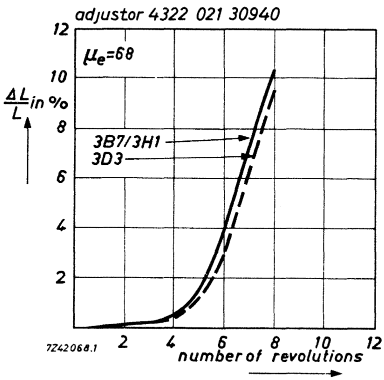
ADJUSTMENT CURVES

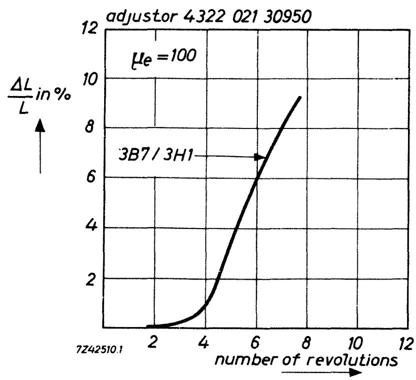


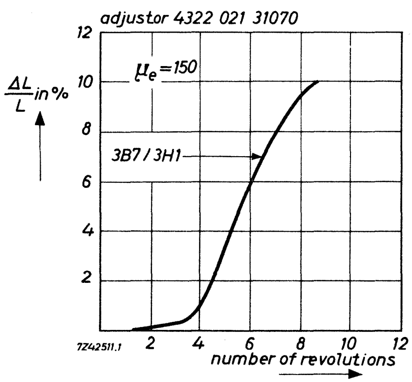


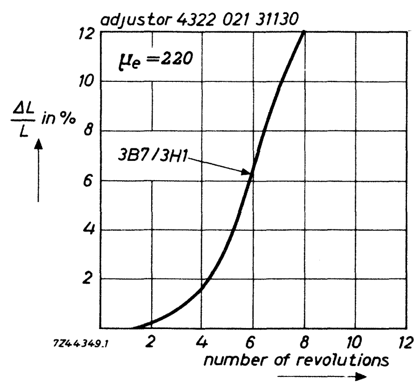





adjustor 4322 021 30940
μ_e=68
ΔL/L in %
3B7/3H1
3D3
7Z42068.1
number of revolutions
2 4 6 8 10 12

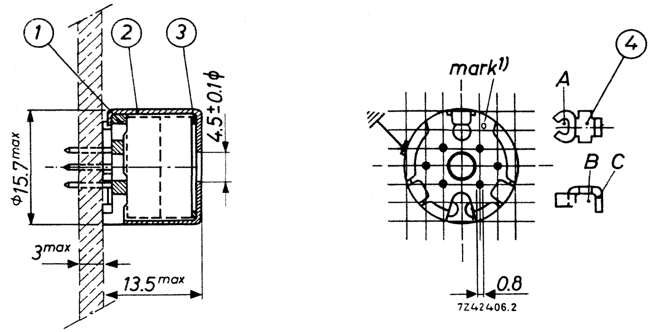

adjustor 4322 021 30950
μ_e =100
ΔL/L in %
3B7/3H1
7Z42510.1
number of revolutions
2 4 6 8 10 12


adjustor 4322 021 31070
μ_e =150
ΔL/L in %
3B7/3H1
7Z42511.1
number of revolutions
2 4 6 8 10 12


adjustor 4322 021 31130
μ_e =220
ΔL/L in %
3B7/3H1
7Z44349.1
number of revolutions
2 4 6 8 10 12

MOUNTING PARTS

MOUNTING ON PRINTED-WIRING BOARDS



(1) tag plate	4322 021 30440
(2) brass container	4322 021 30520
(3) spring	4322 021 30630
(4) soldering spring	4322 021 30700 (6x)

The container is suitable for mounting on printed-wiring boards only.

If stranded wire is applied the use of a soldering spring (4) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over. For solid wire the soldering spring is not strictly necessary.

The six soldering pins are arranged so as to fit a grid of 2.52 mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3 ± 0.1 mm diameter.

The container is provided with an earth tag on its circumference. This tag also serves the purpose of mounting the coil assembly on the printed-wiring board.

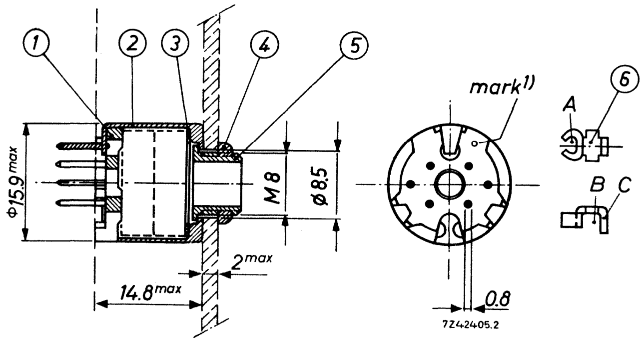
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 60 Newton. After bending the lips the spring will have the correct tension.

---

1) There is another mark hole in a similar position on the top of the container.

MOUNTING ON PANELS



(1) tag plate	4322 021 30440	(4) nut	4322 021 30710
(2) aluminium container	4322 021 30600	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30630	(6) soldering spring	4322 021 30700 (6x)

The container is suitable for mounting on panels only.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The coil assembly may be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

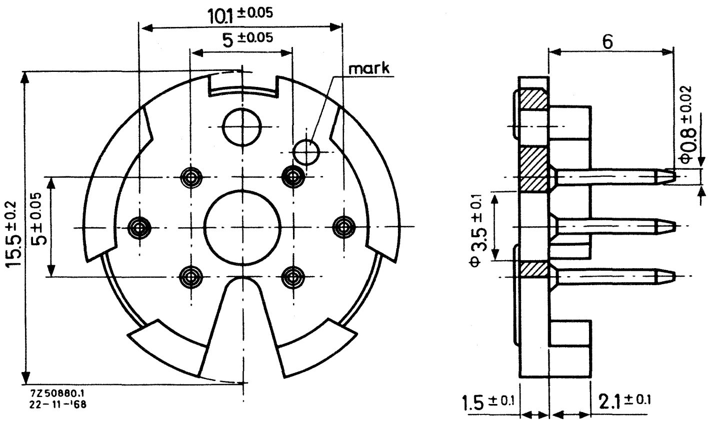
Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 60 Newton. After bending the lips the spring will have the correct tension.

[1]) There is another mark in a similar position on the top of the container.

PART DRAWINGS (dimensions in mm)

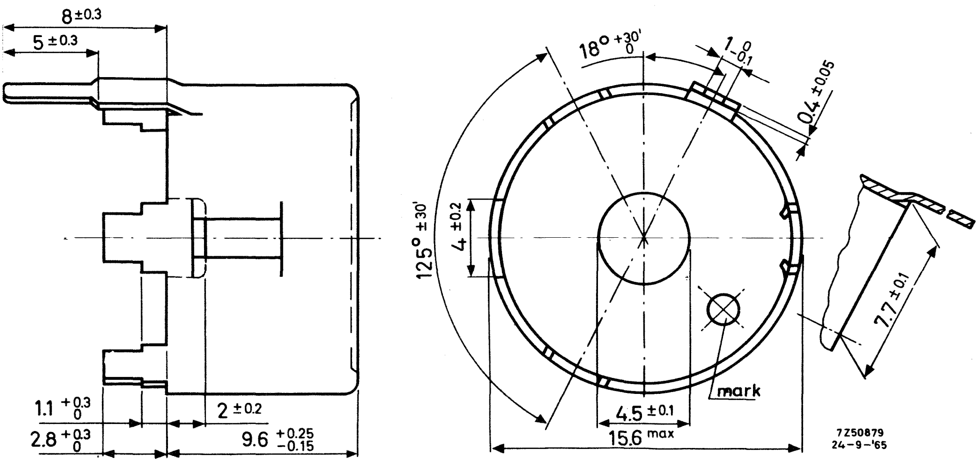
Tag plate 4322 021 30440

Plate : reinforced polyester
Pins : phosphorbronze, dipsoldered

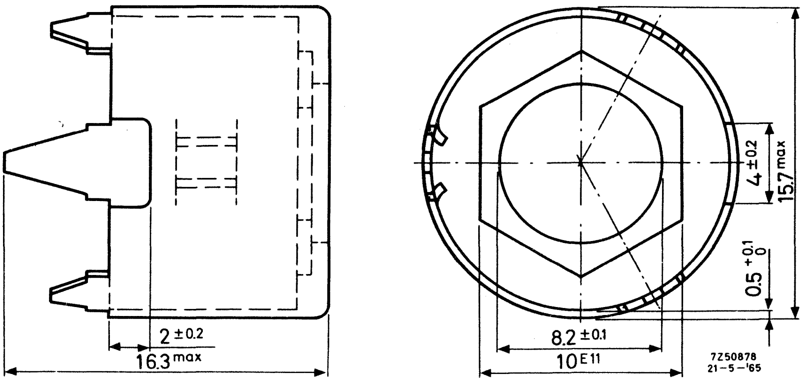


Container for mounting on printed-wiring boards 4322 021 30520

Material : brass, nickel plated

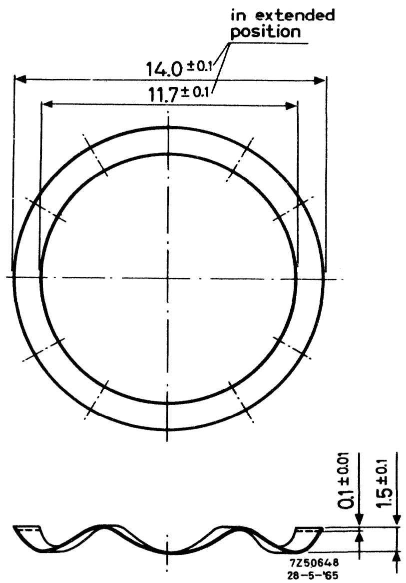


Container for mounting on panels 4322 021 30600 Material: aluminium



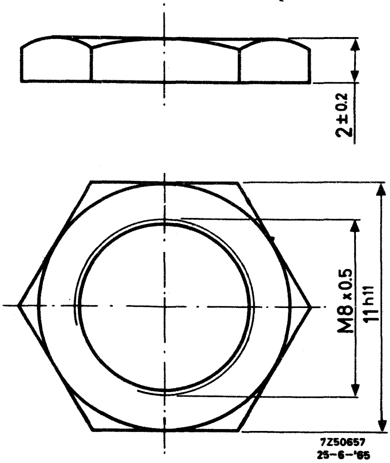
Spring 4322 021 30630

Material : chrome-nickelsteel



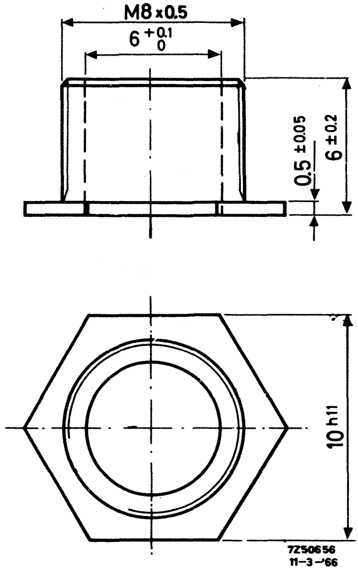
Nut 4322 021 30710

Material: brass, nickel plated



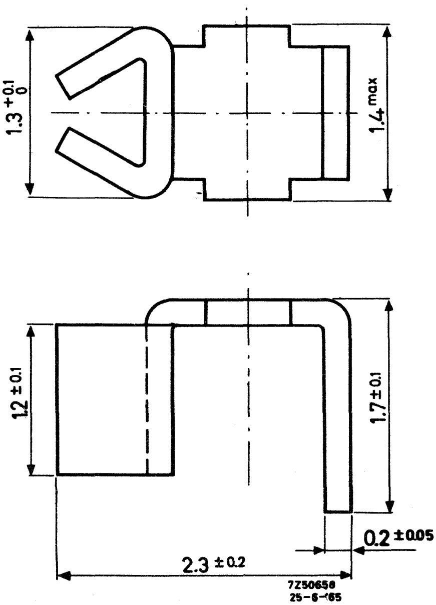
Fixing bush 4322 021 30720

Material: brass, nickel plated



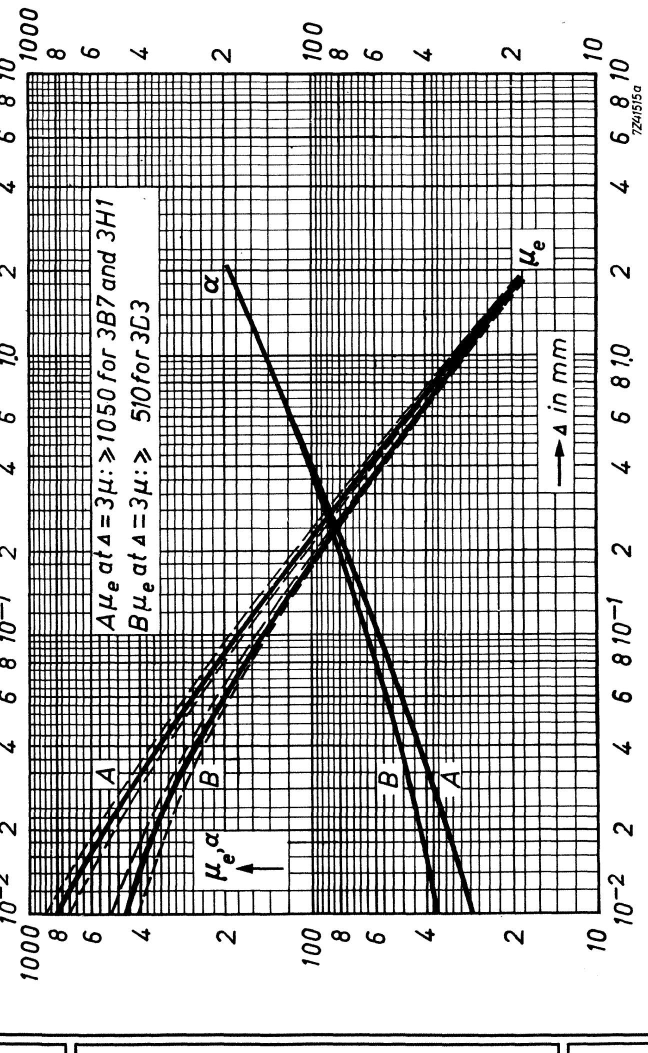
Soldering spring 4322 021 30700

Material: brass, dipsoldered



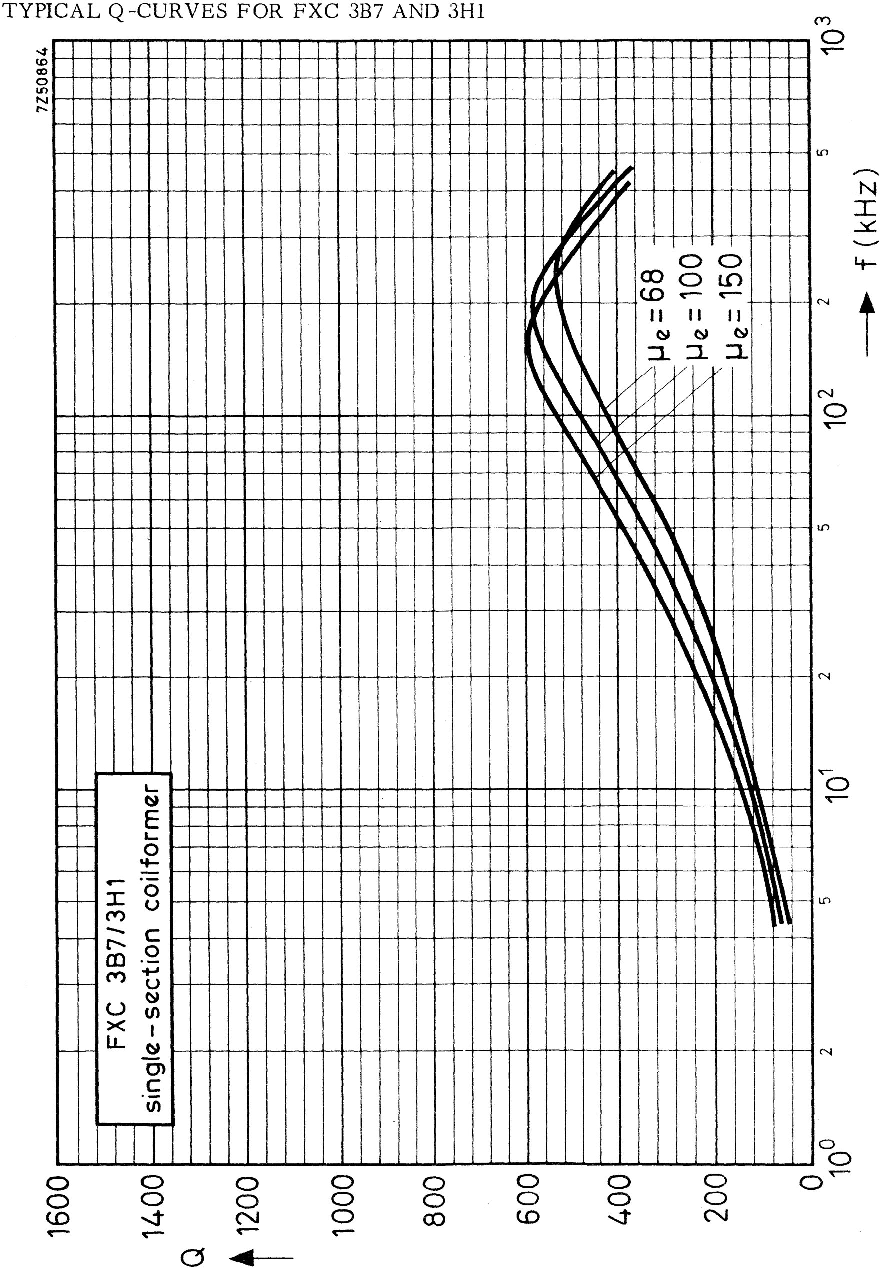
CHARACTERISTIC CURVES

μ_e - α CURVES

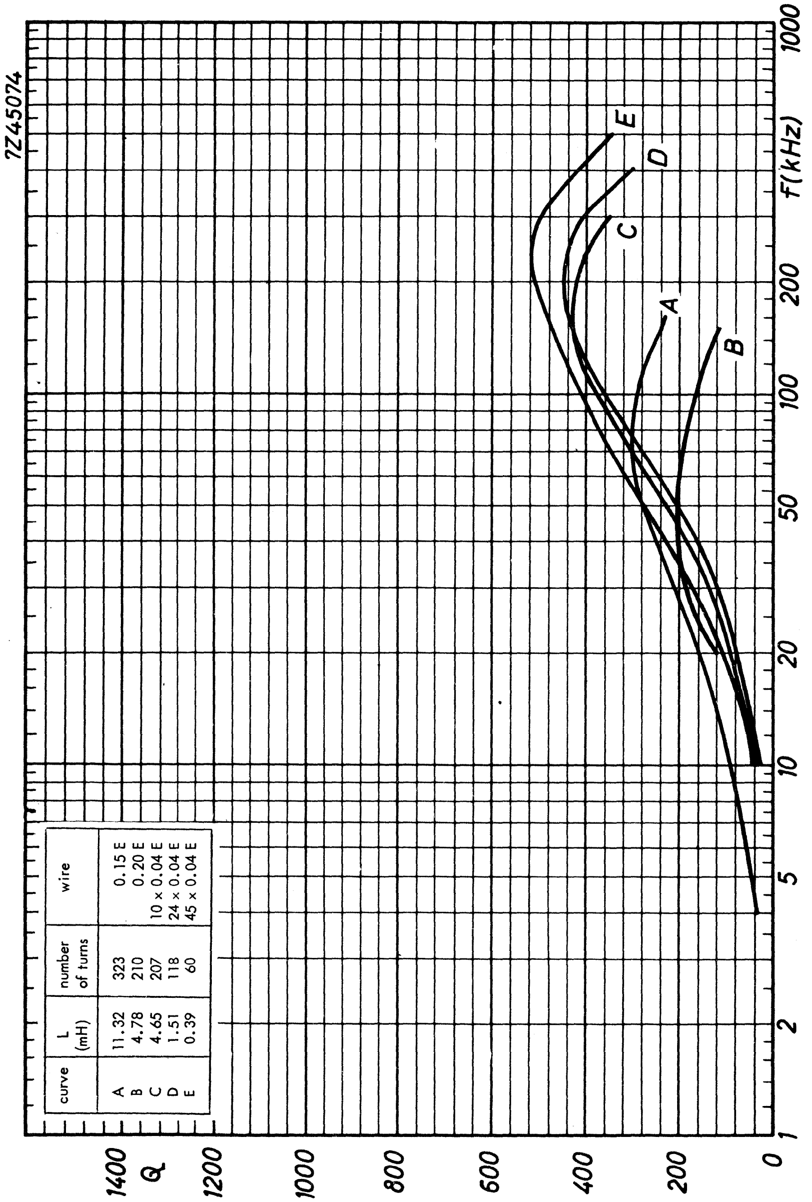


Relative effective permeability and turn factor for 1 mH as a function of the air gap length

TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1



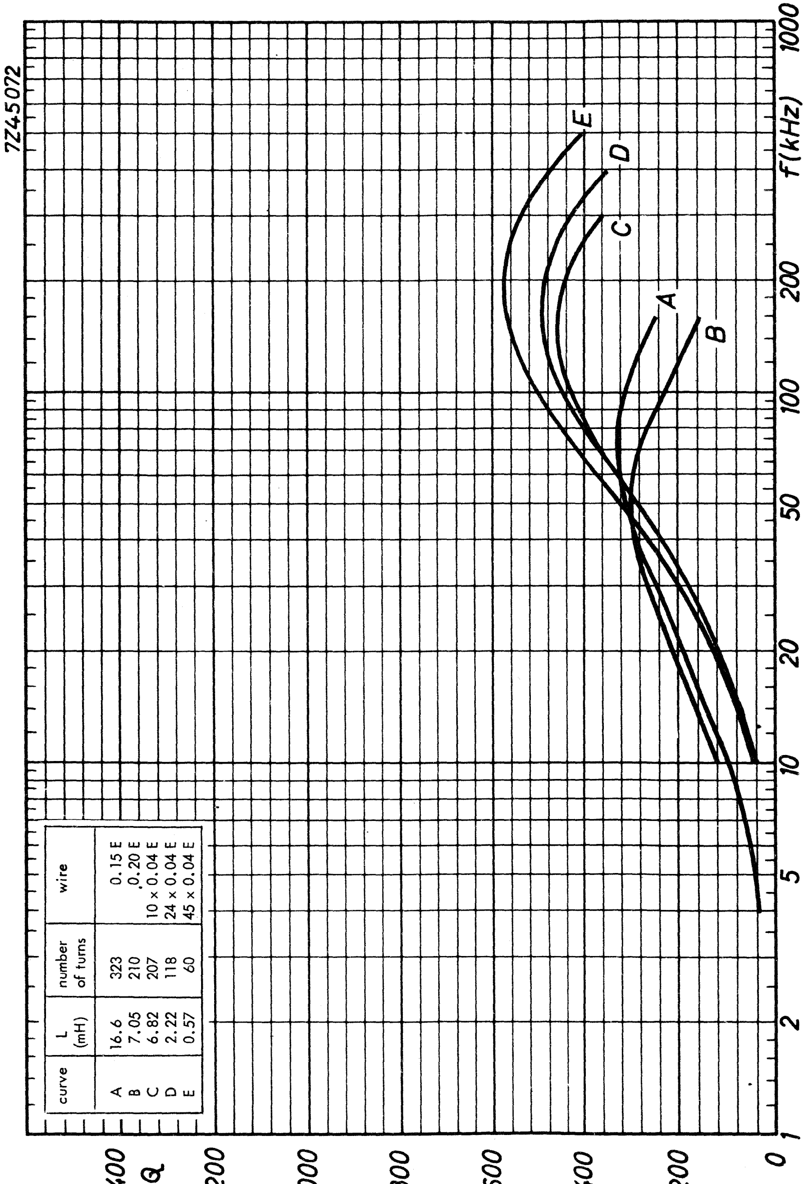
Enveloping curves



curve	L (mH)	number of turns	wire
A	11.32	323	0.15 E
B	4.78	210	0.20 E
C	4.65	207	10 × 0.04 E
D	1.51	118	24 × 0.04 E
E	0.39	60	45 × 0.04 E

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 68$

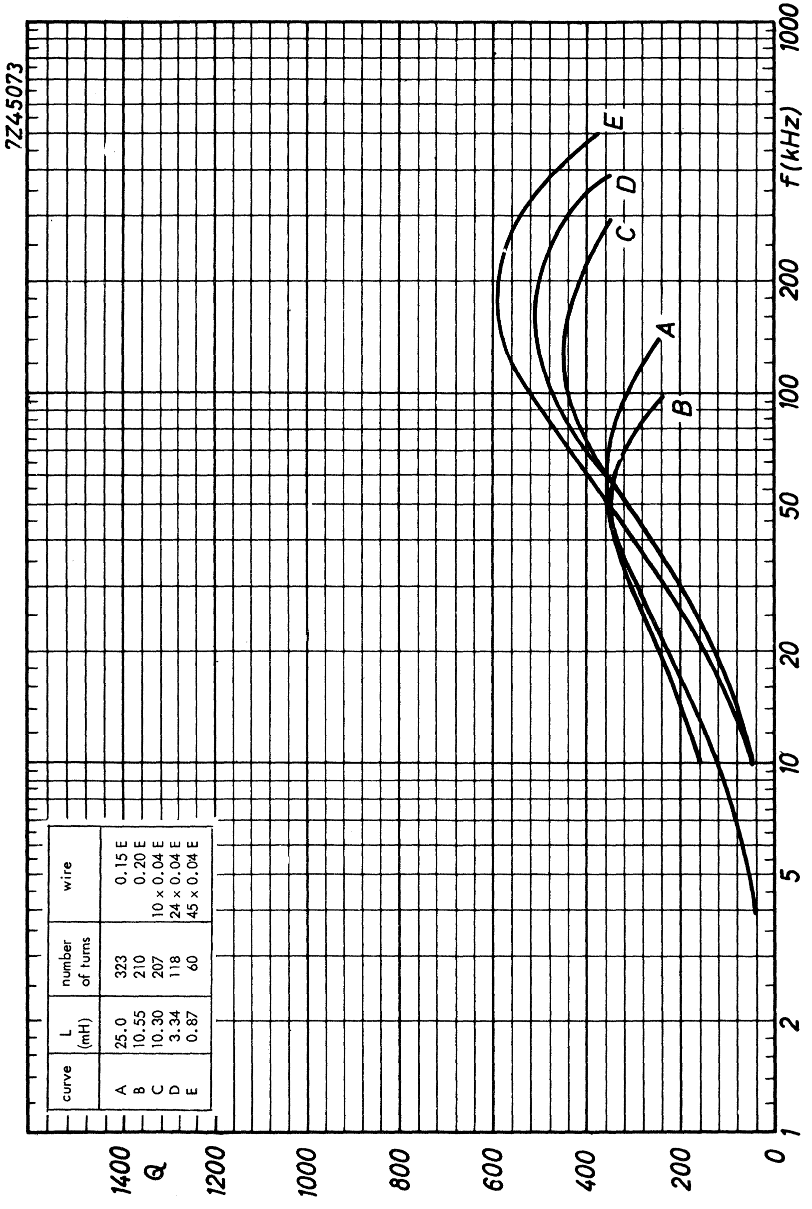


curve	L (mH)	number of turns	wire
A	16.6	323	0.15 E
B	7.05	210	0.20 E
C	6.82	207	10 × 0.04 E
D	2.22	118	24 × 0.04 E
E	0.57	60	45 × 0.04 E

SINGLE-SECTION COIL FORMER

FXC 3B7/3H1

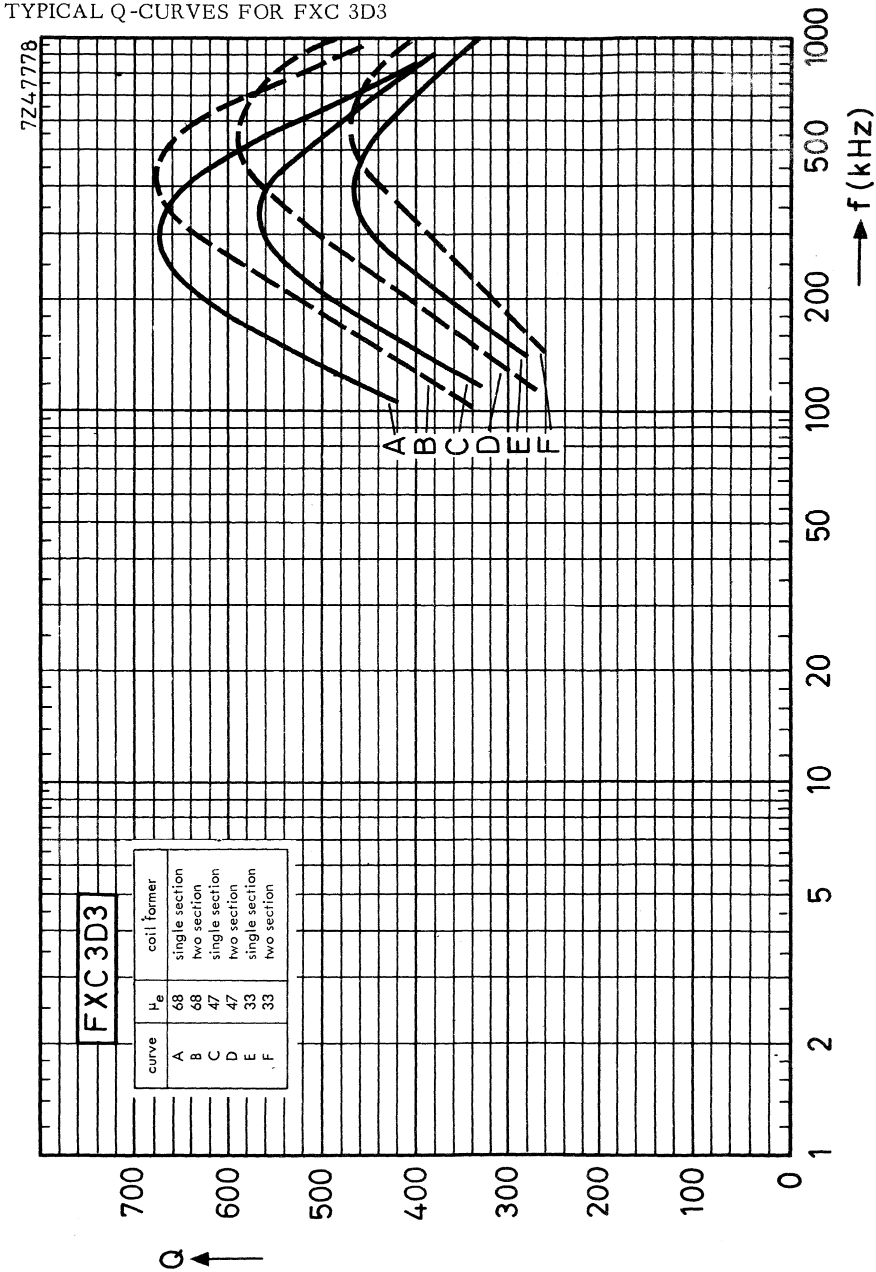
$\mu_e = 100$



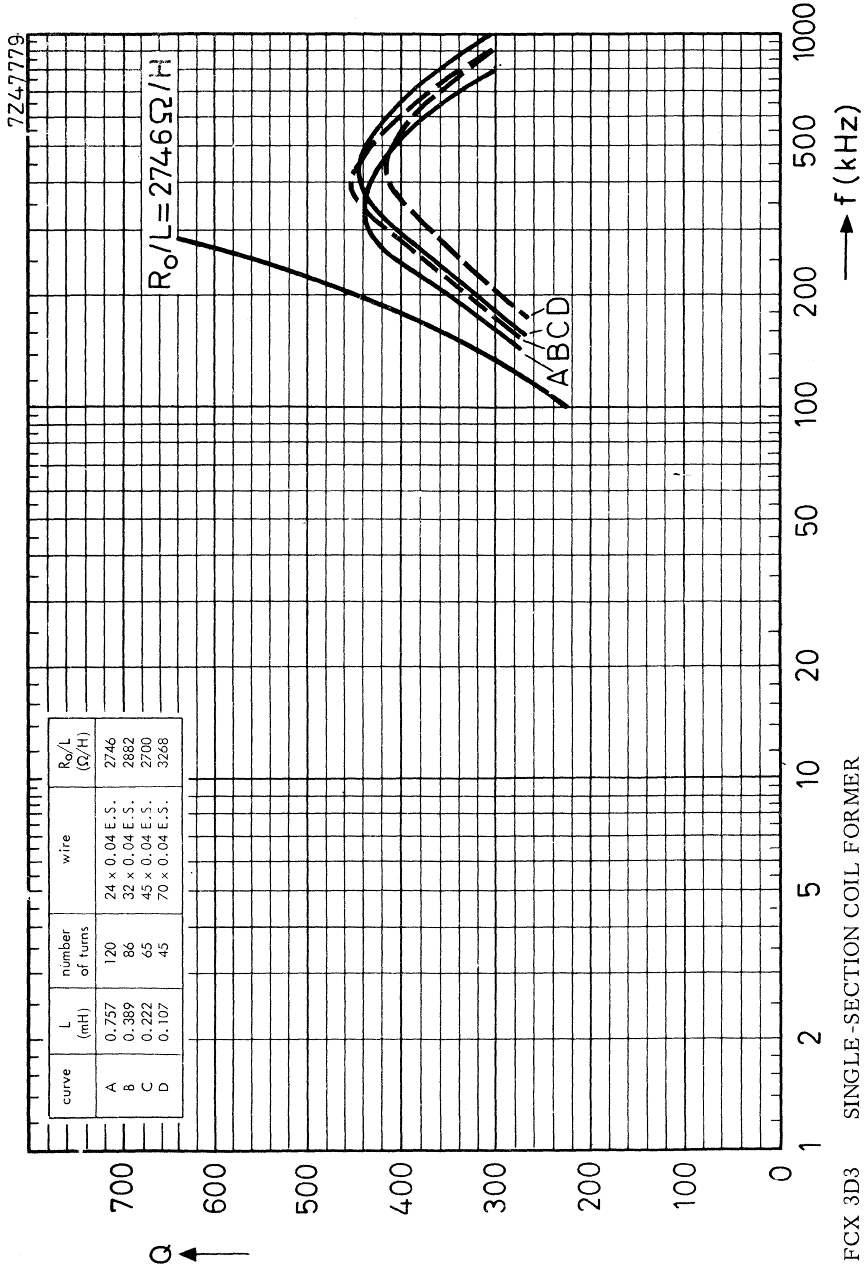
curve	L (mH)	number of turns	wire
A	25.0	323	0.15 E
B	10.55	210	0.20 E
C	10.30	207	10 × 0.04 E
D	3.34	118	24 × 0.04 E
E	0.87	60	45 × 0.04 E

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 150$

TYPICAL Q-CURVES FOR FXC 3D3



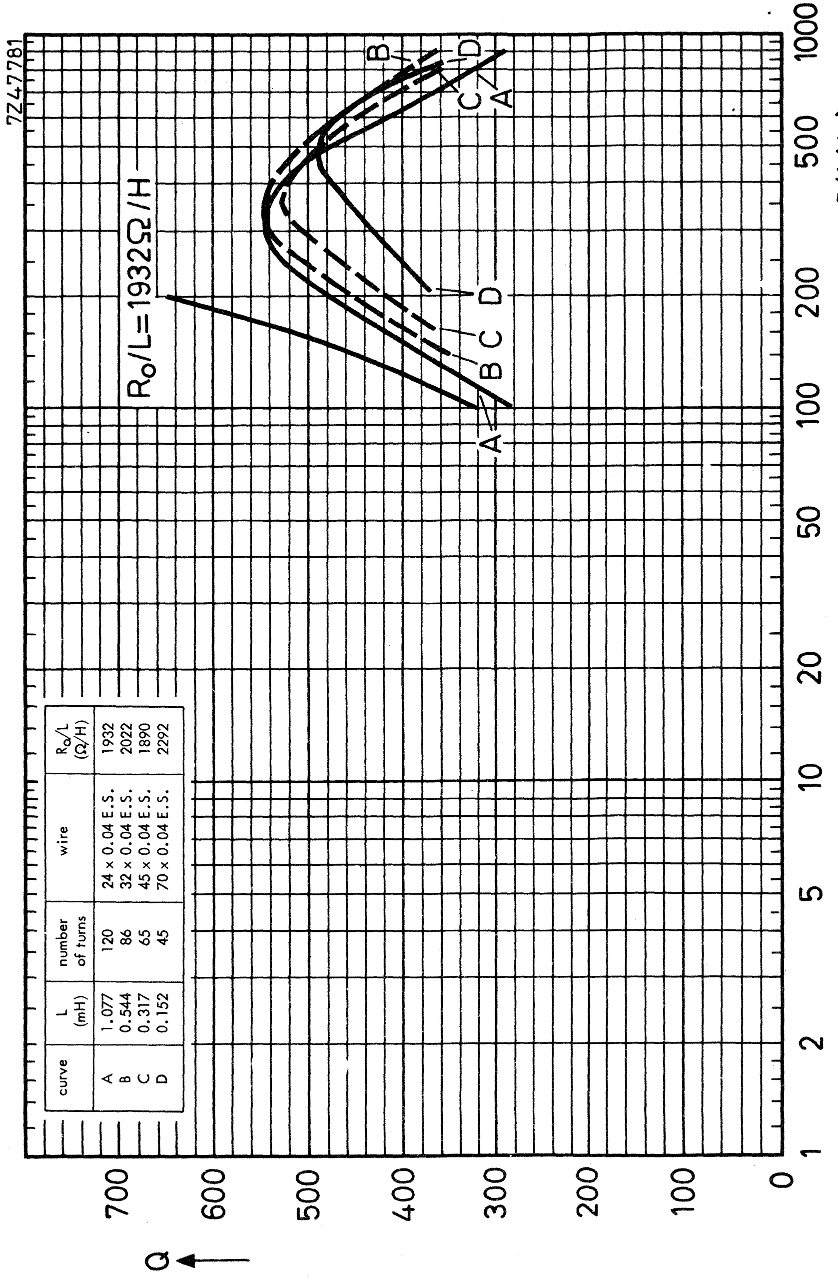
Enveloping curves



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	0.757	120	24 × 0.04 E.S.	2746
B	0.389	86	32 × 0.04 E.S.	2882
C	0.222	65	45 × 0.04 E.S.	2700
D	0.107	45	70 × 0.04 E.S.	3268

FCX 3D3 $\mu_e = 33$

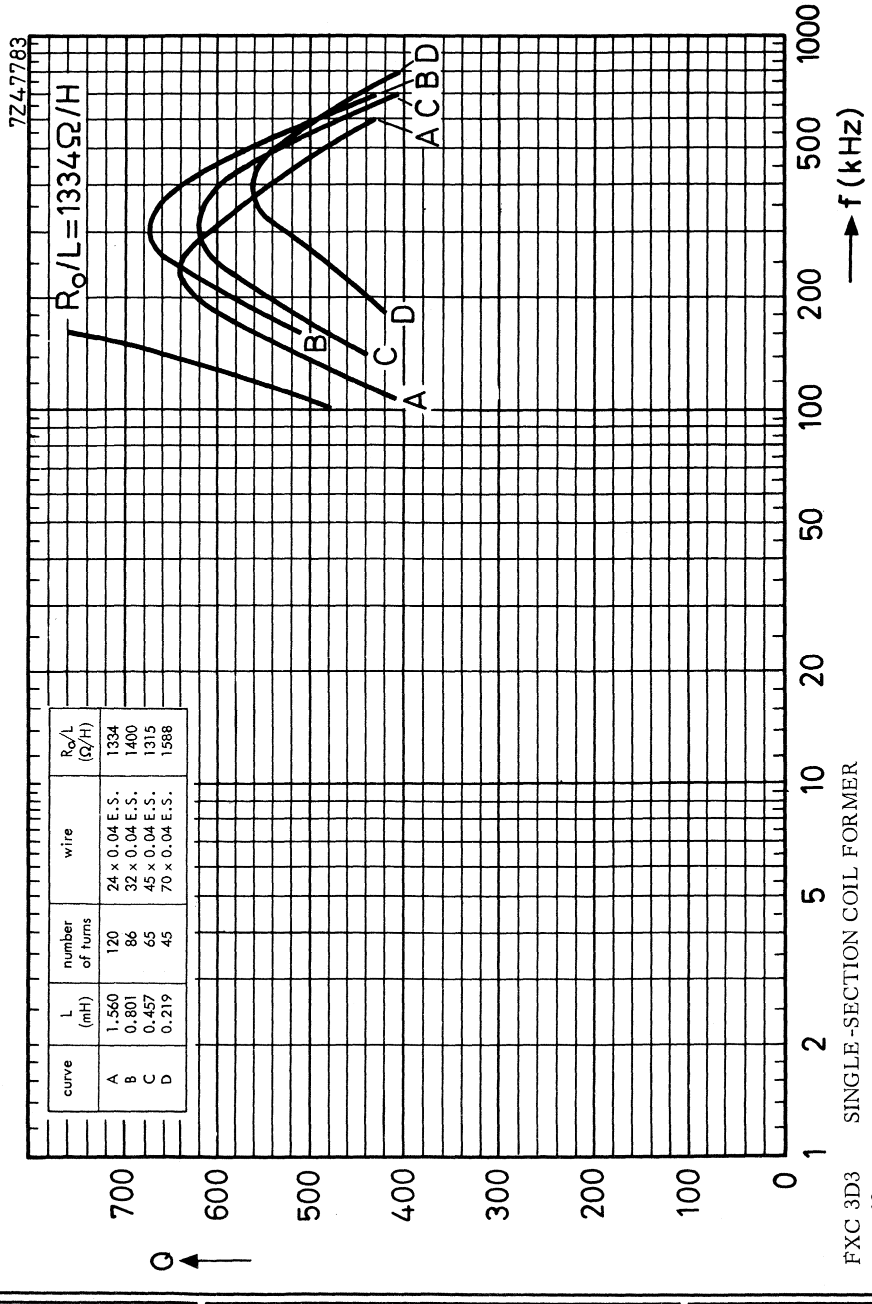
SINGLE-SECTION COIL FORMER



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.077	120	24 × 0.04 E.S.	1932
B	0.544	86	32 × 0.04 E.S.	2022
C	0.317	65	45 × 0.04 E.S.	1890
D	0.152	45	70 × 0.04 E.S.	2292

SINGLE-SECTION COIL FORMER

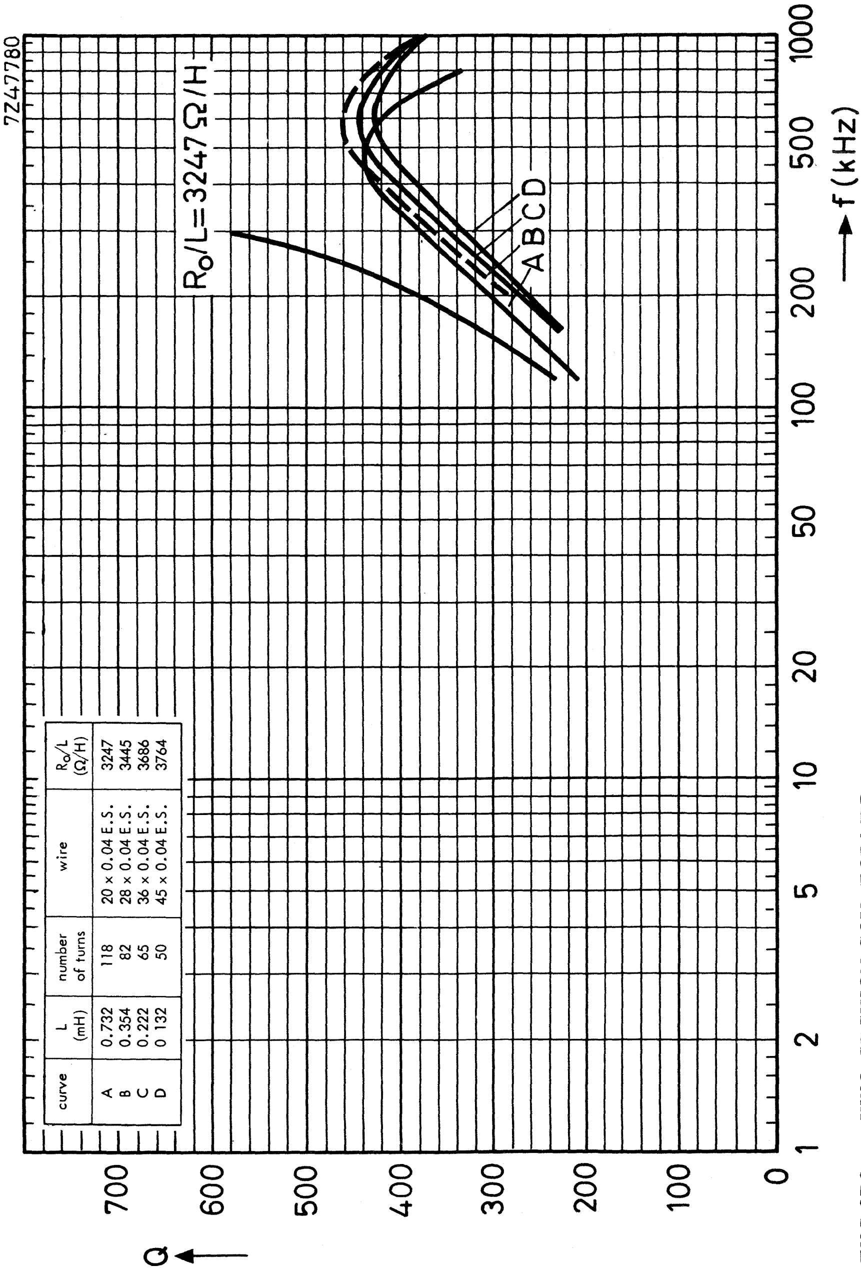
FXC 3D3
$\mu_e = 47$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.560	120	24 × 0.04 E.S.	1334
B	0.801	86	32 × 0.04 E.S.	1400
C	0.457	65	45 × 0.04 E.S.	1315
D	0.219	45	70 × 0.04 E.S.	1588

SINGLE-SECTION COIL FORMER

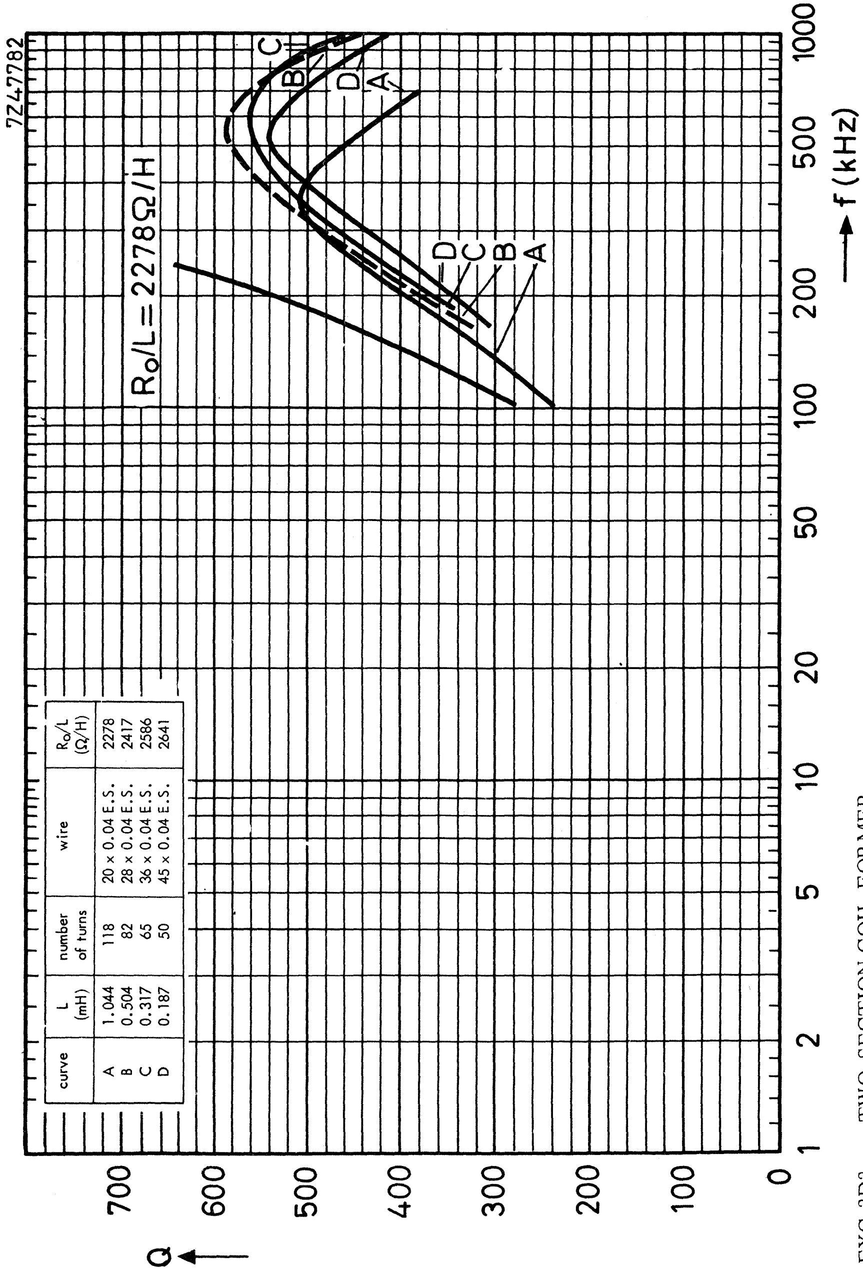
FXC 3D3
$\mu_e = 68$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	0.732	118	20 × 0.04 E.S.	3247
B	0.354	82	28 × 0.04 E.S.	3445
C	0.222	65	36 × 0.04 E.S.	3686
D	0 132	50	45 × 0.04 E.S.	3764

TWO-SECTION COIL FORMER

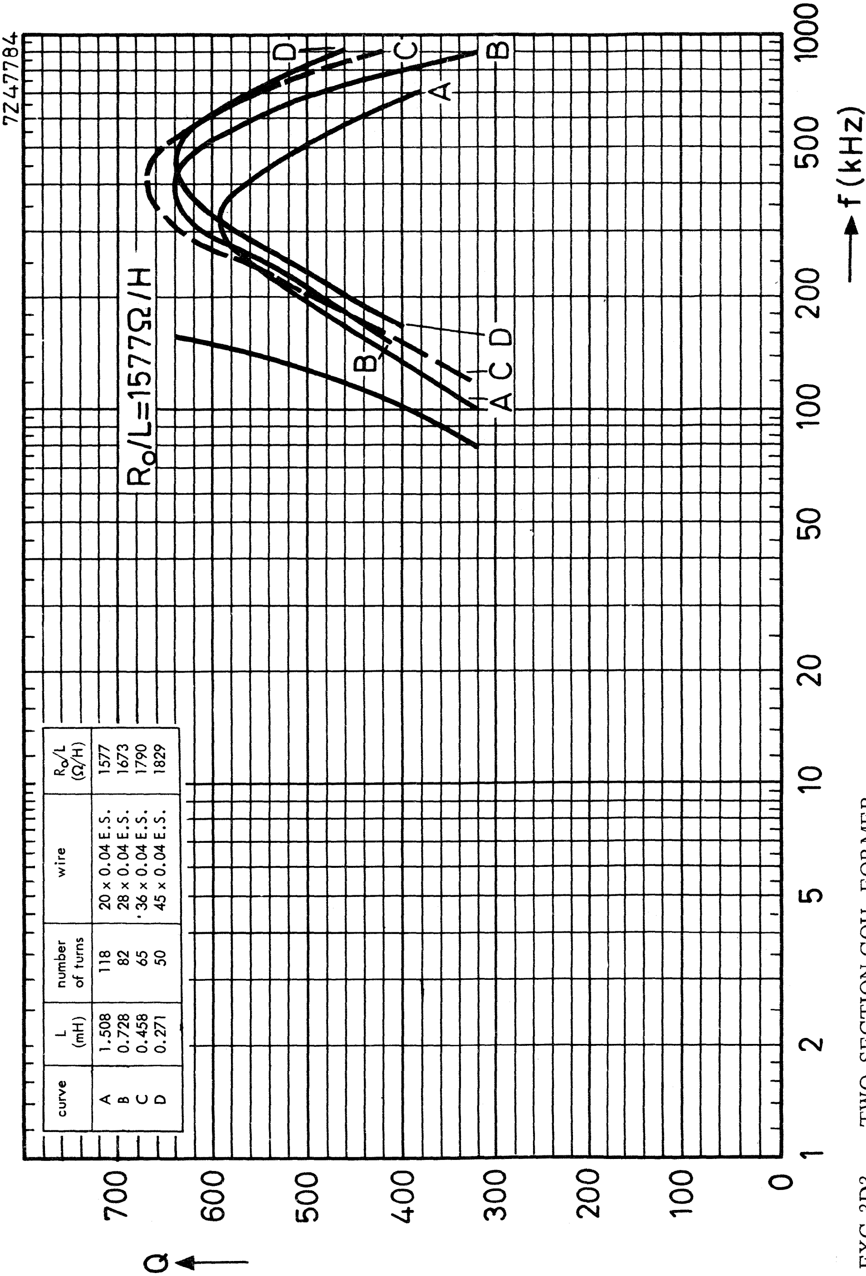
FXC 3D3
$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.044	118	20 × 0.04 E.S.	2278
B	0.504	82	28 × 0.04 E.S.	2417
C	0.317	65	36 × 0.04 E.S.	2586
D	0.187	50	45 × 0.04 E.S.	2641

TWO-SECTION COIL FORMER

FXC 3D3
$\mu_e = 47$

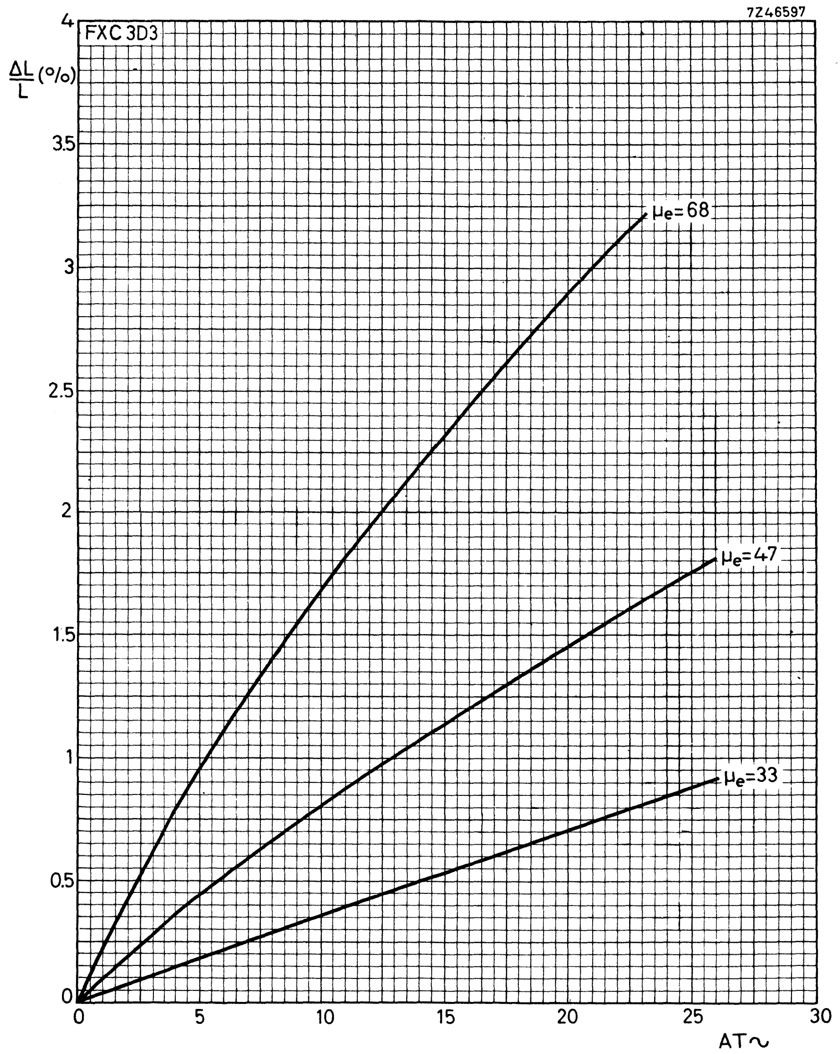


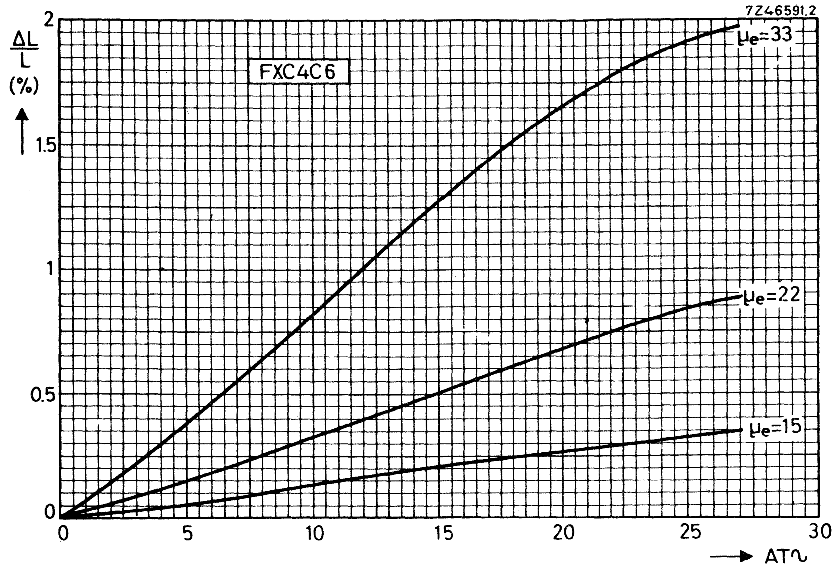
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.508	118	20 × 0.04 E.S.	1577
B	0.728	82	28 × 0.04 E.S.	1673
C	0.458	65	36 × 0.04 E.S.	1790
D	0.271	50	45 × 0.04 E.S.	1829

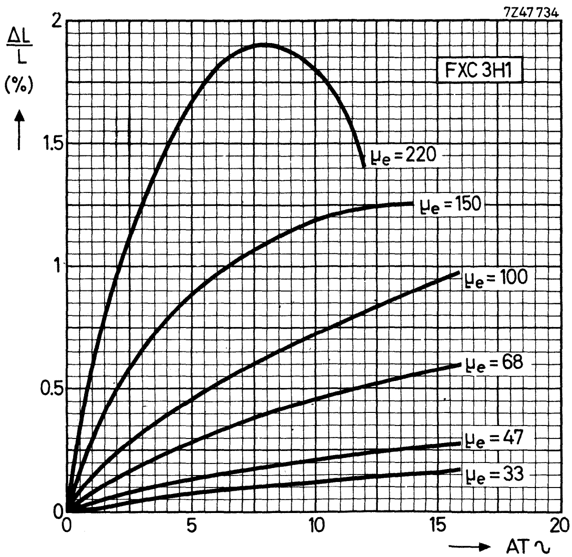
TWO-SECTION COIL FORMER

FXC 3D3
$\mu_e = 68$

INDUCTANCE VARIATION AS A FUNCTION OF AT~

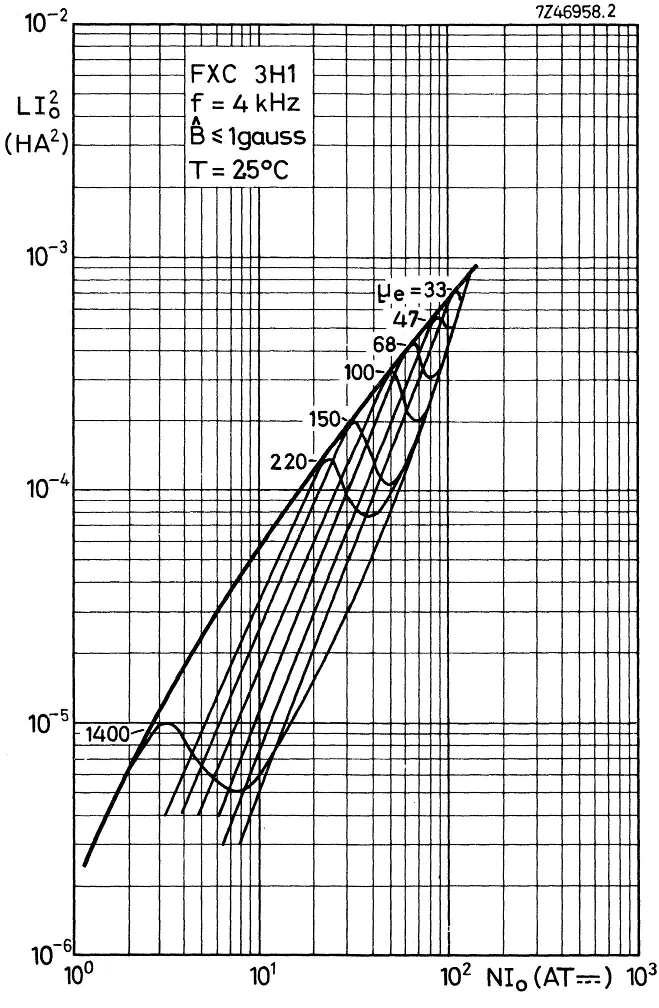


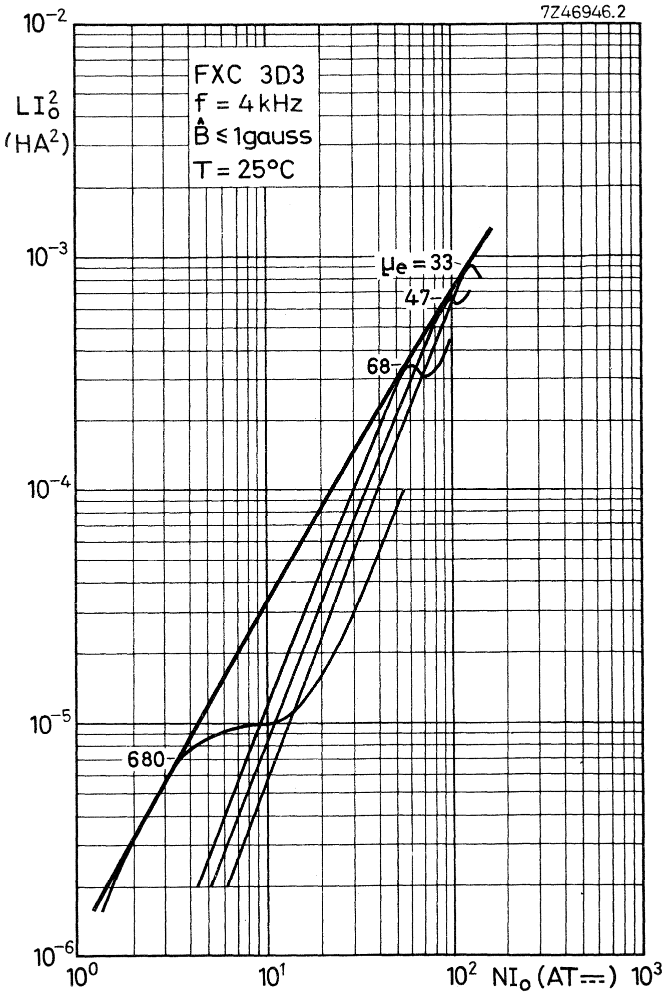

7Z46591.2
FXC4C6
ΔL/L (%)
2
1.5
1
0.5
0
0
5
10
15
20
25
30
AT∿
μe=33
μe=22
μe=15


7Z47734
FXC3H1
ΔL/L (%)
2
1.5
1
0.5
0
0
5
10
15
20
AT∿
μe=220
μe=150
μe=100
μe=68
μe=47
μe=33

HANNA CURVES

Indicating the optimum inductance for a certain μ_e-value and direct current.
Typical values




7Z46946.2
FXC 3D3
f = 4 kHz
B̂ ≤ 1gauss
T = 25°C
LI$_o^2$
(HA^2)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
μ_e = 33
47
68
680
10^0
10^1
10^2
10^3
NI$_o$ (AT⎓)

POTCORES

INTRODUCTION

Three types of core can be supplied:

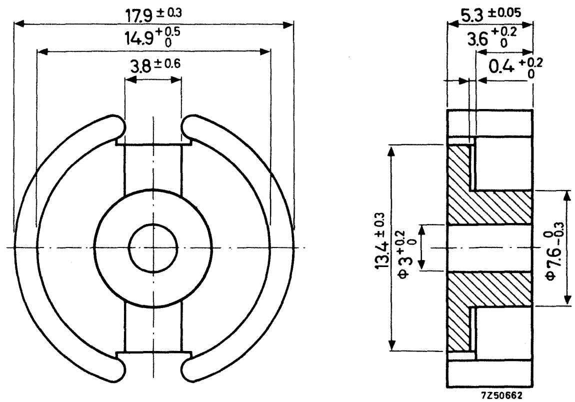
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E_6 range of values or an inductance factor (A_L) in the R5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).

Potcores and associated parts are ordered by their 12-digit catalog number.
Quantity: a primary pack contains 20 potcore halves or 10 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 21500
3H1	4322 020 21510
3D3	4322 020 21520
improved 3E1	4322 020 21640
4C6	4322 020 21610

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (^{o}C)	grade				
		3B7	3H1	3D3		4C6
T.F. x 10^6	+ 5 to +23	-	+0.5 to +1.5	-		-2 to +4
	+ 5 to +55	-	-	-		-
	+23 to +55	-	+0.5 to +1.5	-		0 to +6
	+23 to +70	-0.6 to +0.6	1)	0 to 2		
D.F. x 10^6 (10-100 min)	23 $\pm$ 1	$\leq$4.3	$\leq$4.3	$\leq$12		$\leq$10

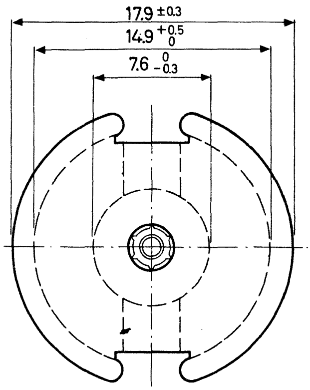
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 100 Newton, the values in Table II are guaranteed at 25 $\pm$ 10 ^{o}C.

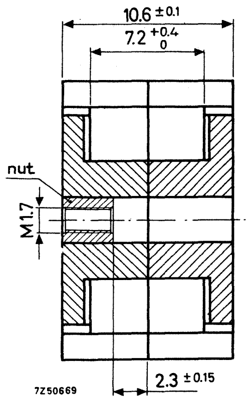
Table II	$\hat{B}$ (Gs)	freq. (MHz)	grade				
			3B7	3H1	3D3	impr. 3E1	4C6
μ_e	$\leq$ 1	0.004	-	-	-	2100-3500	-
	$\leq$ 1	0.1	$\geq$ 1310	$\geq$ 1310	$\geq$ 530	-	$\geq$ 93
A_L	$\leq$ 1	0.004	-	-	-	4450-7400	-
α	$\leq$ 1	0.1	$\leq$ 19.0	$\leq$ 1910	$\leq$ 29.9	-	$\leq$ 71.1
$\frac{\tan \delta}{\mu_i} \times 10^6$	$\leq$ 1	0.004	-	-	-	$\leq$ 2.5	-
	$\leq$ 1	0.1	$\leq$ 5	$\leq$ 5	$\leq$ 8	$\leq$ 20	-
	$\leq$ 1	0.5	-	-	$\leq$ 14	$\leq$ 200	-
	$\leq$ 1	1	-	-	$\leq$ 30	-	-
	-	2	-	-	-	-	$\leq$ 40
	-	10	-	-	-	-	$\leq$ 100
q2-24-100	3-12	0.1	-	-	$\leq$ 3.0	-	$\leq$ 10
	15-30	0.004	$\leq$ 1.8	$\leq$ 1.4	-	$\leq$ 3.0	-

1) For orientation: +0.5 to +1.5

PRE-ADJUSTED POTCORES

Dimensions in mm





With nut, catalog number = 4322 022 2....
Without nut, catalog number = 4322 022 0....

Weight			6.4 g
Mean length of lines of force	l_e	=	2.58 cm
	$\Sigma \frac{l_e}{A_e}$	=	5.97 cm^{-1}
Effective volume	V_e	=	1.12 cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 15, grade 4C6, potcore with nut, catalog number = 4322 022 24810
   A_L = 100, grade 3B7, potcore without nut, catalog number = 4322 022 05040
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

Potcores with standard μ_e values [1)]

μ_e	α	tolerance on inductance (%)	catal. No. 4322 022 2.... with nut / 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
15	178	± 1	-	-	-	4810
22	147	± 1	-	-	-	4820
33	120	± 1	4030	4230	4430	4830
47	100.5	± 1	4040	4240	4440	-
68	83.6	± 1	4050	4250	4450	-
100	68.9	± 1.5	4060	4260	-	-
150	56.3	± 2	4070	4270	-	-
220	46.5	± 3	4080	4280	-	-
705	25.9	± 25	-	-	4400*	-
1750	16.5	± 25	4000*	4200*	-	-

Number of turns $N = \alpha\sqrt{L}$ (L in 10^{-3} H)

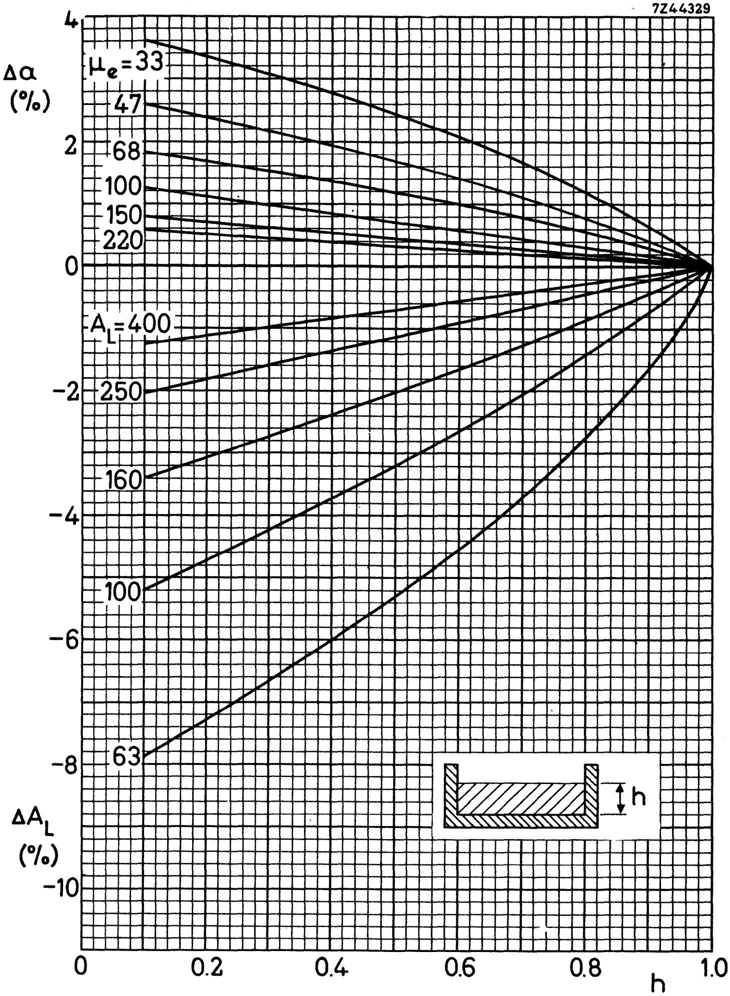
Potcores with standard A_L factors [1)]

A_L	corresponding μ_e - value	tolerance on inductance (%)	catal. No. 4322 022 2.... with nut / 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
25	11.9	± 1	-	-	-	5810
40	19.0	± 1	-	-	5420	5820
63	30	± 1	5030	5230	5430	5830
100	47.5	± 1	5040	5240	5440	-
160	76	± 1	5050	5250	5450	-
250	119	± 1.5	5060	5260	-	-
315	149	± 2	5070	5270	-	-
400	190	± 2	5080	5280	-	-
630	298	± 3	5100	5300	-	-

Inductance $L = N^2 A_L$ (in 10^{-9} H)

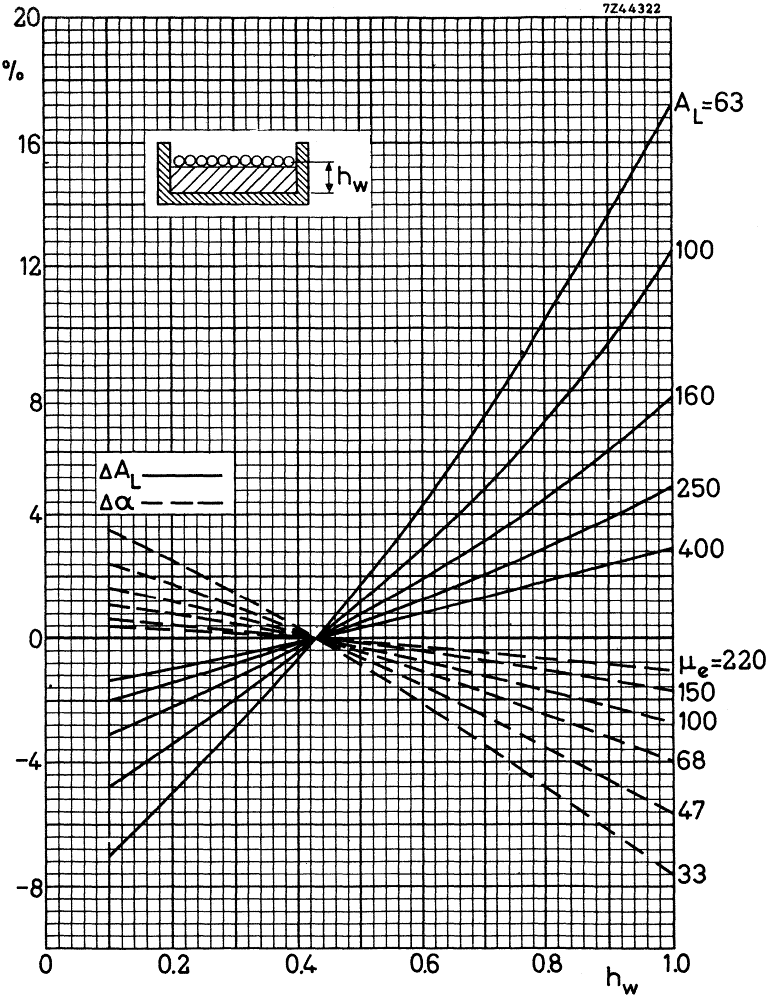
1) See Notes on the previous page.
*) Only available without nut.

DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.
Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: Of a single-section coil former only 0.4 part of the available neight is used. A potcore with μ_e = 68 in that case obtains an α factor of 83.6 + 1.30 %.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_w on a single-section coil former.
Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 68 obtains for that winding an α factor of 83.6 - 1.7 %.

COIL FORMERS

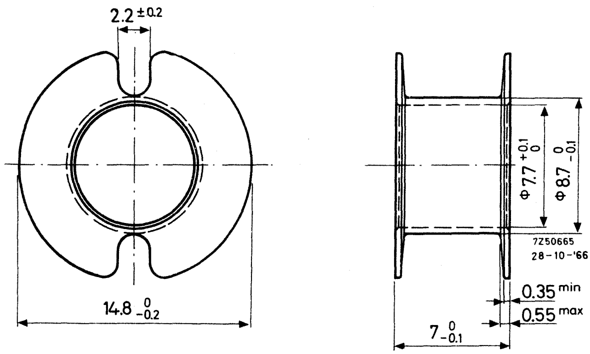
GENERAL

Four types of coil former can be supplied:

- with one section
- with two sections
- with three sections
- with one section and with soldering pins to fit 0.1" and 2.50 mm grid.

The dimensions conform with the following specifications: I.E.C.133 (international), C.C.T.U.0.6-02 (France) and D.I.N.41 294 (Germany).
The dimensions in the drawings are in mm.

SINGLE-SECTION COIL FORMER



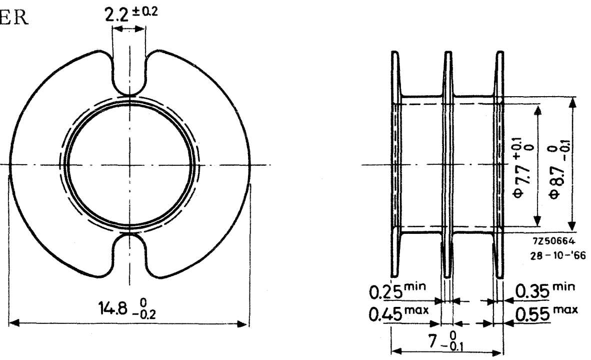
Catalog number	4322 021 30270
→ Material	glassfibre-reinforced polyacetal
Window area	18 mm^2
Mean length of turn	3.7 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 16.4 \times 10^3 \quad \Omega/H$$

Weight 0.35 g

TWO-SECTION
COIL FORMER



Catalog number 4322 021 30280

Material glassfibre-reinforced polyacetal

Window area 2 x 8.7 mm^2

Mean length of turn 3.7 cm

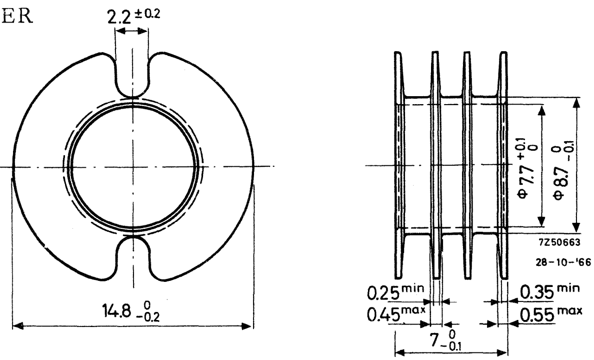
Max. temperature 130 °C

D.C. losses

$$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 17.2 \times 10^3 \quad \Omega/H$$

Weight 0.35 g

THREE-SECTION
COIL FORMER



Catalog number 4322 021 30290

Material glassfibre-reinforced polyacetal

Window area 3 x 5.4 mm^2

Mean length of turn 3.7 cm

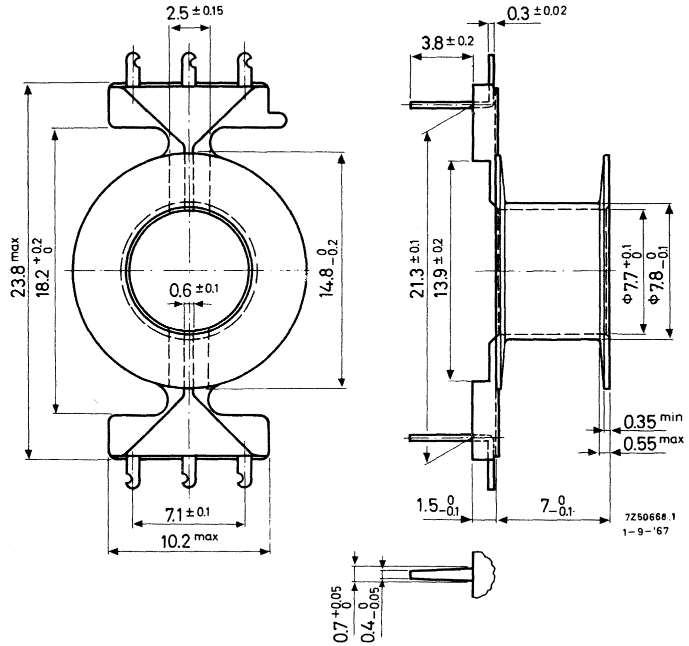
Max. temperature 130 °C

D.C. losses

$$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 18.4 \times 10^3 \quad \Omega/H$$

Weight 0.4 g

SINGLE-SECTION COIL FORMER WITH SOLDERING PINS



→ Catalog number 4322 021 30090

Material: reinforced polyester with brass dipsoldered pins

Window area 18 mm^2

Mean length of turn 3.7 cm

→ Max. temperature 180 °C

Solderability according to I.E.C.68-2-20, part 2, test T

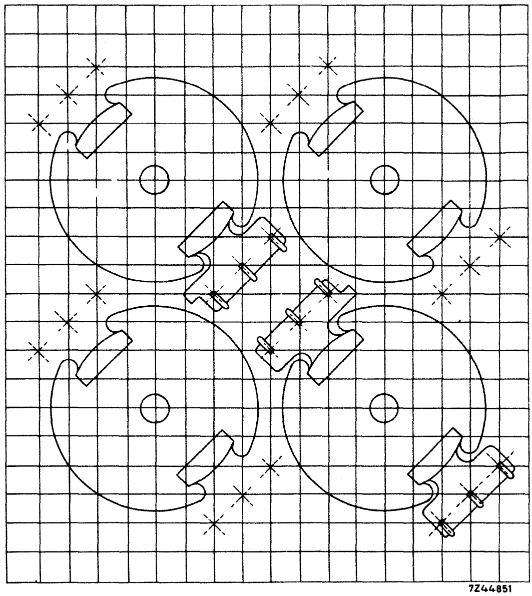
D.C. losses

$$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 16.4 \times 10^3 \ \Omega/H$$

Weight 0.45 g

The coil formers are packed in boxes containing 5 layers of 80 coil formers, so please order in multiples of 80.

The soldering pins are so arranged that they will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes 1.3 + 0.1 mm diameter.
For this coil former the potcore halves must be cemented together, and it is recommended to cement the coil former to the lower potcore half.



INDUCTANCE ADJUSTORS

ADJUSTORS

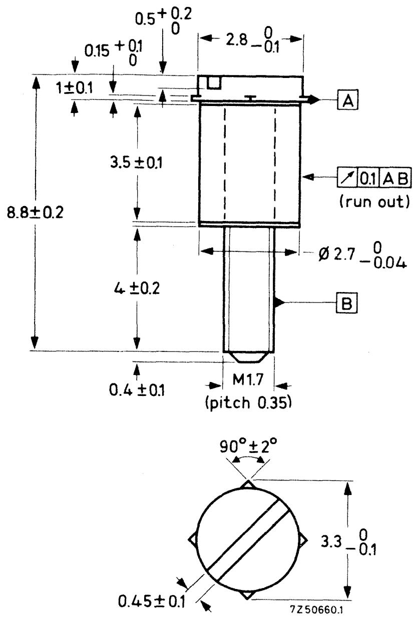


Fig. A

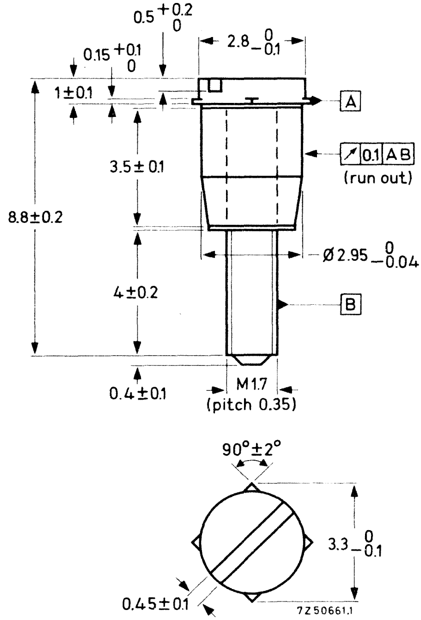


Fig. B

The tolerances on inductance of the pre-adjusted potcores (without adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.
Table II shows the type of adjustor recommended for different potcores.

Table I, available types:

Fig.	colour	catalogue number
A	brown	4322 021 30730
A	green	4322 021 30760
A	red	4322 021 30770
B	yellow	4322 021 30960
B	white	4322 021 30970
B	grey	4322 021 31080

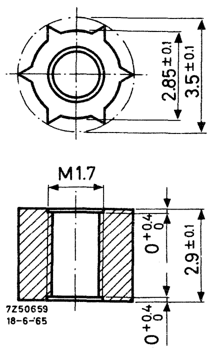
The adjustors are packed in bags of 100 so please order in multiples of 100.

Table II, recommended application:

μ_e	A_L	3B7/3H1/3D3	4C6
		cat.number 4322 021	
15		-	30760
	25	-	30760
	40	-	30770
22		-	30770
	63	30760	-
33		30760	30970
	100	30770	
47		30770	
68		30960	
	160	30960	
	250	30970	
100		30970	
	315	30730	
150		30730	
	400	31080	
220		31080	
	630	31080	

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

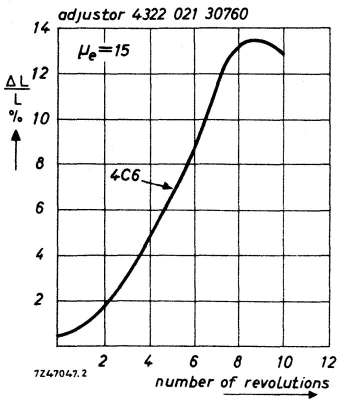


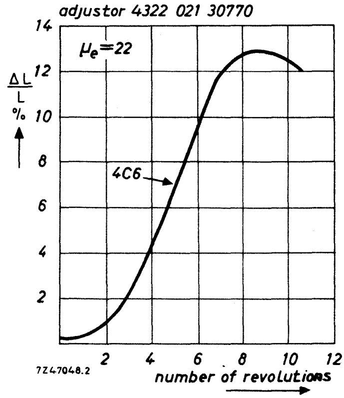
Catalogue number	4322 021 30140
Material	polycarbonate
Max. impregnation temperature during 24 hours	120 °C
Recommended distance from mating surface to nut	2.3 ± 0.15 mm

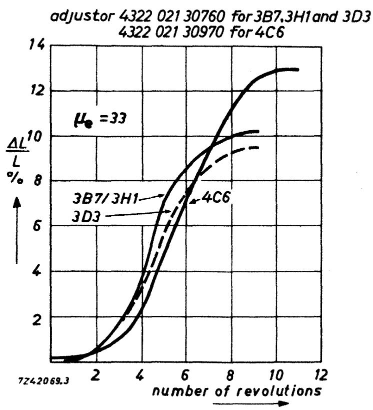
For more information see Potcores General, Inductance adjustment.

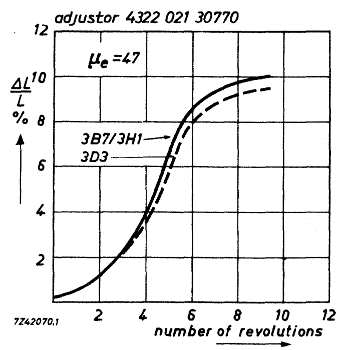
The nuts are packed in bags of 100, so please order in multiples of 100.

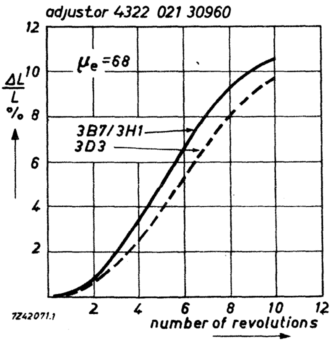
ADJUSTMENT CURVES

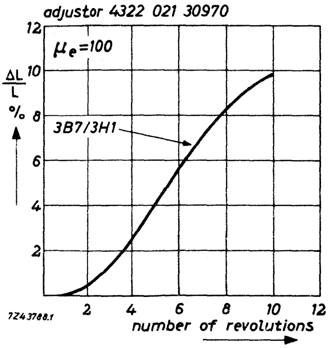


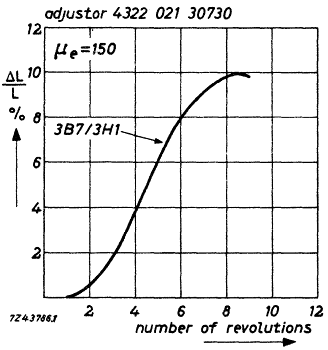


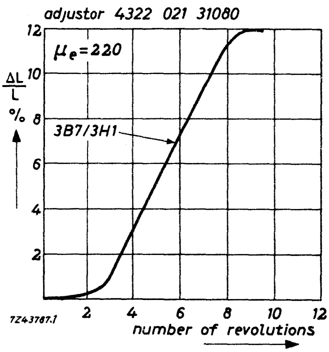





adjustor 4322 021 30960
μ_e=68
3B7/3H1
3D3
ΔL/L
%
12
10
8
6
4
2
2
4
6
8
10
12
number of revolutions
7Z42071.1

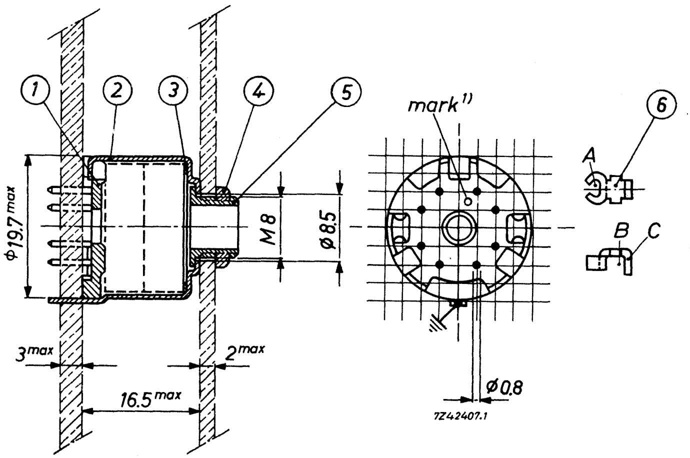

adjustor 4322 021 30970
μ_e=100
3B7/3H1
ΔL/L
%
12
10
8
6
4
2
2
4
6
8
10
12
number of revolutions
7Z43788.1


adjustor 4322 021 30730
μ_e=150
3B7/3H1
ΔL/L
%
12
10
8
6
4
2
2
4
6
8
10
12
number of revolutions
7Z43786.1


adjustor 4322 021 31080
μ_e=220
3B7/3H1
ΔL/L
%
12
10
8
6
4
2
2
4
6
8
10
12
number of revolutions
7Z43787.1

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30450	(4) nut	4322 021 30710
(2) brass container	4322 021 30530	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30640	(6) soldering spring	4322 021 30700 (8x)

The core is suitable for mounting on printed-wiring boards and on conventional panels.

The parts 1, 2, 3 (and 6) are sufficient to construct an assembly for use in combination with printed wiring.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The eight soldering pins are arranged so as to fit a grid of 2.52 mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness up to 3 mm. The board should be provided with holes of 1.3+0.1 mm diameter.

---

[1]) There is another mark hole in a similar position on the top of the container.

If one-hole mounting is preferred, the parts 4 and 5 should be added. The coil assembly may then be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

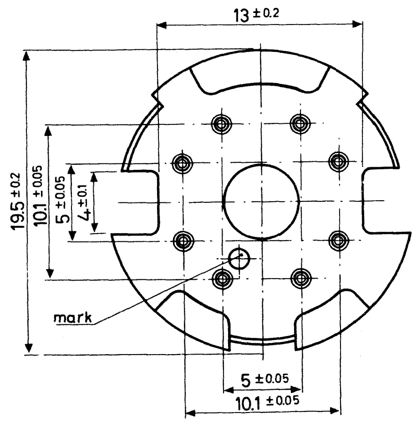
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

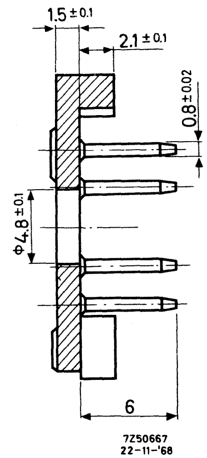
Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 100 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

(1) Tag plate 4322 021 30450

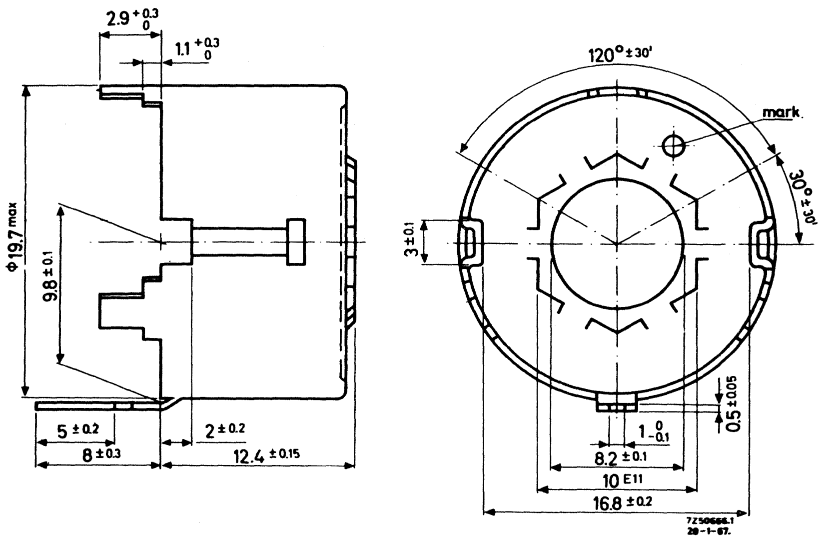
Plate : reinforced polyester
Pins : phosphorbronze, dipsoldered





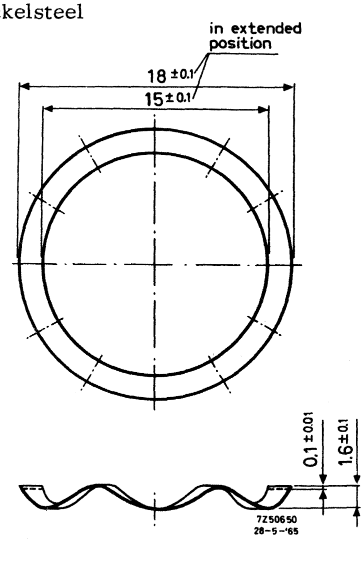
(2) Container 4322 021 30530

Material : brass, nickel plated



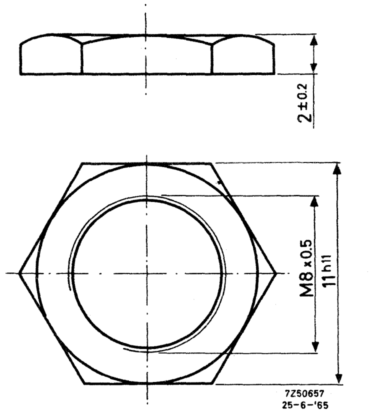
(3) Spring 4322 021 30640

Material : chrome-nickelsteel



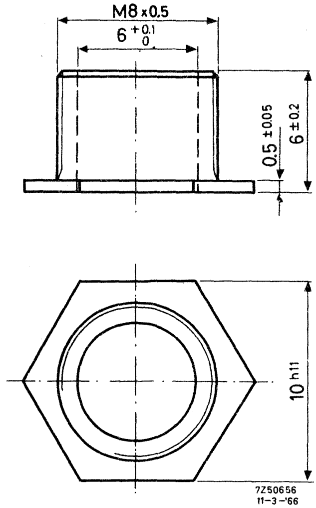
(4) Nut 4322 021 30710

→ Material : brass, nickel plated



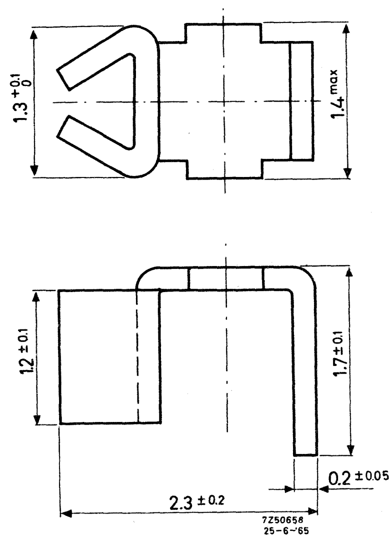
(5) Fixing bush 4322 021 30720

Material : brass, nickel plated



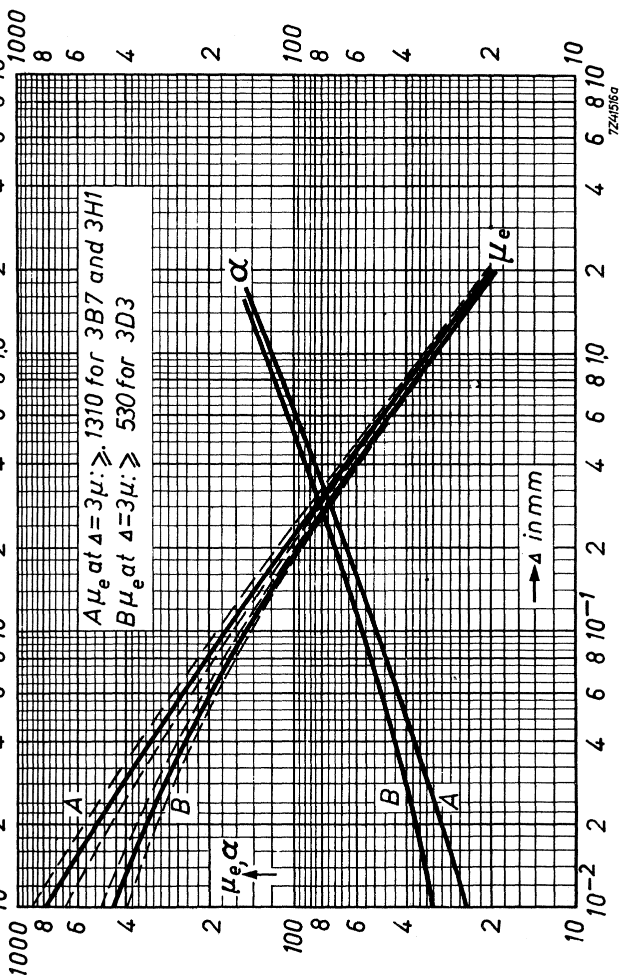
(6) Soldering spring 4322 021 30700

Material : brass, dipsoldered



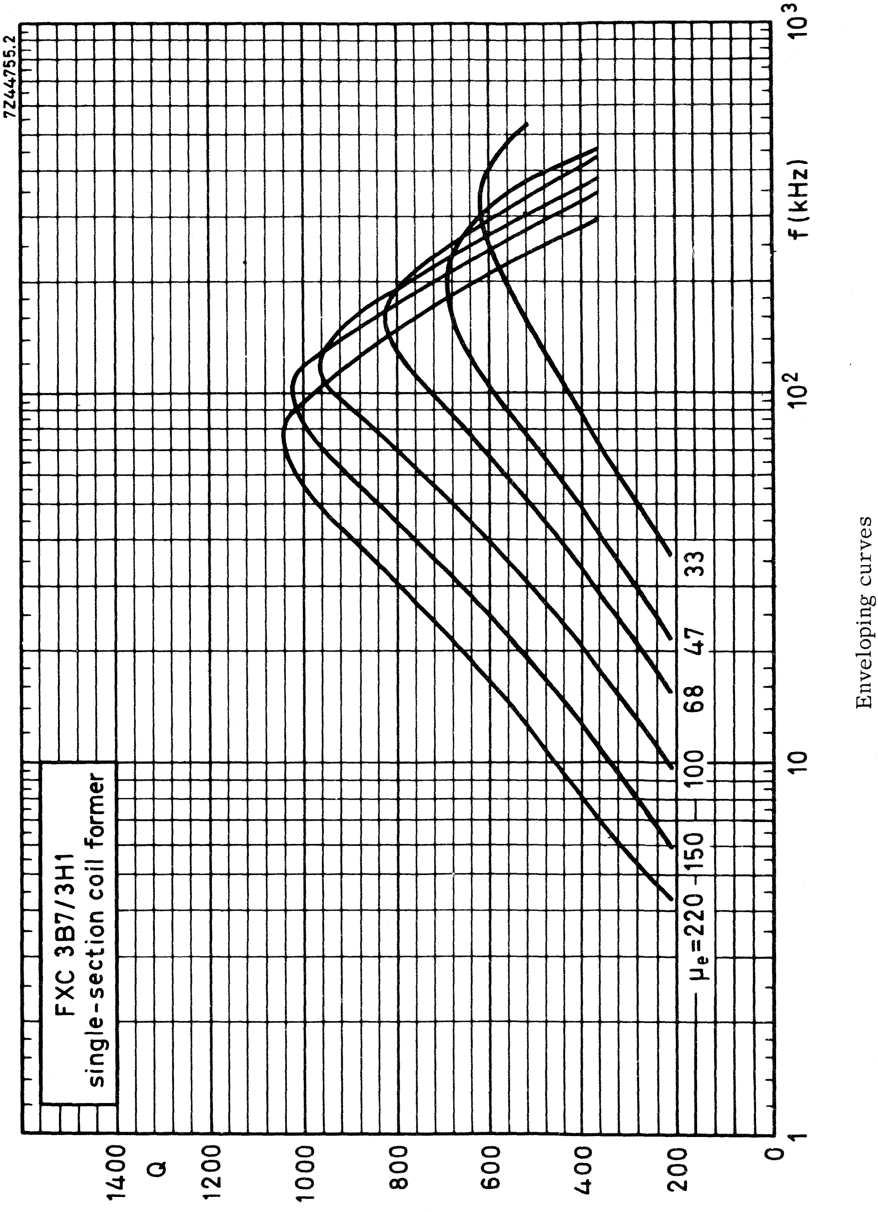
CHARACTERISTIC CURVES

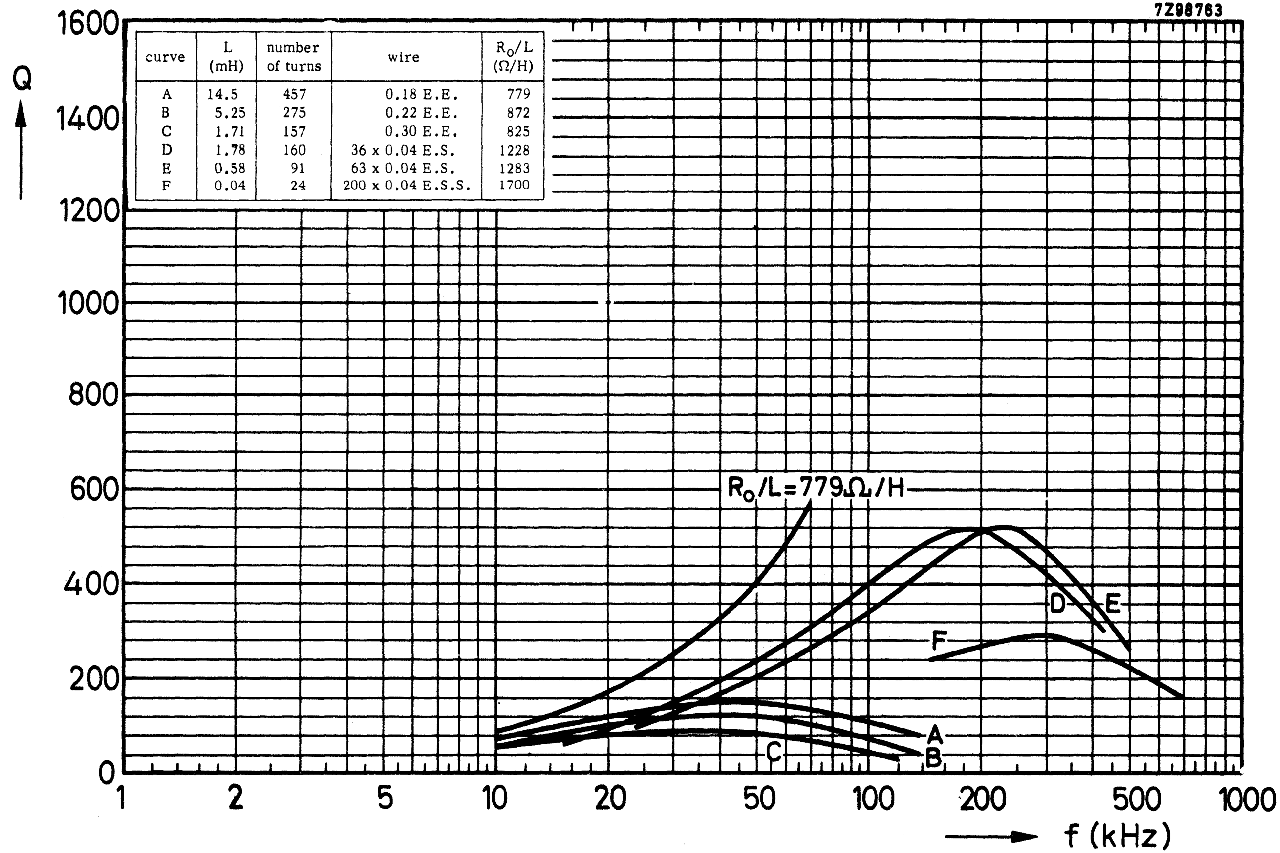
μ_e - α CURVES



Relative effective permeability and turn factor for 1 mH as a function of the air gap length

TYPICAL Q-CURVES FOR FXC 3B7/3H1

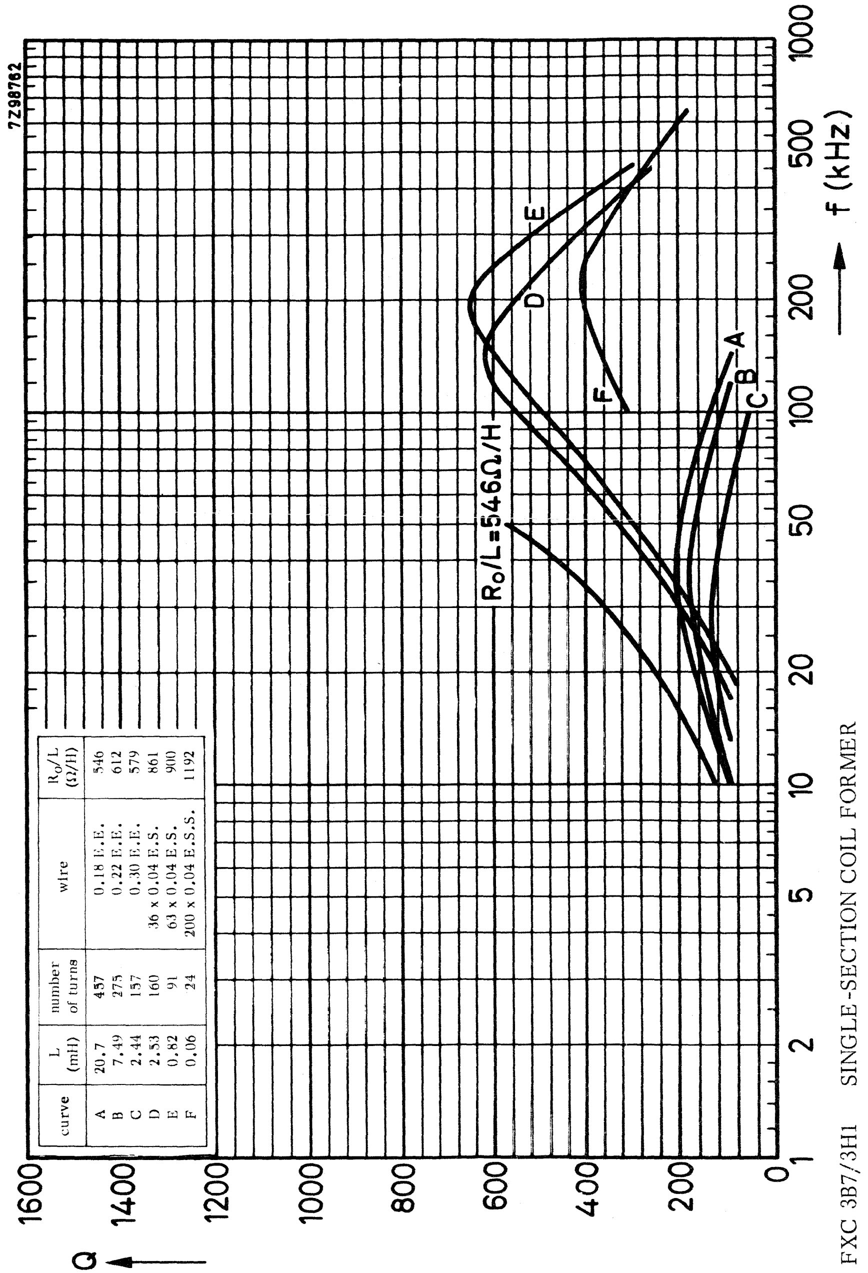




curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	14.5	457	0.18 E.E.	779
B	5.25	275	0.22 E.E.	872
C	1.71	157	0.30 E.E.	825
D	1.78	160	36 x 0.04 E.S.	1228
E	0.58	91	63 x 0.04 E.S.	1283
F	0.04	24	200 x 0.04 E.S.S.	1700

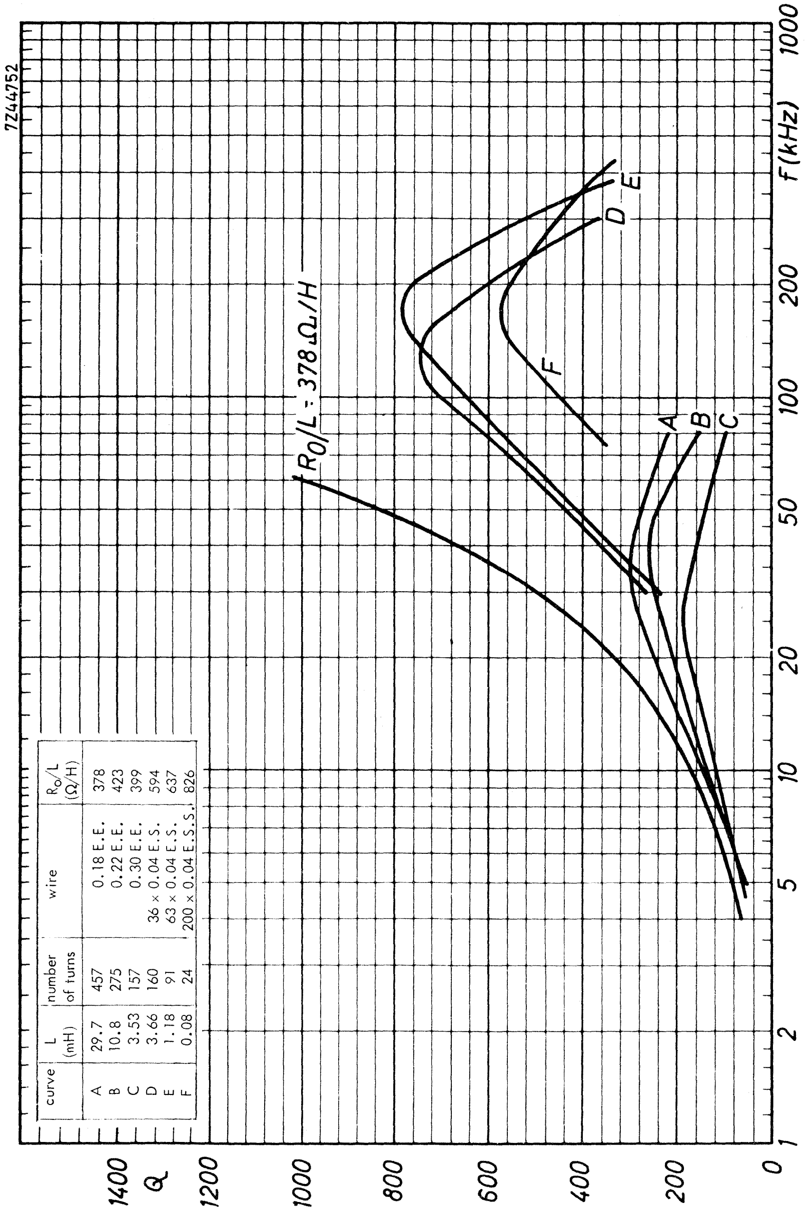
FXC3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	20.7	457	0.18 E.E.	546
B	7.49	275	0.22 E.E.	612
C	2.44	157	0.30 E.E.	579
D	2.53	160	36 x 0.04 E.S.	861
E	0.82	91	63 x 0.04 E.S.	900
F	0.06	24	200 x 0.04 E.S.S.	1192

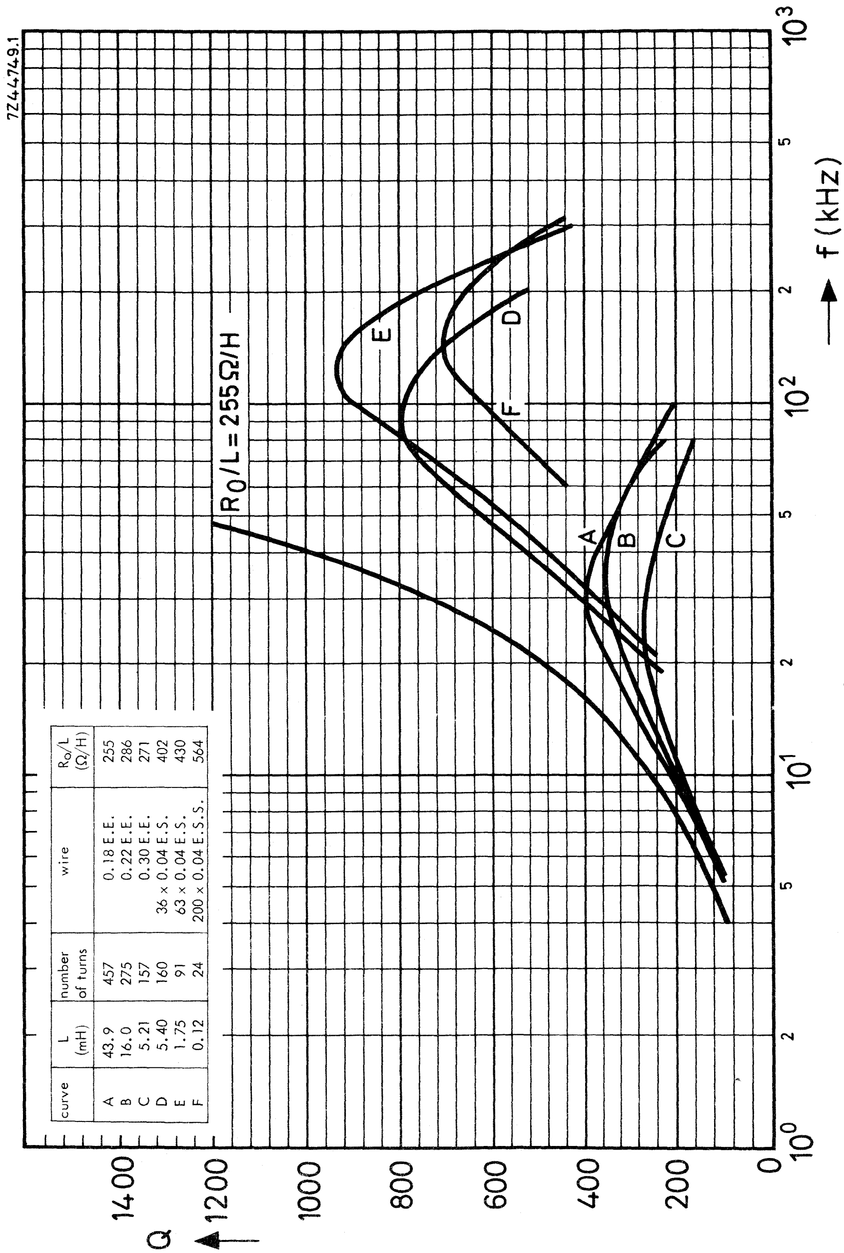
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 47$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	29.7	457	0.18 E.E.	378
B	10.8	275	0.22 E.E.	423
C	3.53	157	0.30 E.E.	399
D	3.66	160	36 × 0.04 E.S.	594
E	1.18	91	63 × 0.04 E.S.	637
F	0.08	24	200 × 0.04 E.S.S.	826

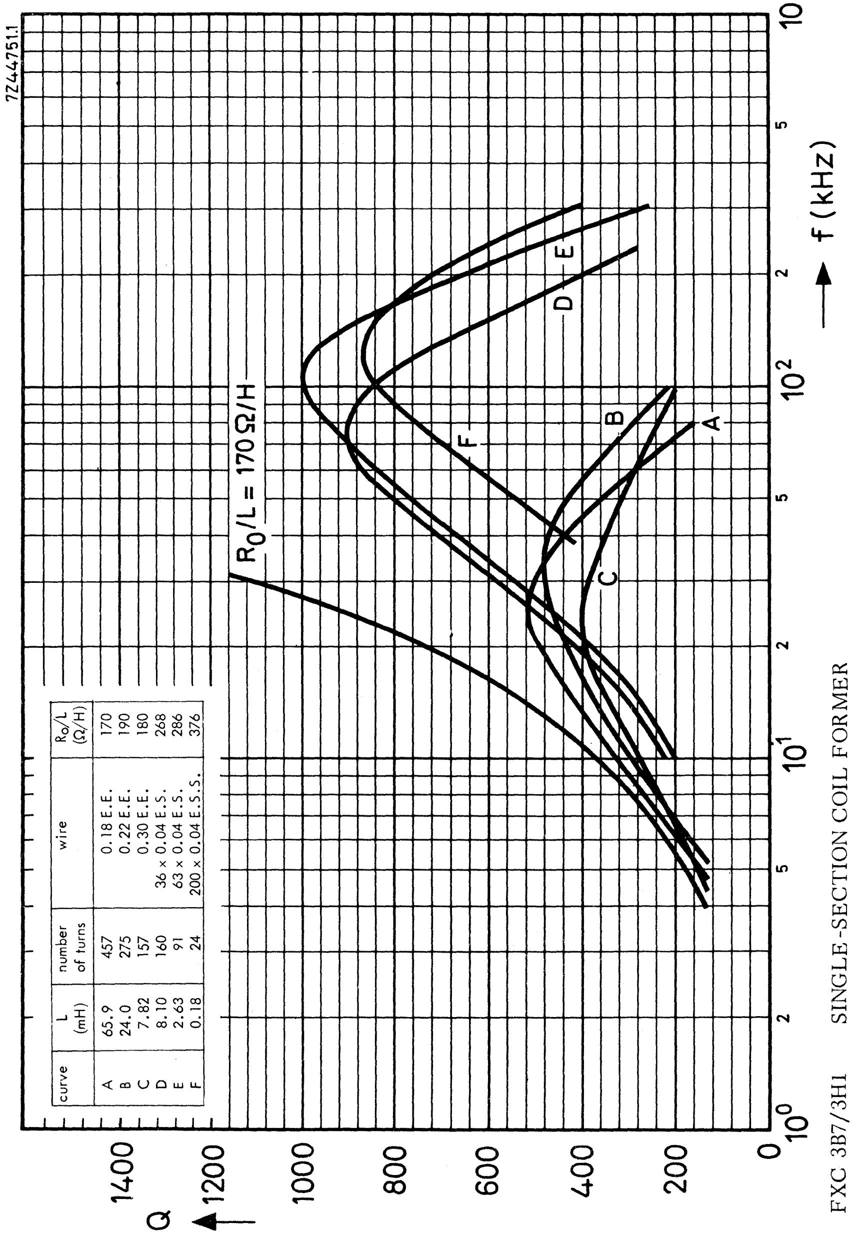
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 68$



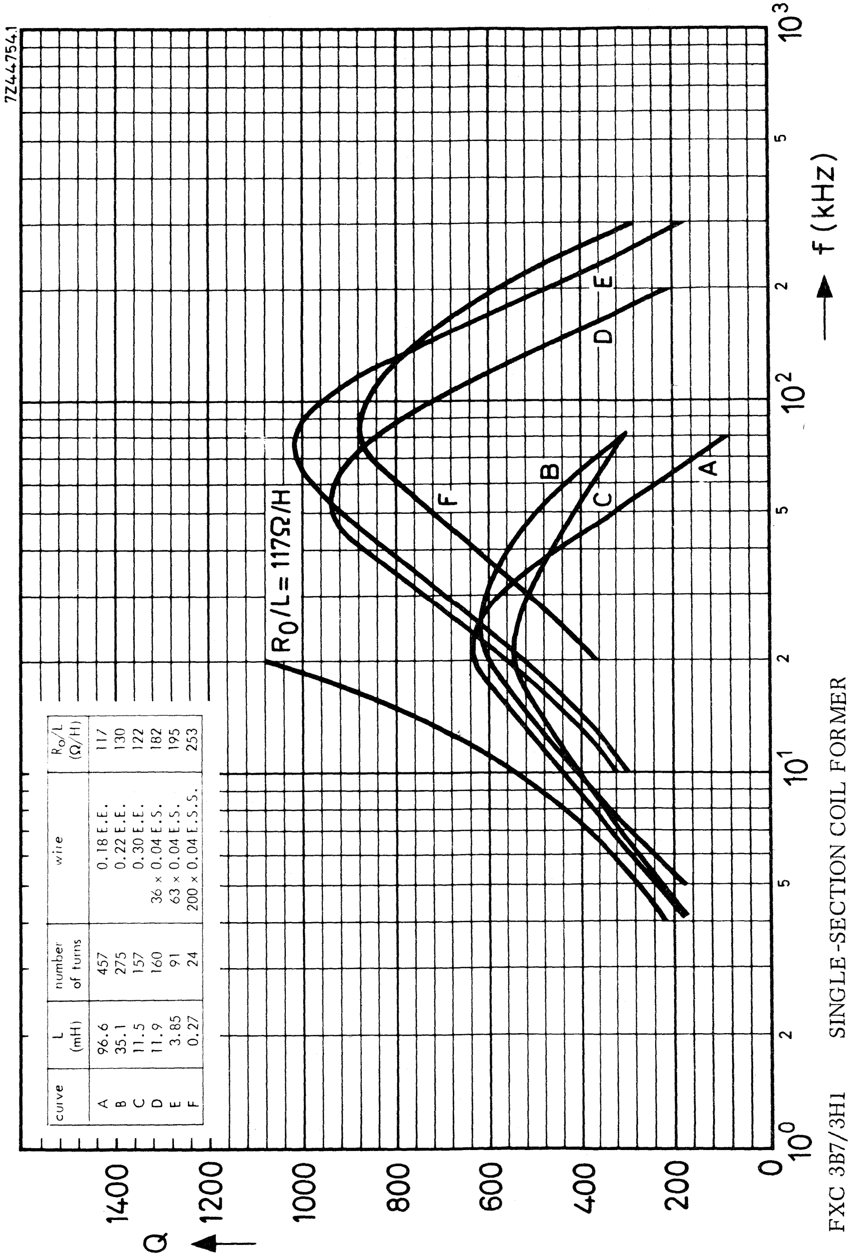
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	43.9	457	0.18 E.E.	255
B	16.0	275	0.22 E.E.	286
C	5.21	157	0.30 E.E.	271
D	5.40	160	36 × 0.04 E.S.	402
E	1.75	91	63 × 0.04 E.S.	430
F	0.12	24	200 × 0.04 E.S.S.	564

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 100$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	65.9	457	0.18 E.E.	170
B	24.0	275	0.22 E.E.	190
C	7.82	157	0.30 E.E.	180
D	8.10	160	36 × 0.04 E.S.	268
E	2.63	91	63 × 0.04 E.S.	286
F	0.18	24	200 × 0.04 E.S.S.	376

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 150$



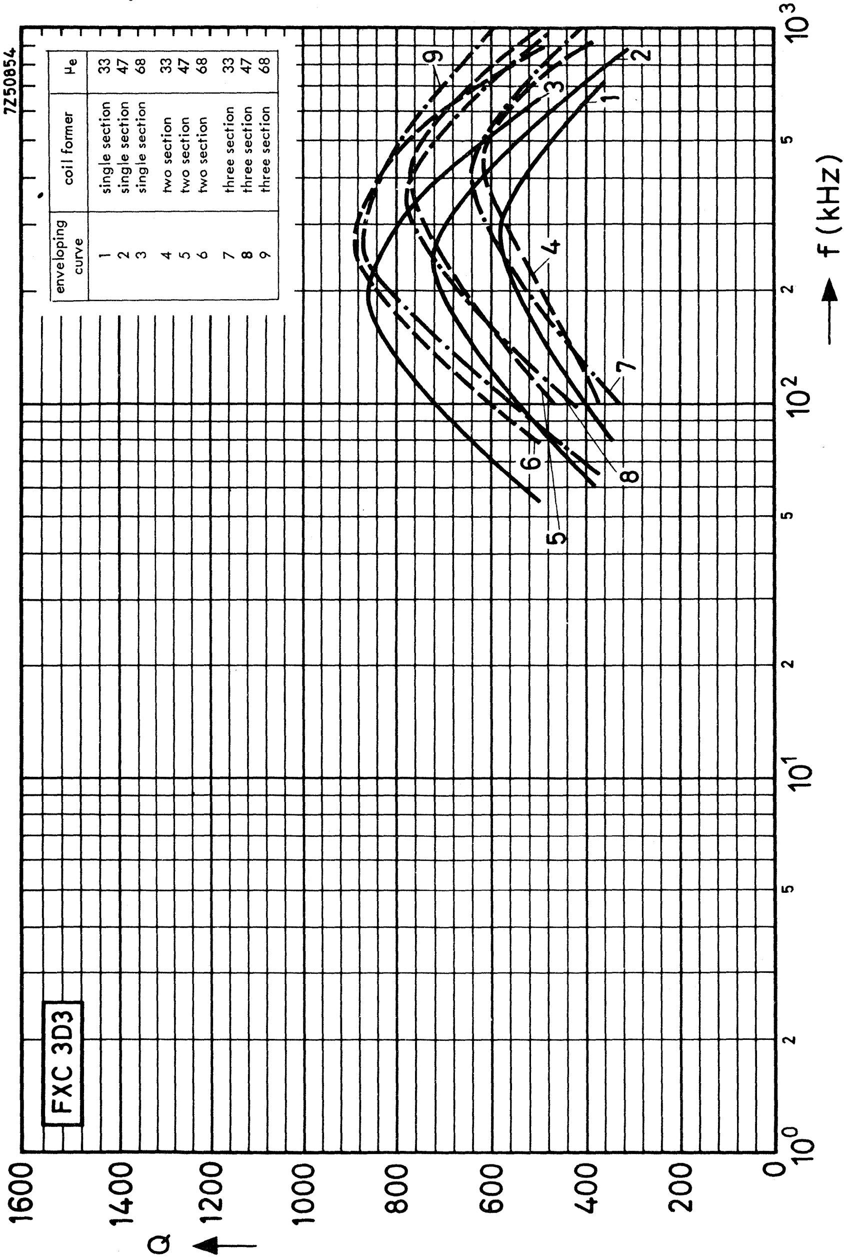
curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	96.6	457	0.18 E.E.	117
B	35.1	275	0.22 E.E.	130
C	11.5	157	0.30 E.E.	122
D	11.9	160	36 × 0.04 E.S.	182
E	3.85	91	63 × 0.04 E.S.	195
F	0.27	24	200 × 0.04 E.S.S.	253

SINGLE-SECTION COIL FORMER

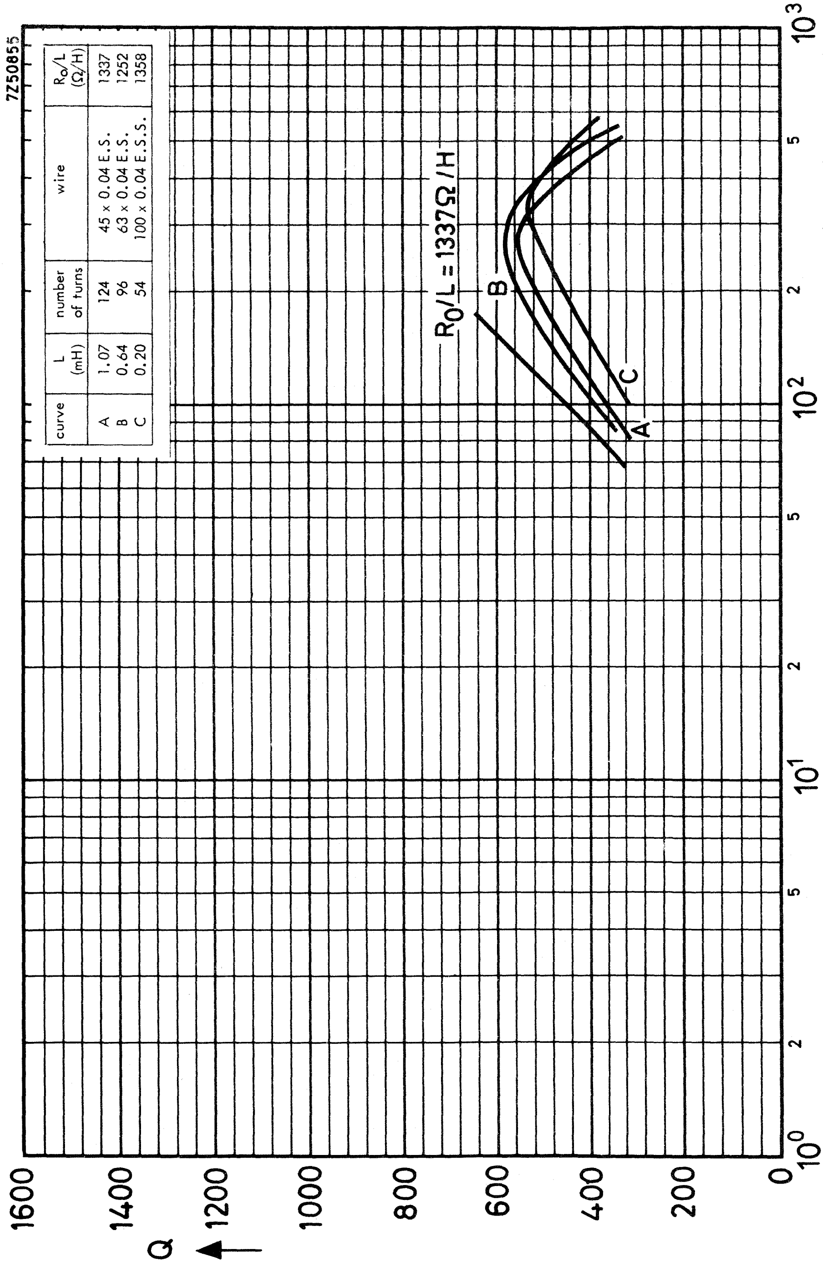
FXC 3B7/3H1

$\mu_e = 220$

TYPICAL Q-CURVES FOR FXC 3D3



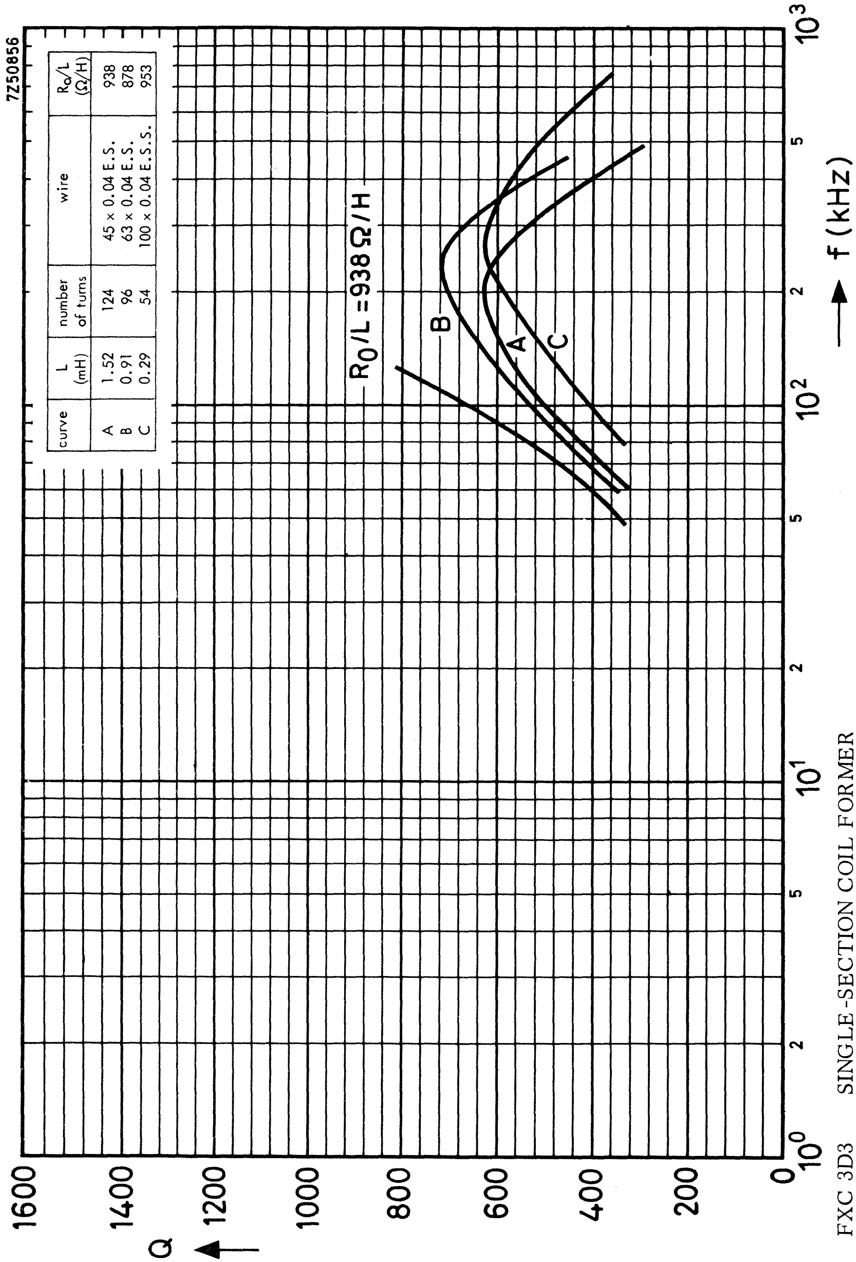
Enveloping curves



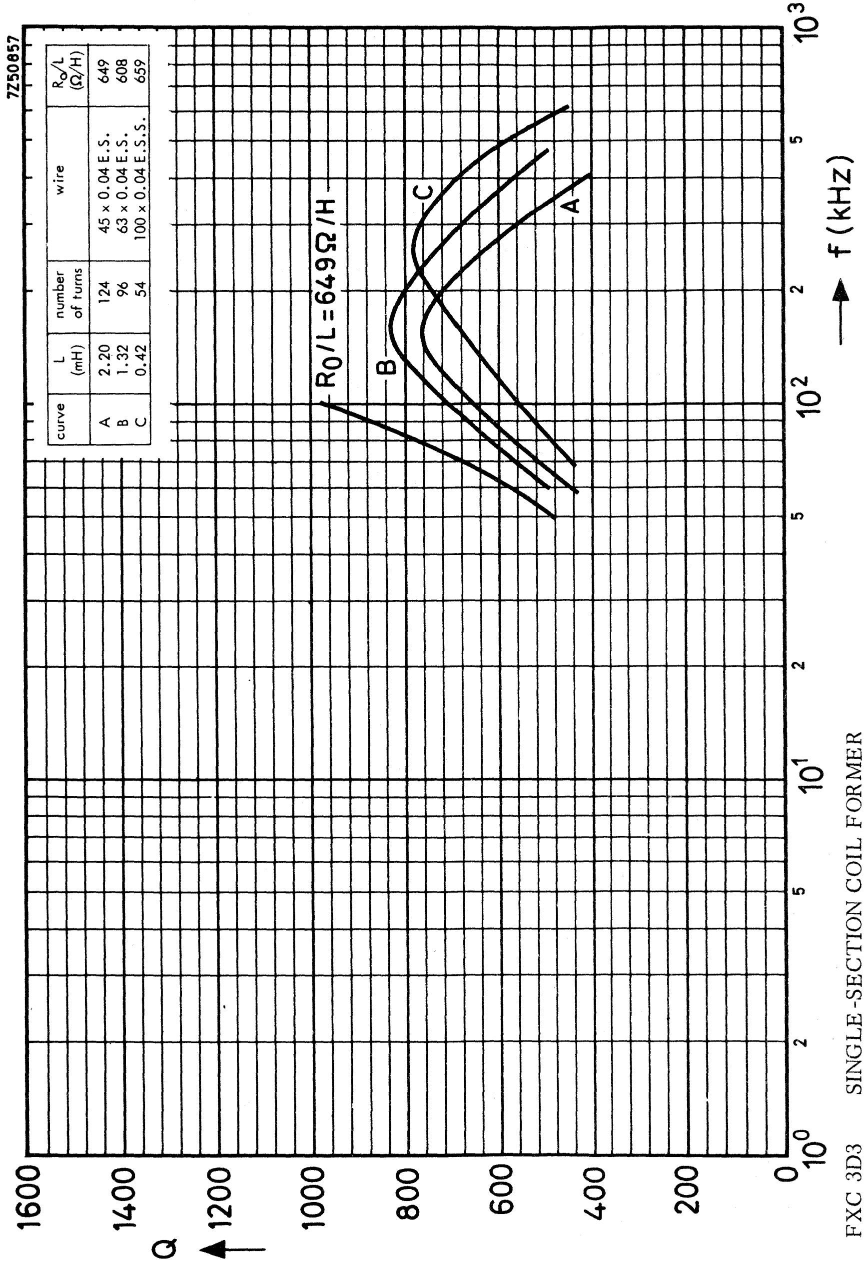
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.07	124	45 x 0.04 E.S.	1337
B	0.64	96	63 x 0.04 E.S.	1252
C	0.20	54	100 x 0.04 E.S.S.	1358

FXC 3D3 SINGLE-SECTION COIL FORMER

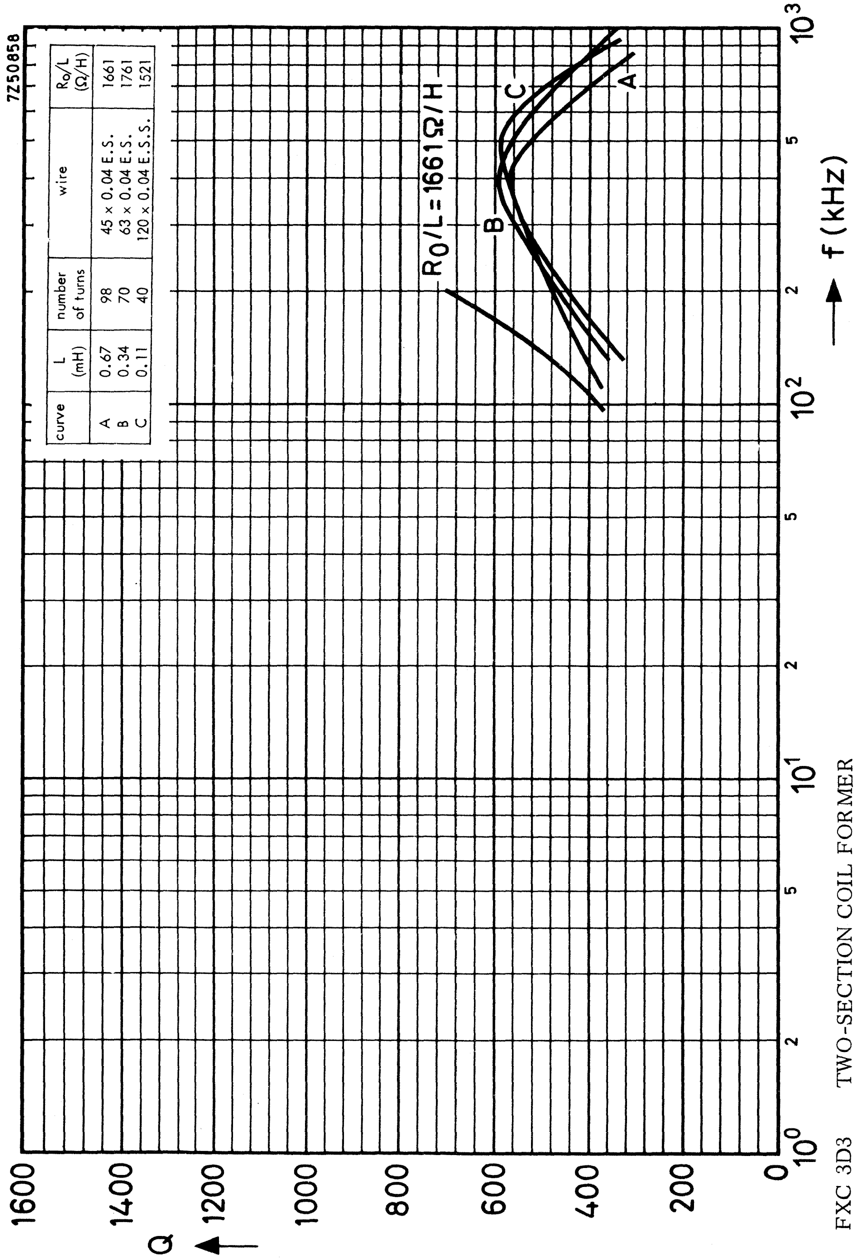
$\mu_e = 33$



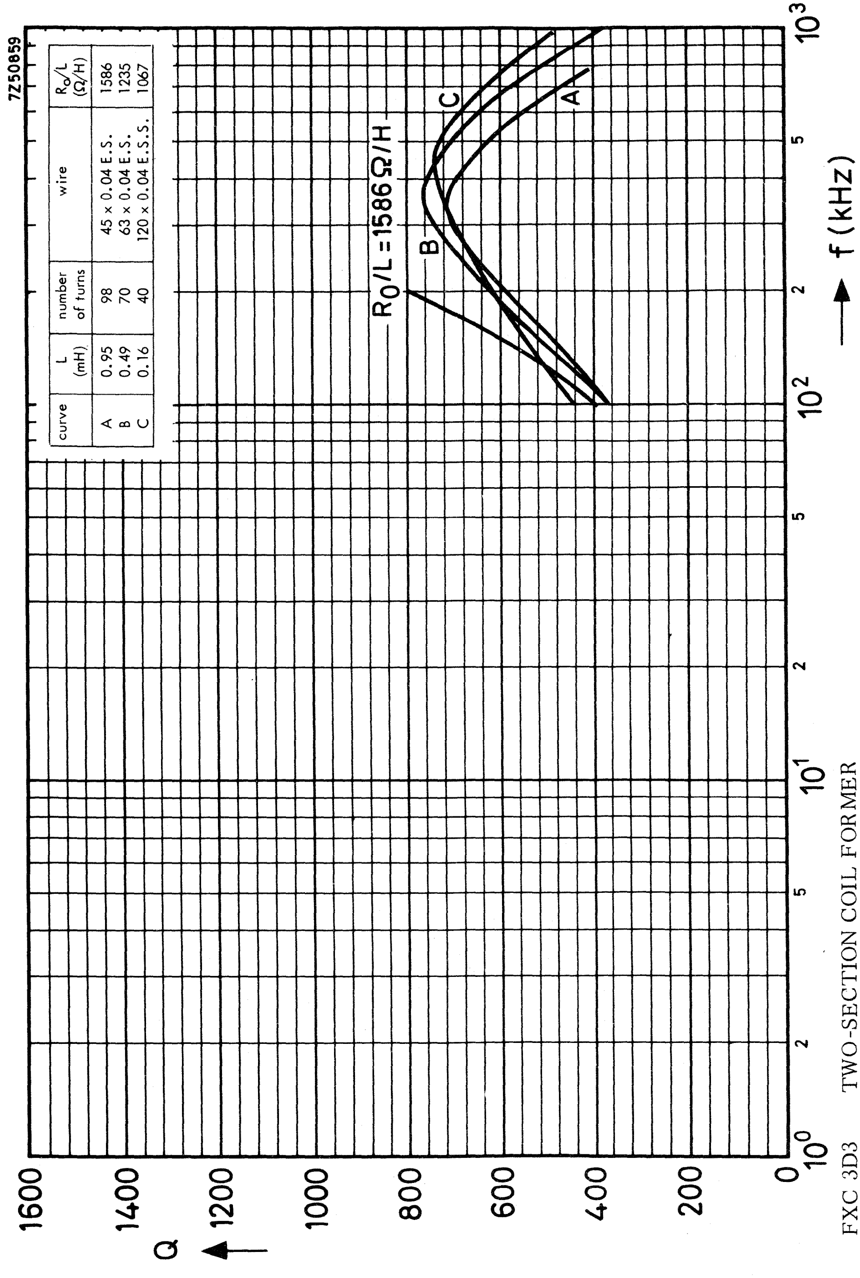
FXC 3D3 SINGLE-SECTION COIL FORMER
$\mu_e = 47$



FXC 3D3 SINGLE-SECTION COIL FORMER
$\mu_e = 68$

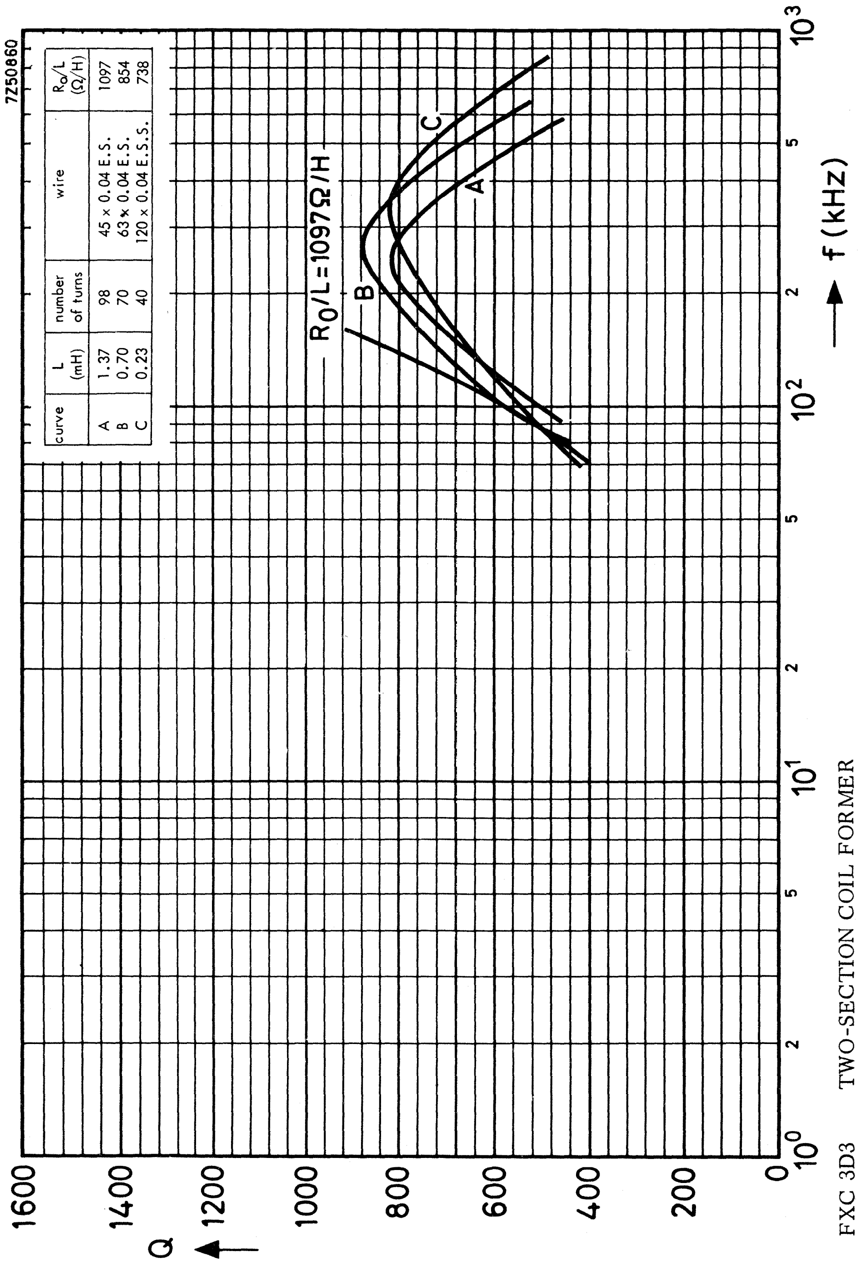


FXC 3D3 TWO-SECTION COIL FORMER
$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	0.95	98	45 × 0.04 E.S.	1586
B	0.49	70	63 × 0.04 E.S.	1235
C	0.16	40	120 × 0.04 E.S.S.	1067

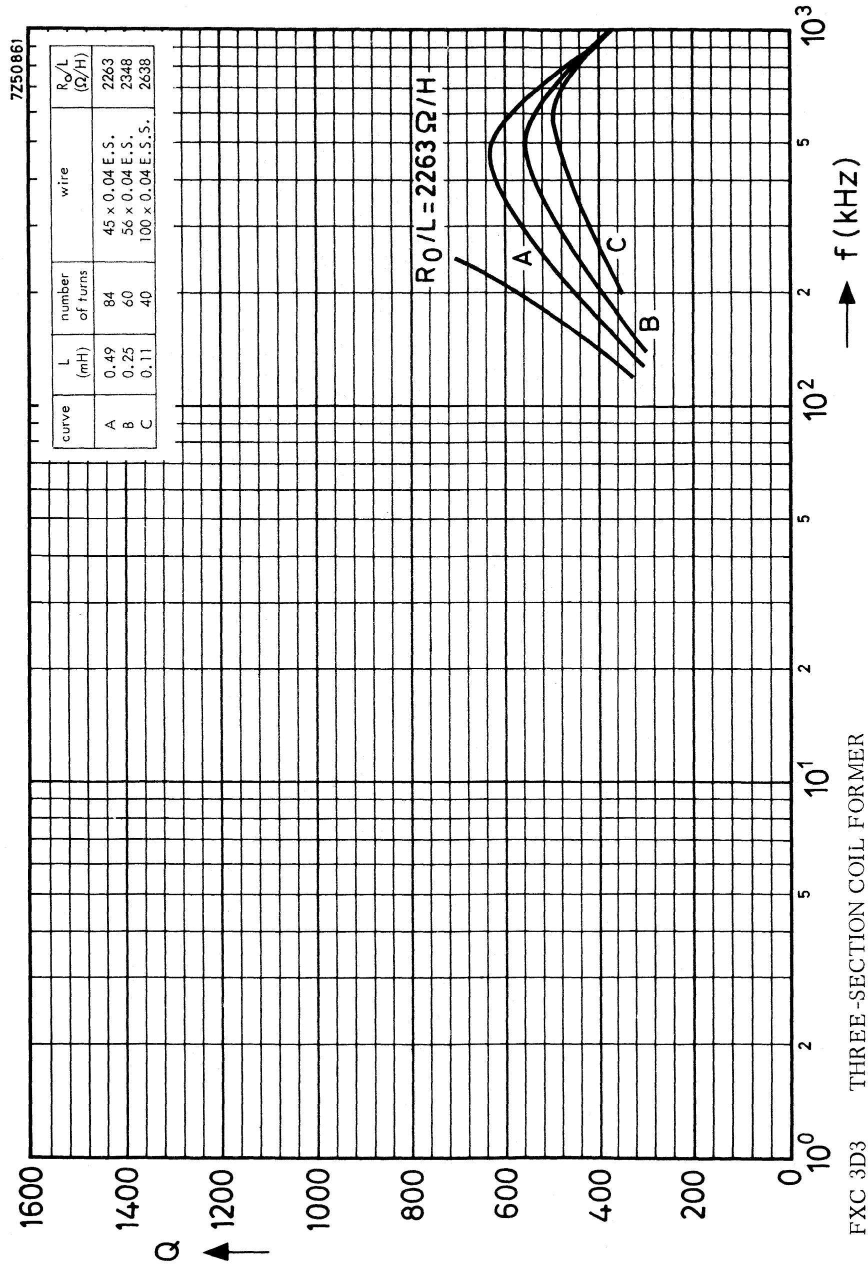
FXC 3D3 TWO-SECTION COIL FORMER
$\mu_e = 47$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.37	98	45 × 0.04 E.S.	1097
B	0.70	70	63 × 0.04 E.S.	854
C	0.23	40	120 × 0.04 E.S.S.	738

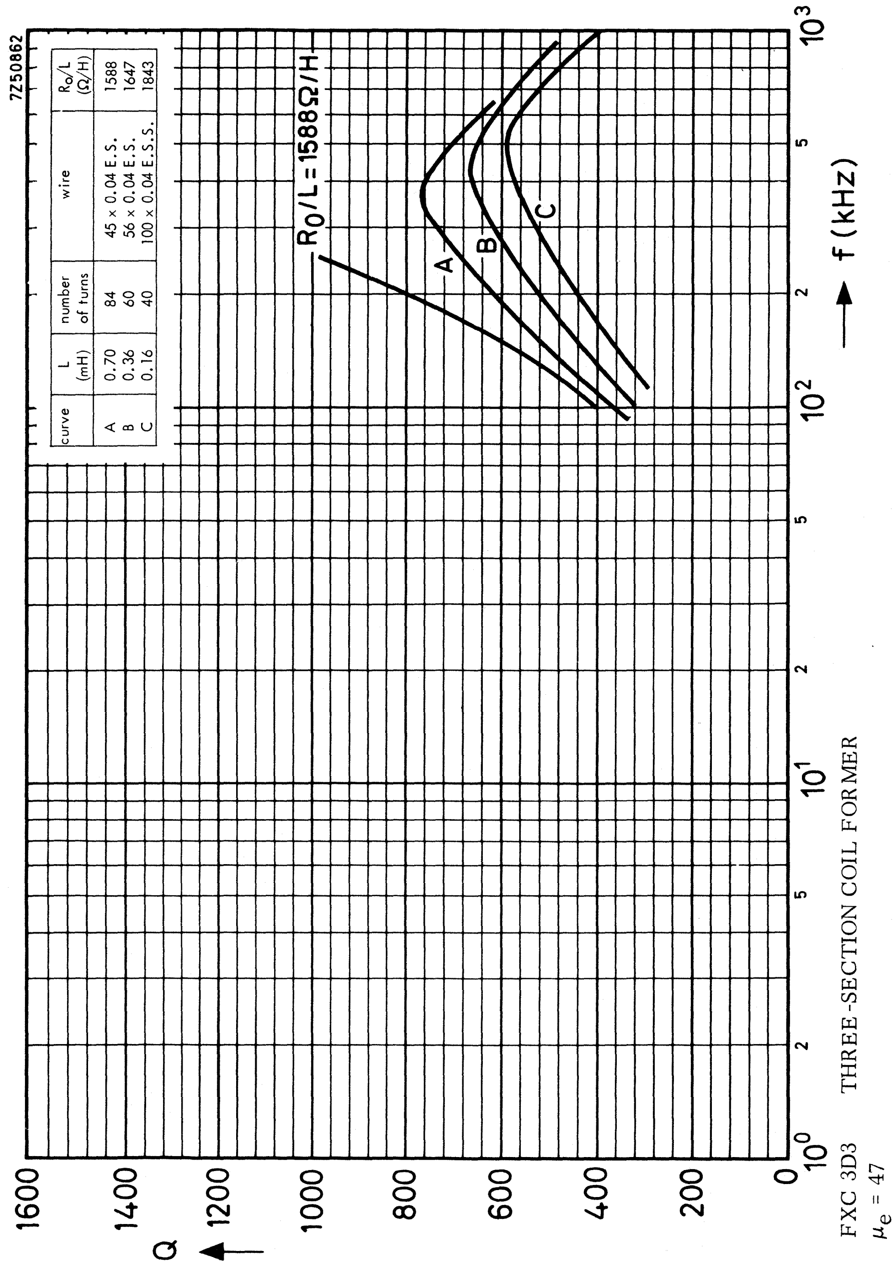
TWO-SECTION COIL FORMER

FXC 3D3
$\mu_e = 68$



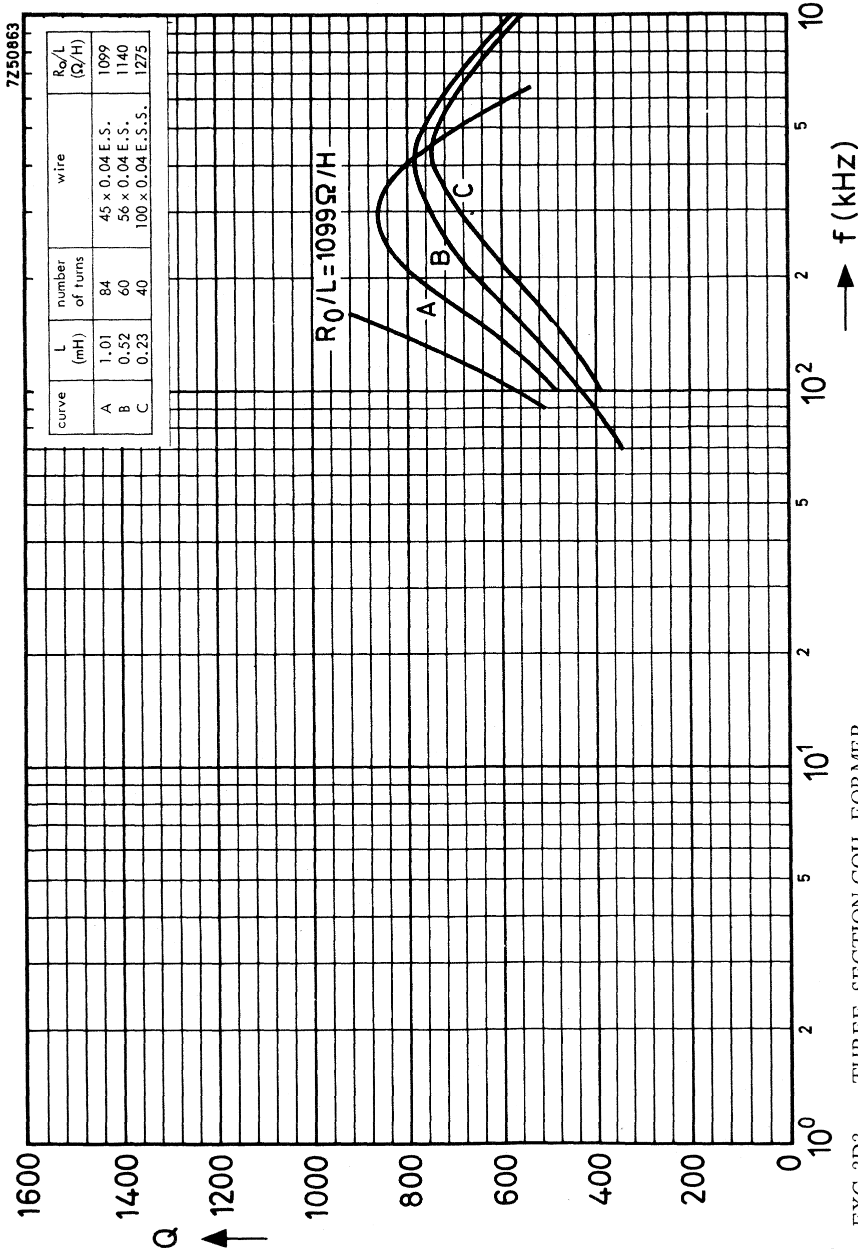
FXC 3D3 THREE-SECTION COIL FORMER

$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	0.70	84	45 × 0.04 E.S.	1588
B	0.36	60	56 × 0.04 E.S.	1647
C	0.16	40	100 × 0.04 E.S.S.	1843

FXC 3D3 THREE-SECTION COIL FORMER
$\mu_e = 47$

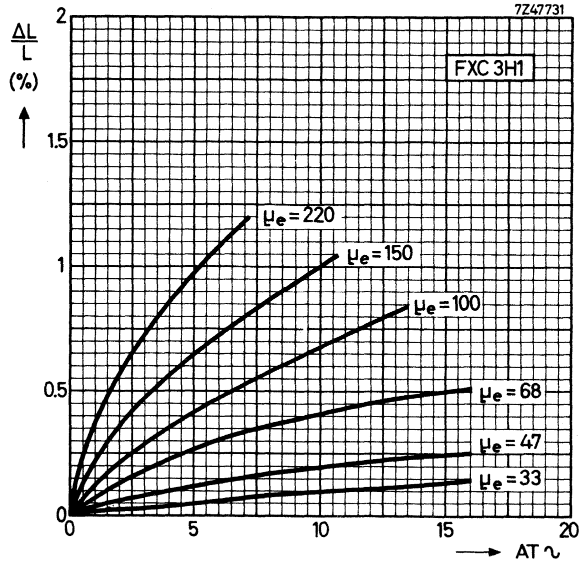


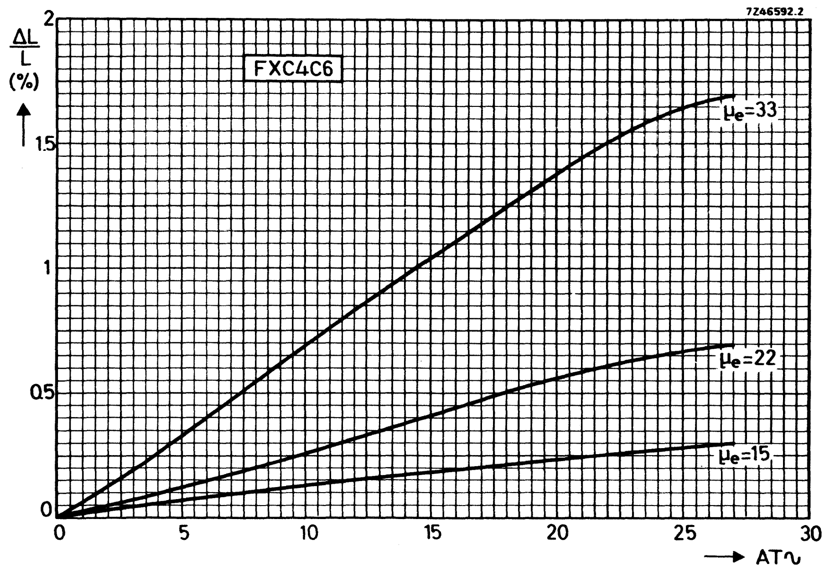
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.01	84	45 × 0.04 E.S.	1099
B	0.52	60	56 × 0.04 E.S.	1140
C	0.23	40	100 × 0.04 E.S.S.	1275

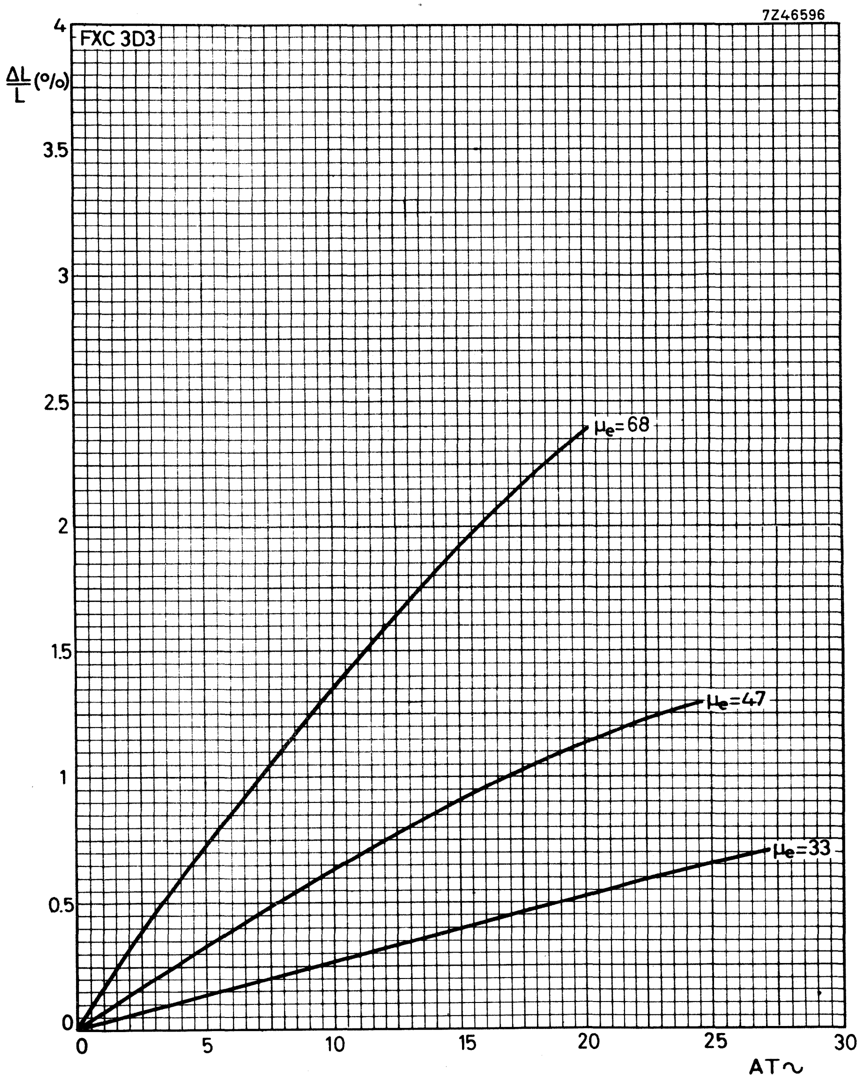
FXC 3D3 THREE-SECTION COIL FORMER

$\mu_e = 68$

INDUCTANCE VARIATION AS A FUNCTION OF AT~

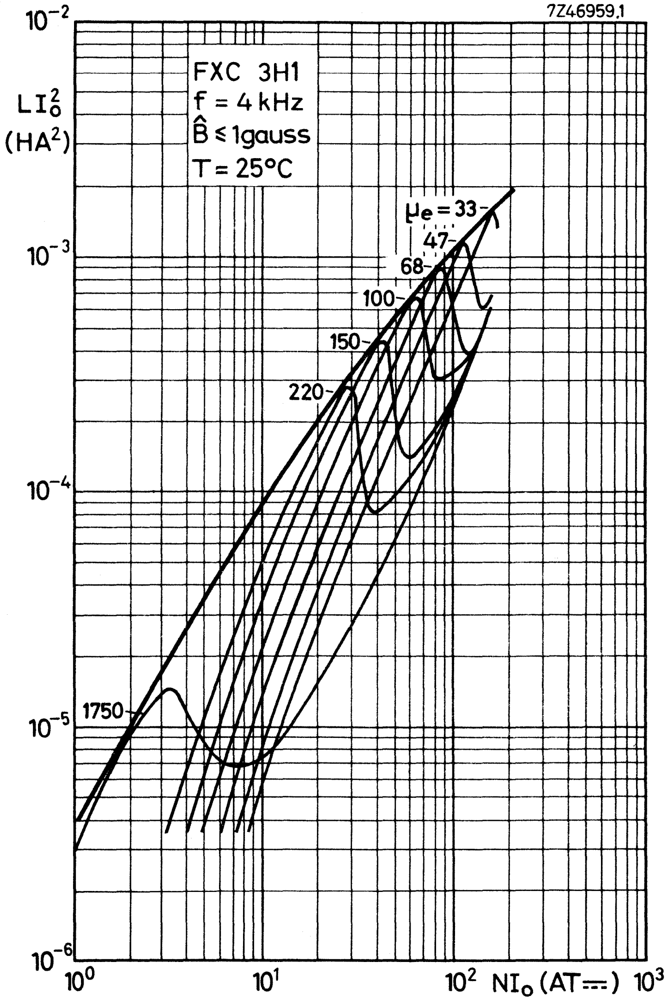


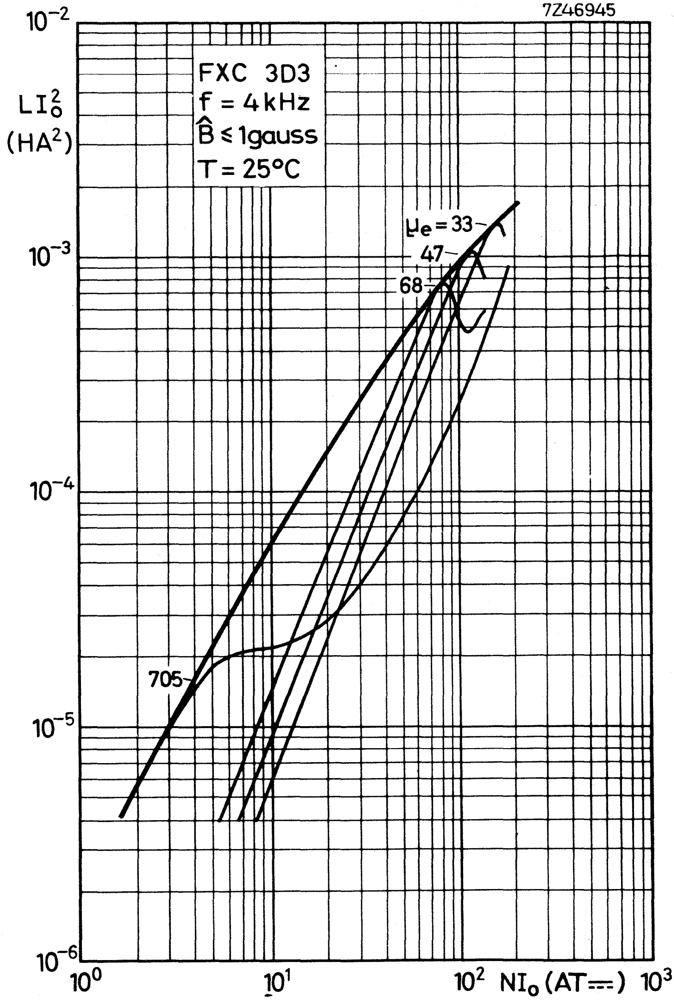



7Z46596
FXC 3D3
ΔL/L (%)
4
3.5
3
2.5
2
1.5
1
0.5
0
μe=68
μe=47
μe=33
0
5
10
15
20
25
30
AT~

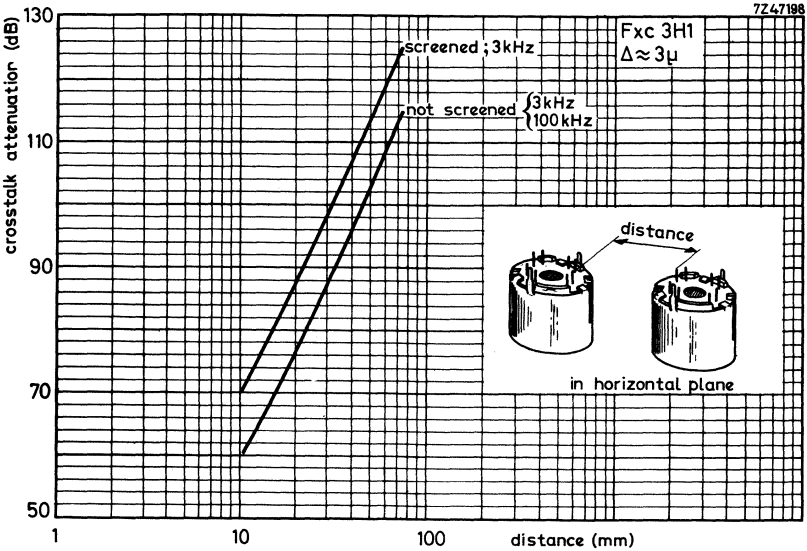
HANNA CURVES (typical values)

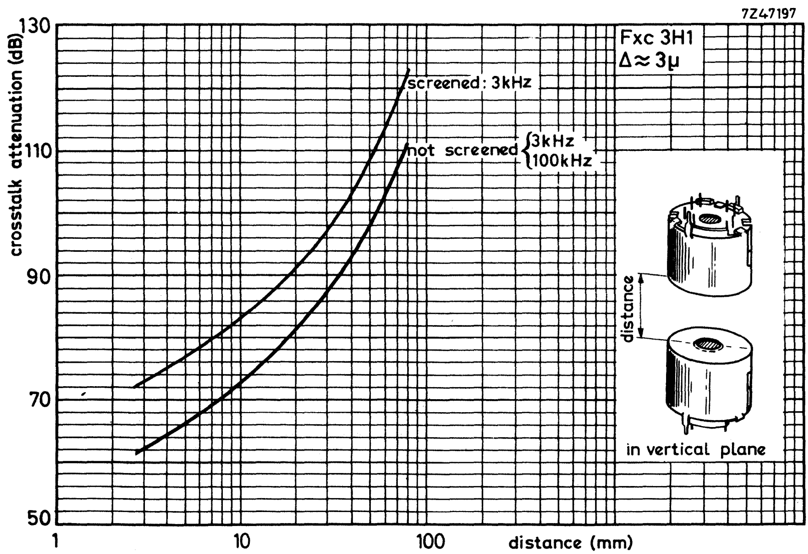
These curves indicate the optimum inductance for a certain μ_e-value and direct current.

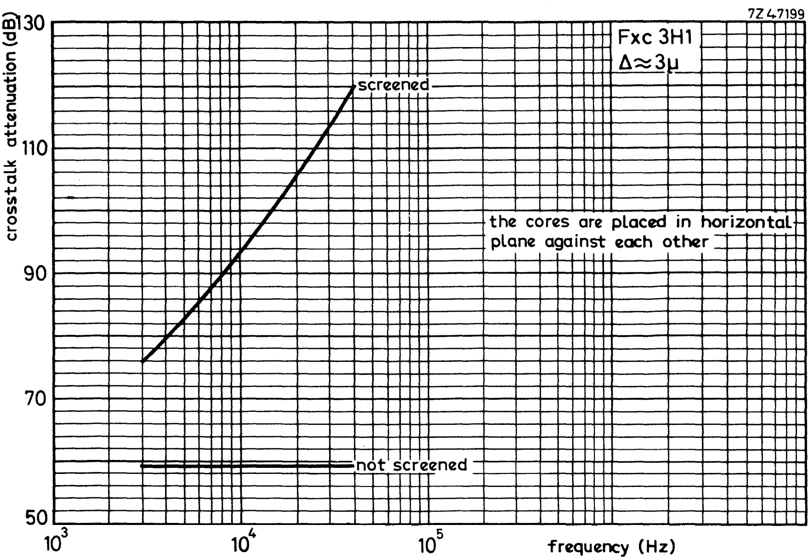



7Z46945
FXC 3D3
f = 4 kHz
B̂ ≤ 1gauss
T = 25°C
LI$_o^2$
(HA^2)
μ_e = 33
47
68
705
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^0
10^1
10^2
NI$_o$ (AT ⎓)
10^3

CROSSTALK ATTENUATION






7Z47199
Fxc 3H1
Δ≈3μ
crosstalk attenuation (dB)
130
110
90
70
50
screened
not screened
the cores are placed in horizontal plane against each other
10^3
10^4
10^5
frequency (Hz)

POTCORES

INTRODUCTION

Three types of core can be supplied:

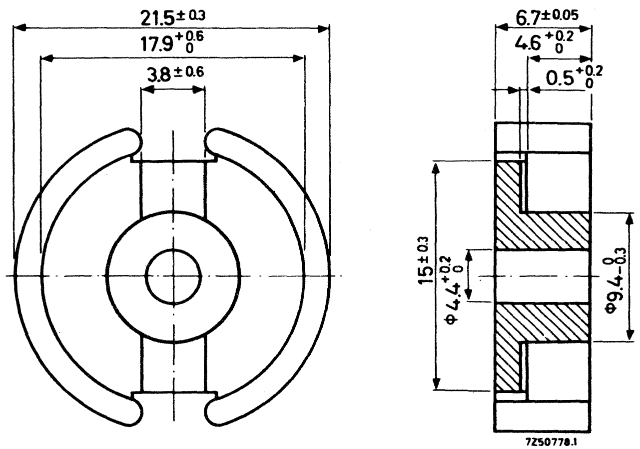
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E_6 range of values or an inductance factor (A_L) in the R_5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).

Potcores and associated parts are ordered by their 12-digit catalog number. Quantity: a primary pack contains 20 potcore halves or 10 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 21750
3H1	4322 020 21760
3D3	4322 020 21770
improved 3E1	4322 020 21850
4C6	4322 020 21830

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I

	temp. (^{o}C)	grade 3B7	3H1	3D3		4C6
T.F. x 10^6	+5 to +23	-	+0.5 to +1.5			-2 to +4
	+5 to +55	-	-			-
	+23 to +55	-	+0.5 to +1.5			0 to +6
	+23 to +70	-0.6 to +0.6	1)	0 to 2		-
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 12		≤ 10

For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 140 Newton, the values in Table II are guaranteed at 25±10 ^{o}C.

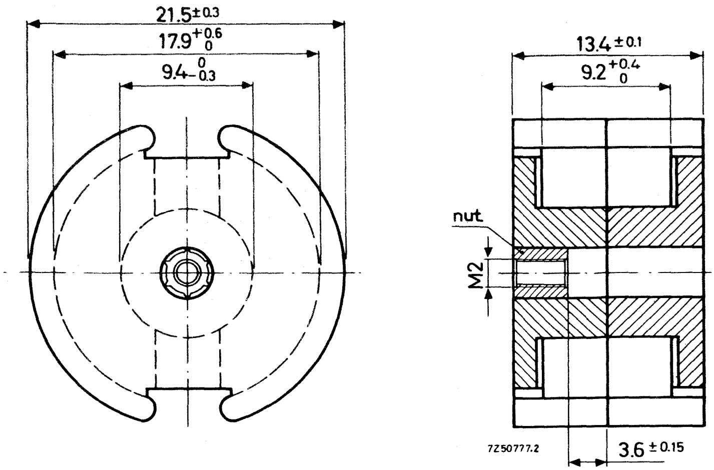
Table II

	$\hat{B}$ (Gs)	freq. (MHz)	grade 3B7	3H1	3D3	impr. 3E1	4C6
μ_e	≤ 1	0.004	≥ 1400	≥ 1400		2200-3675	
	≤ 1	0.1			≥ 540		≥ 93
A_L	≤ 1	0.004				5550-9300	
α	≤ 1	0.004	≤ 16.8	≤ 16.8			
	≤ 1	0.1			≤ 27.0		≤ 64.7
$\frac{\tan\delta}{\mu_i}$ x 10^6	≤ 1	0.004	≤ 1.2	≤ 1.2		≤ 2.5	
	≤ 1	0.1	≤ 5	≤ 5	≤ 8	≤ 20	
	≤ 1	0.5			≤ 14	≤ 200	
	≤ 1	1			≤ 30		
		2					≤ 40
		10					≤ 100
q2-24-100	15-30	0.004	≤ 1.8	≤ 1.4		≤ 3.0	
	3-12	0.1			≤ 3.0		≤ 10

1) For orientation: +0.5 to +1.5

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 2....
Without nut, catalog number = 4322 022 0....

Weight			12	g
Mean length of lines of force	l_e	=	3.15	cm
	$\Sigma \frac{l_e}{A_e}$	=	4.97	cm^{-1}
Effective volume	V_e	=	2.00	cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 15, grade 4C6, potcore with nut, catalog number . = 4322 022 26810
   A_L = 100, grade 3B7, potcore without nut, catalog number = 4322 022 07040
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

Potcores with standard μ_e values [1])

μ_e	α	tolerance on inductance (%)	catal. No. 4322 022 2.... with nut; 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
15	162	± 1	-	-	-	6810
22	134	± 1	-	-	-	6820
33	109.4	± 1	-	-	6430	6830
47	91.7	± 1	-	-	6440	-
68	76.2	± 1	6050	6250	6450	-
100	62.8	± 1.5	6060	6260	-	-
150	51.3	± 2	6070	6270	-	-
220	42.4	± 3	6080	6280	-	-
330	34.6	± 3	6090	6290	-	-
720	23.4	± 25	-	-	6400*	-
1840	14.6	± 25	6000*	6200*	-	-

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

Potcores with standard A_L factors [1])

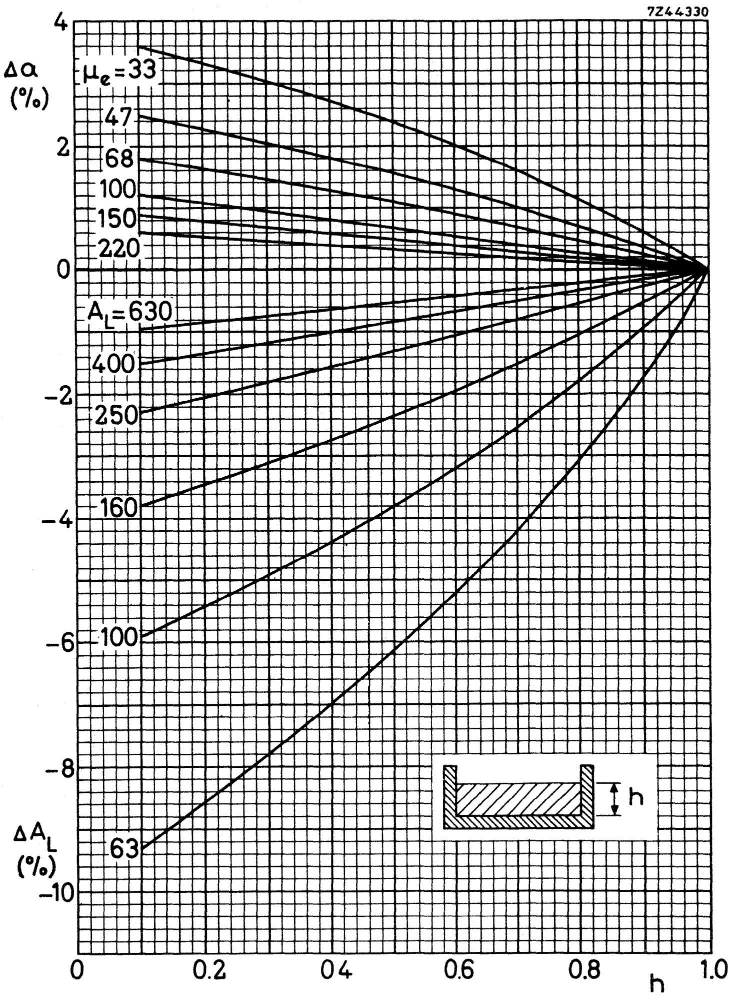
A_L	corresponding μ_e-value	tolerance on inductance (%)	catal. No. 4322 022 2.... with nut; 4322 022 0.... without nut			
			3B7	3H1	3D3	4C6
25	9.9	± 1				7810
40	15.8	± 1	-	-	-	7820
63	25	± 1	-	-	7430	7830
100	39.5	± 1	7040	7240	7440	7840
160	63.5	± 1	7050	7250	7450	-
250	99	± 1.5	7060	7260	7460	-
315	124.5	± 2	7070	7270	-	-
400	158	± 2	7080	7280	-	-
630	249	± 3	7100	7300	-	-
1000	395	± 3	7110	7310	-	-

Inductance $L = N^2 A_L$ (in 10^{-9} H)

1) See Notes on the previous page.

*) Only available without nut.

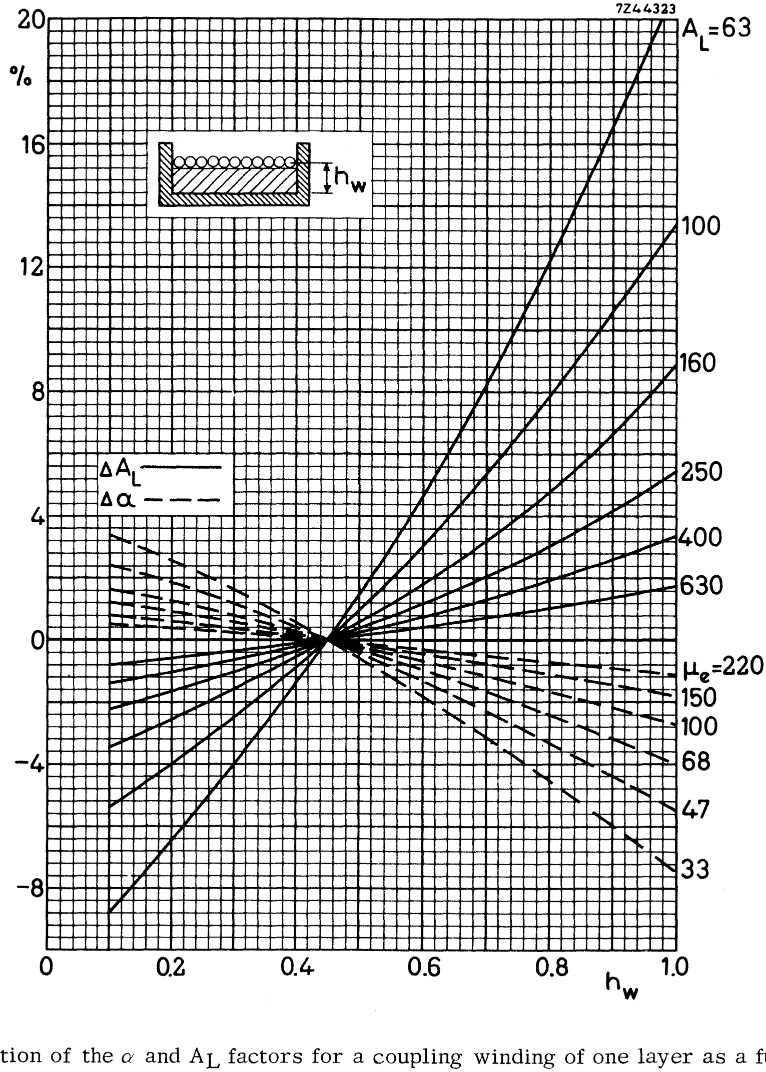
DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former only 0.4 part of the available height is used. A potcore with μ_e = 68 in that case obtains an α factor of 76.2 + 1.25 %.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_w on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 68 obtains for that winding an α factor of 76.2 - 1.7 %.

COIL FORMERS

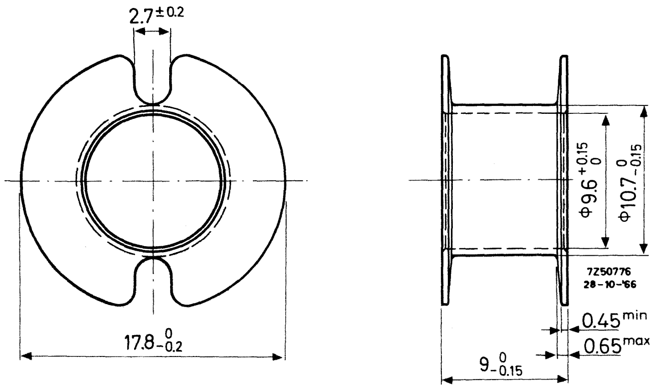
GENERAL

Four types of coil former can be supplied:

- with one section
- with two sections
- with three sections
- with one section and with soldering pins to fit 0.1" and 2.50 mm grid.

The dimensions conform with the following specifications: I.E.C.133 (international), C.C.T.U.06-02 (France) and D.I.N.41 294 (Germany).
The dimensions in the drawings are in mm.

SINGLE-SECTION COIL FORMER



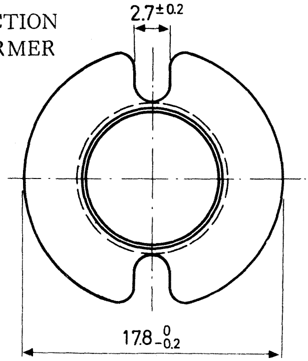
Catalog number	4322 021 30300
Material	glassfibre-reinforced polyacetal
Window area	28 mm^2
Mean length of turn	4.4 cm
Max. temperature	130 ^oC

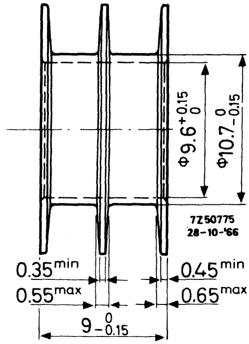
D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 11.0 \times 10^3 \ \Omega/H$$

Weight 0.35 g

TWO-SECTION COIL FORMER





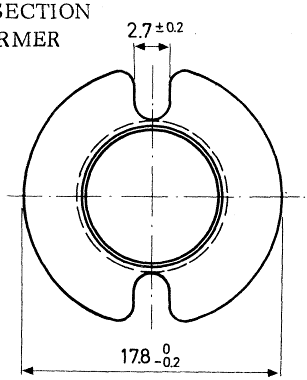
Catalog number	4322 021 30310
Material	glassfibre-reinforced polyacetal
Window area	2 x 13 mm^2
Mean length of turn	4.4 cm
Max. temperature	130 °C

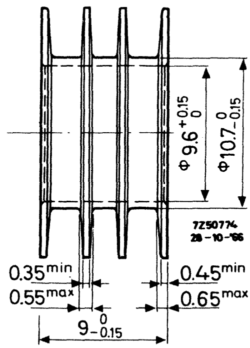
D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 11.6 \times 10^3 \ \Omega/H$$

Weight 0.4 g

THREE-SECTION COIL FORMER





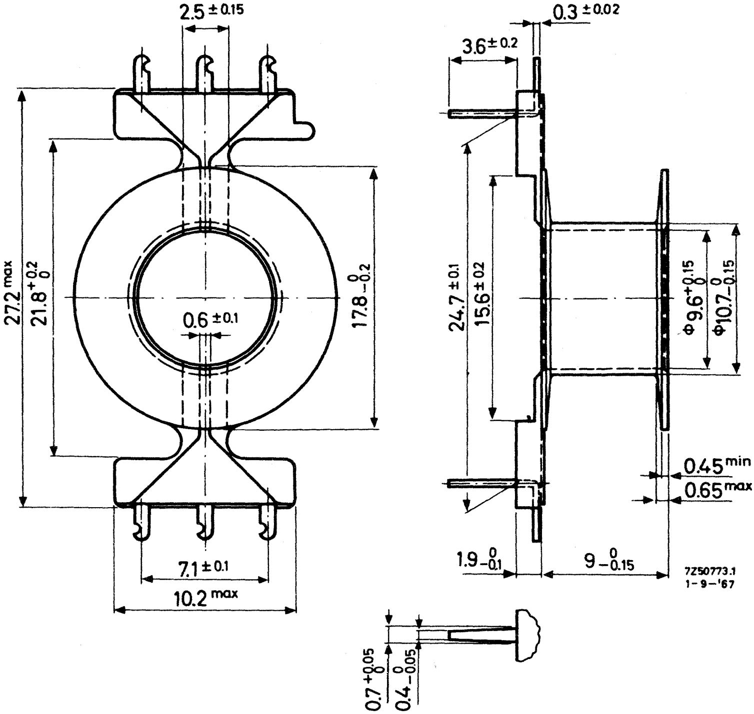
Catalog number	4322 021 30320
Material	glassfibre-reinforced polyacetal
Window area	3 x 8.2 mm
Mean length of turn	4.4 mm^2
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 12.4 \times 10^3 \ \Omega/H$$

Weight 0.45 g

SINGLE-SECTION COIL FORMER WITH SOLDERING PINS



Catalog number	4322 021 30110
Material	reinforced polyester with brass dip-soldered pins
Window area	28 mm^2
Mean length of turn	4.4 cm
Max. temperature	180 ^oC

Solderability according to I.E.C.68-2-20, part 2, test T

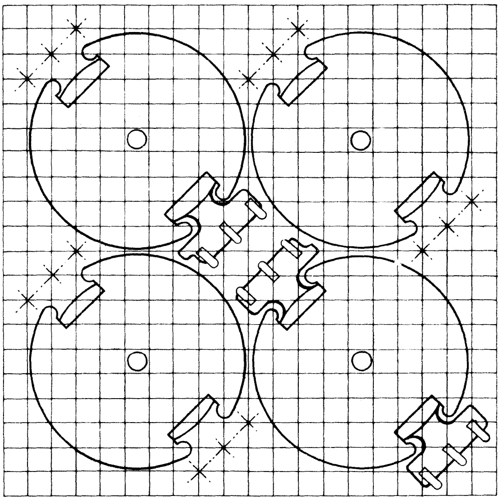
D.C. losses:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 11.0 \times 10^3 \ \Omega/H$$

Weight 0.45 g

The coil formers are packed in boxes containing 5 layers of 50 coil formers, so please order in multiples of 50.

The soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes 1.3 ± 0.1 mm diameter.
For this coil former the potcore halves must be cemented together, and it is recommended to cement the coil former to the lower potcore half.



7Z47202

INDUCTANCE ADJUSTORS

ADJUSTORS

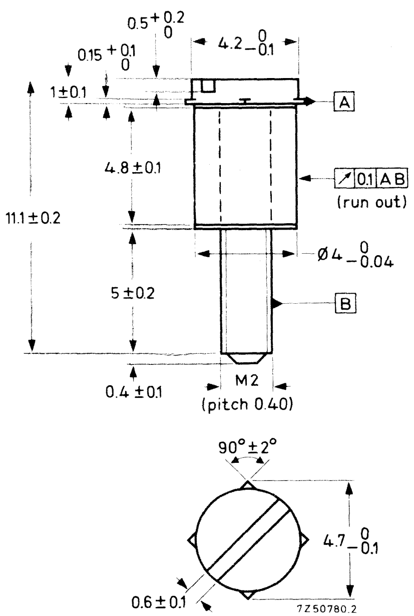


Fig. A

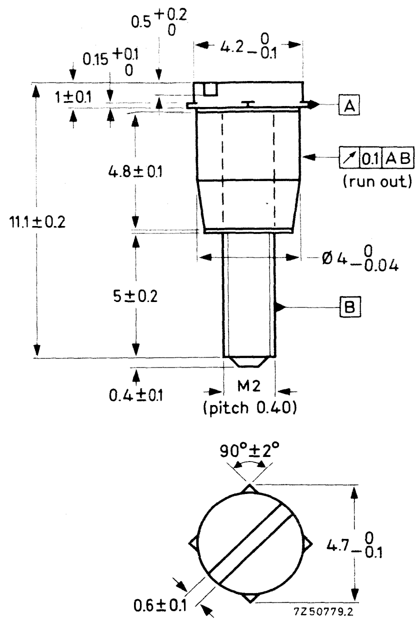


Fig. B

The tolerances on inductance of the pre-adjusted potcores (with adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.
Table II shows the type of adjustor recommended for different potcores.

Table I, types of adjustor

Fig.	colour	catalogue number
B	yellow	4322 021 31000
B	white	4322 021 31020
B	green	4322 021 31040
B	red	4322 021 31060
A	brown	4322 021 31100
B	black	4322 021 31240

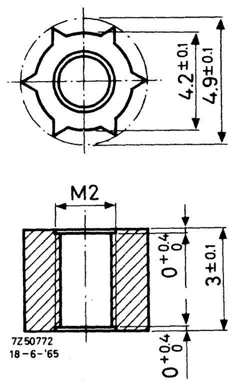
The adjustors are packed in bags of 100, so please order in multiples of 100.

Table II, recommended application

μ_e	A_L	3B7/3H1/3D3	4C6
		catal. No. 4322 021	
	25	-	31060
15		-	31060
	40	-	31060
22		-	31000
	63	31040	31000
33		31040	31020
	100	31060	-
47		31060	-
68		31000	-
	160	31000	-
	250	31020	-
100		31020	-
	315	31020	-
150		31100	-
	400	31100	-
220		31100	-
	630	31100	-
330		31240	-

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

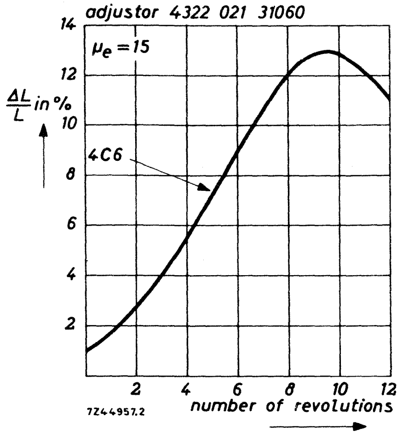


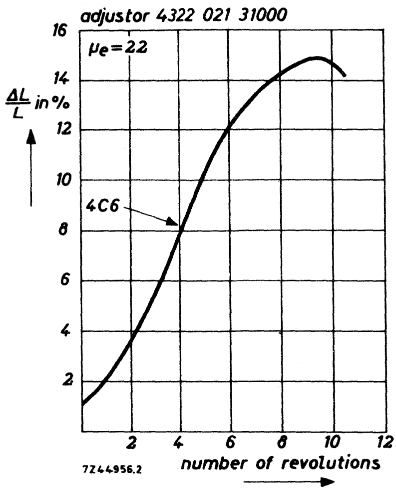
Catalogue number	4322 021 30150
Material	polycarbonate
Max. impregnation temperature for 24 hours	120 °C
Recommended distance from mating surface to nut	3.6 ± 0.15 mm

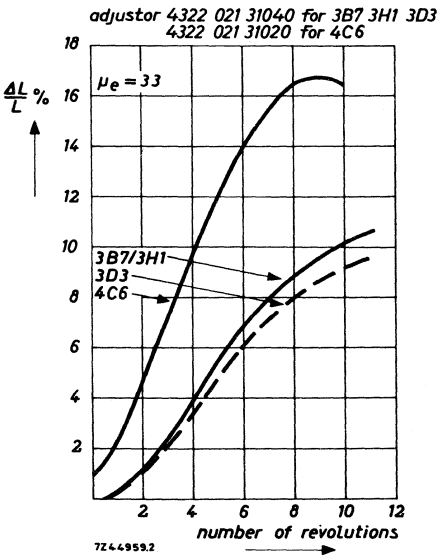
For more information see Potcores General, Inductance adjustment.

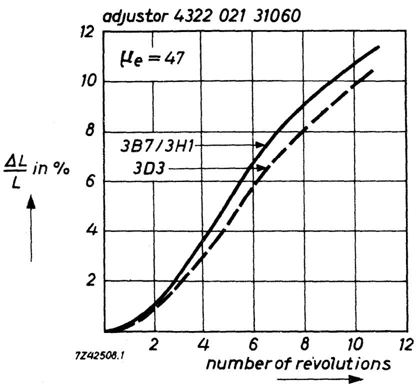
The nuts are packed in bags of 100, so please order in multiples of 100.

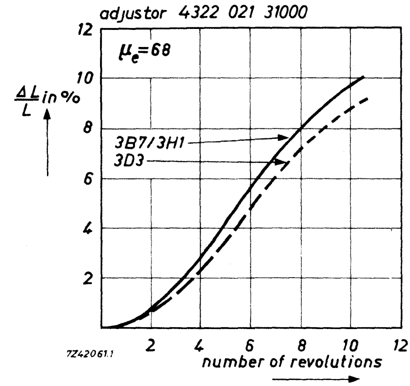
ADJUSTMENT CURVES

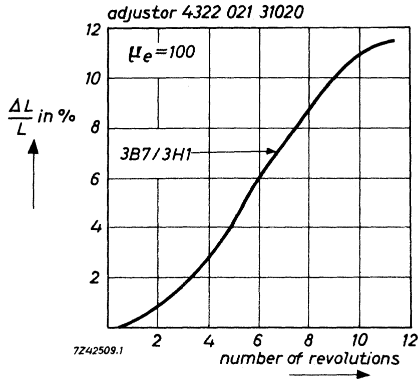


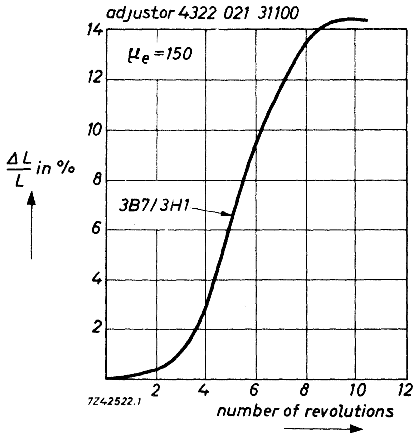


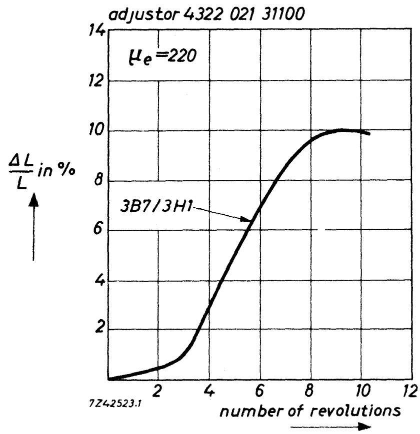


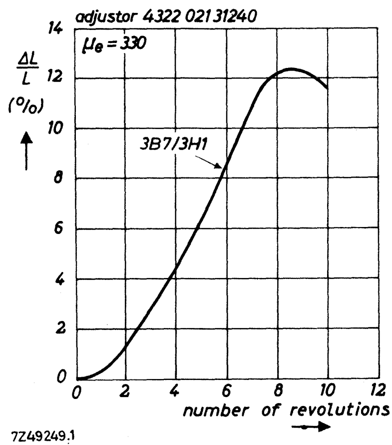



adjustor 4322 021 31000
$\mu_e = 68$
$\frac{\Delta L}{L}$ in %
3B7/3H1
3D3
number of revolutions
7Z42061.1


adjustor 4322 021 31020
$\mu_e = 100$
$\frac{\Delta L}{L}$ in %
3B7/3H1
number of revolutions
7Z42509.1

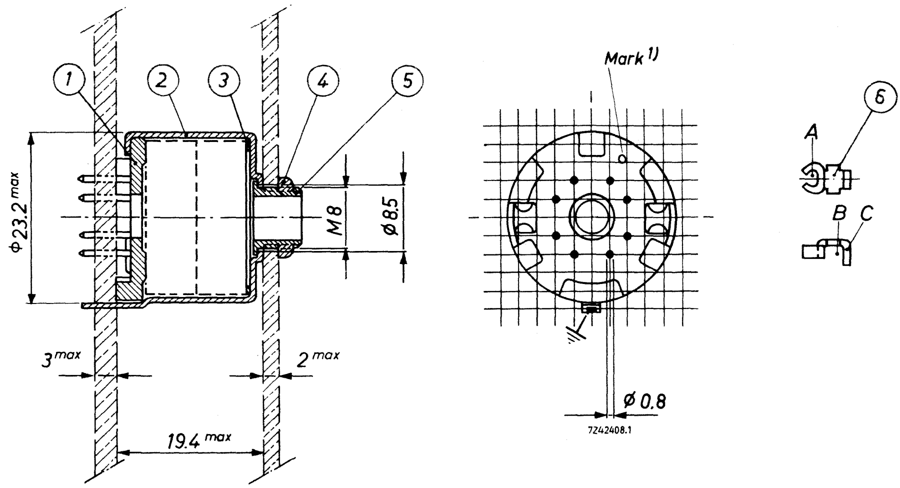

adjustor 4322 021 31100
$\mu_e = 150$
$\frac{\Delta L}{L}$ in %
3B7/3H1
number of revolutions
7Z42522.1


adjustor 4322 021 31100
$\mu_e = 220$
$\frac{\Delta L}{L}$ in %
3B7/3H1
number of revolutions
7Z42523.1


adjustor 4322 021 31240
$\mu_e = 330$
$\frac{\Delta L}{L}$ (%)
3B7/3H1
number of revolutions
7Z49249.1

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30460	(4) nut	4322 021 30710
(2) brass container	4322 021 30540	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30650	(6) soldering spring	4322 021 30700 (8x)

The core is suitable for mounting on printed-wiring boards and on conventional panels.

The parts 1, 2, 3 (and 6) are sufficient to construct an assembly for use in combination with printed wiring.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The eight soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness up to 3 mm. The board should be provided with holes of 1.3 + 0.1 mm diameter.

---

1) There is another mark hole in a similar position on the top of the container.

If one-hole mounting is preferred, the parts 4 and 5 should be added. The coil assembly may then be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

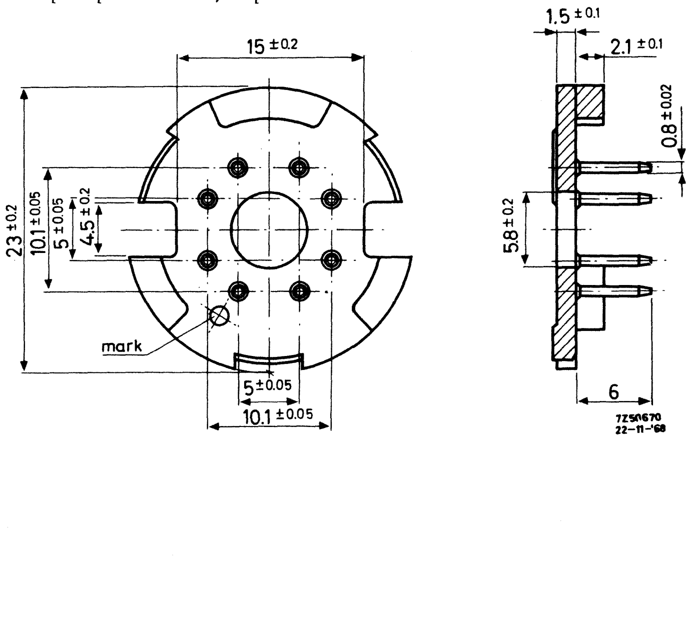
Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 140 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

(1) Tag plate 4322 021 30460

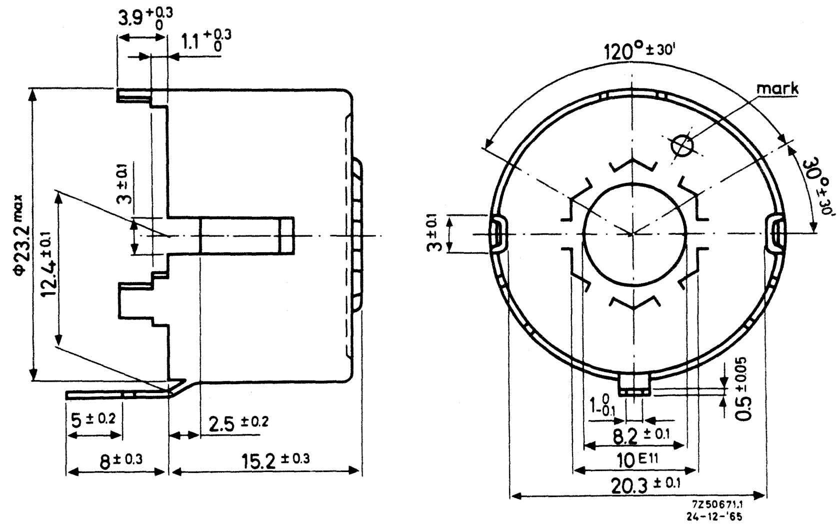
Plate : reinforced polyester

Pins : phosphorbronze, dipsoldered



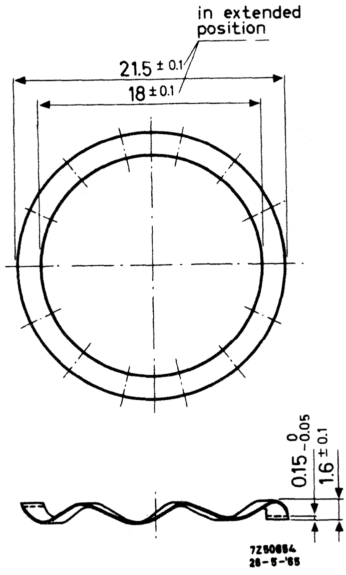
(2) Container 4322 021 30540

Material : brass, nickel plated



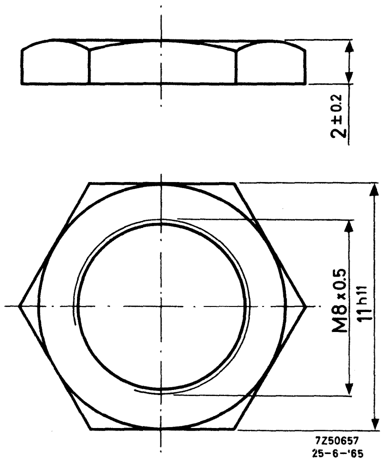
(3) Spring 4322 021 30650

Material : chrome- nickelsteel



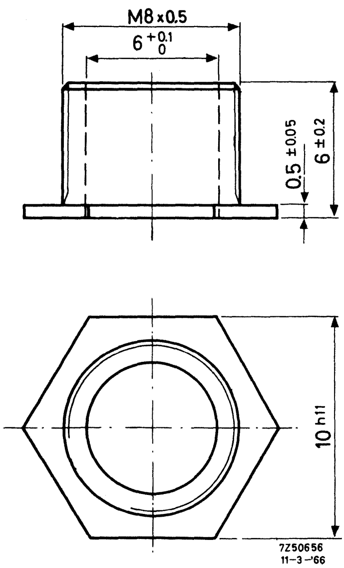
(4) Nut 4322 021 30710

Material: brass, nickel plated



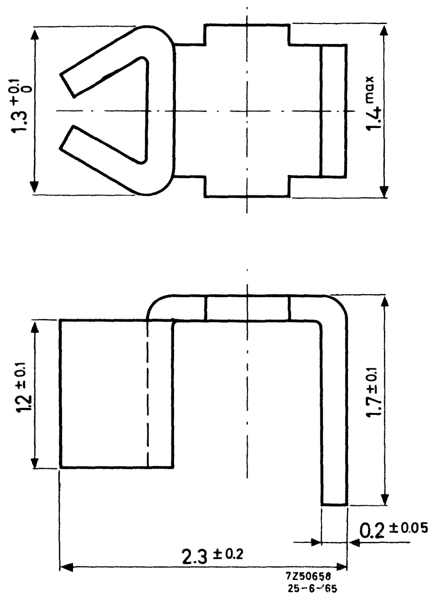
(5) Fixing bush 4322 021 30720

Material: brass, nickel plated



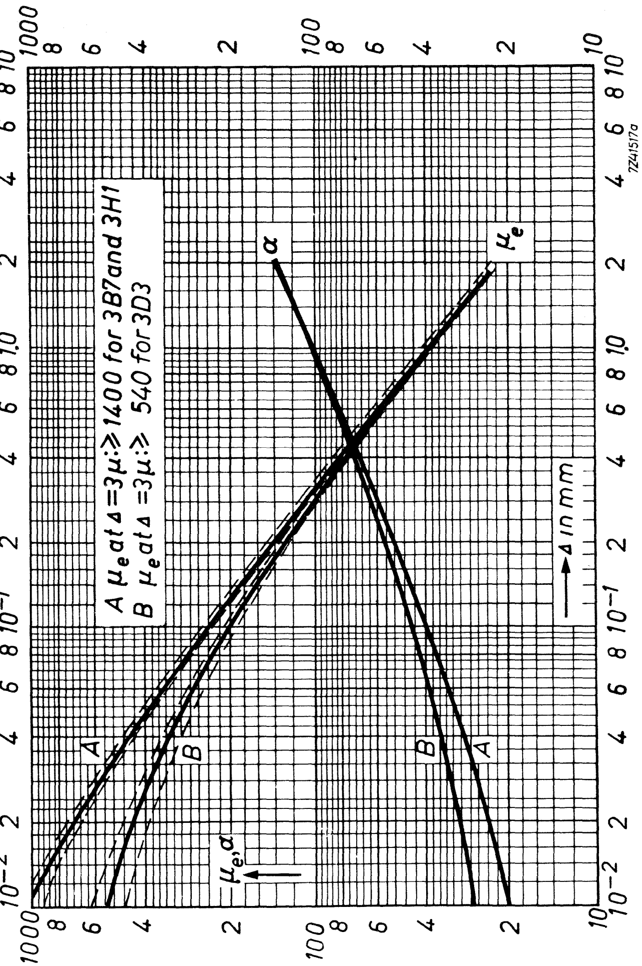
(6) Soldering spring 4322 021 30700

Material: brass, dipsoldered



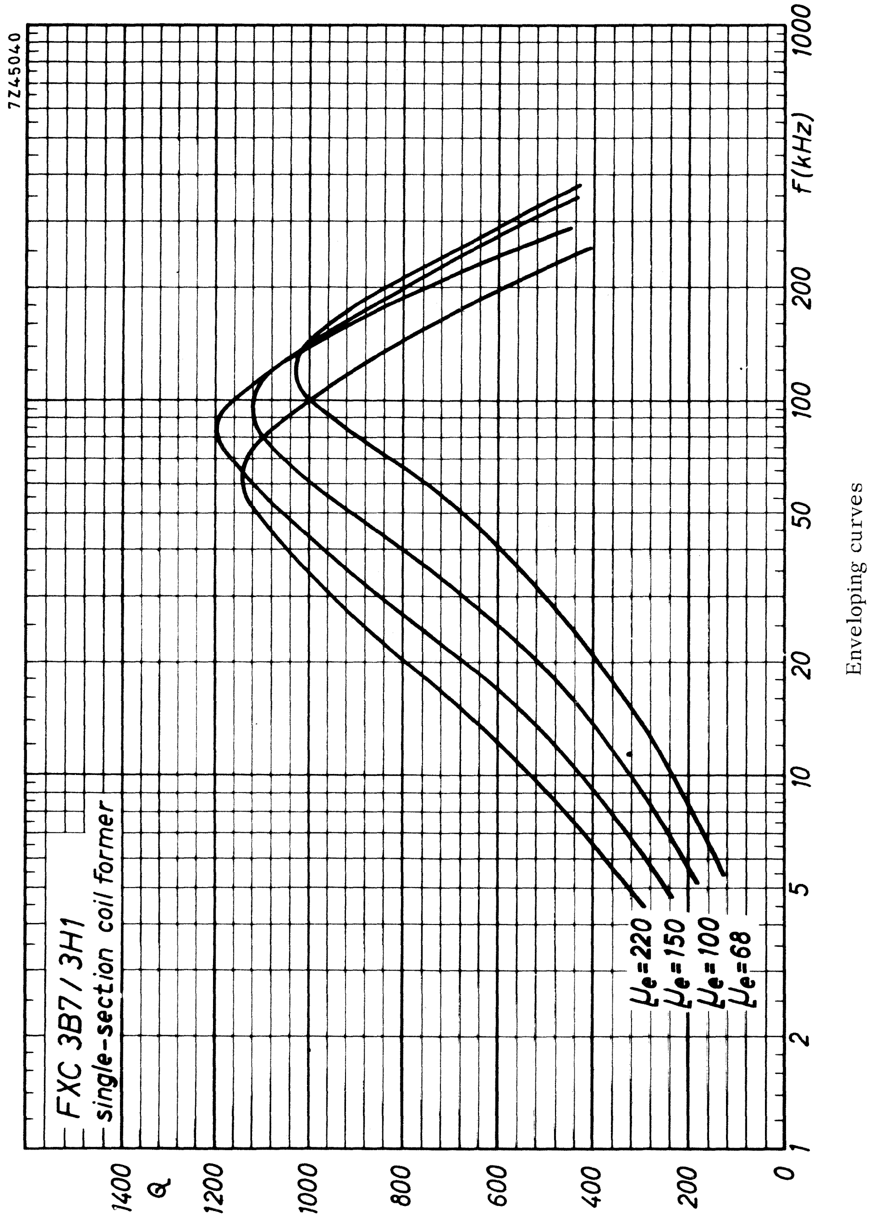
CHARACTERISTIC CURVES

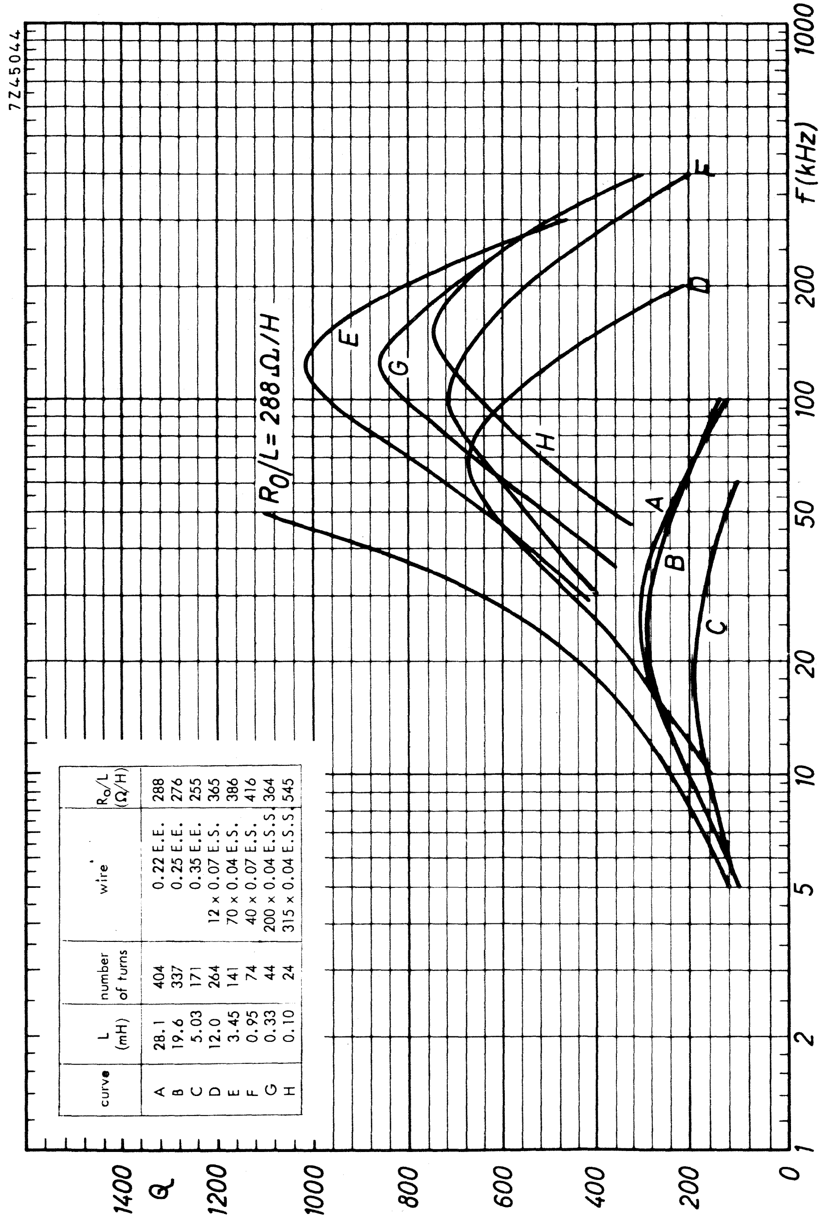
μ_e - α curves



Relative effective permeability and turn factor for 1 mH as a function of the air gap length

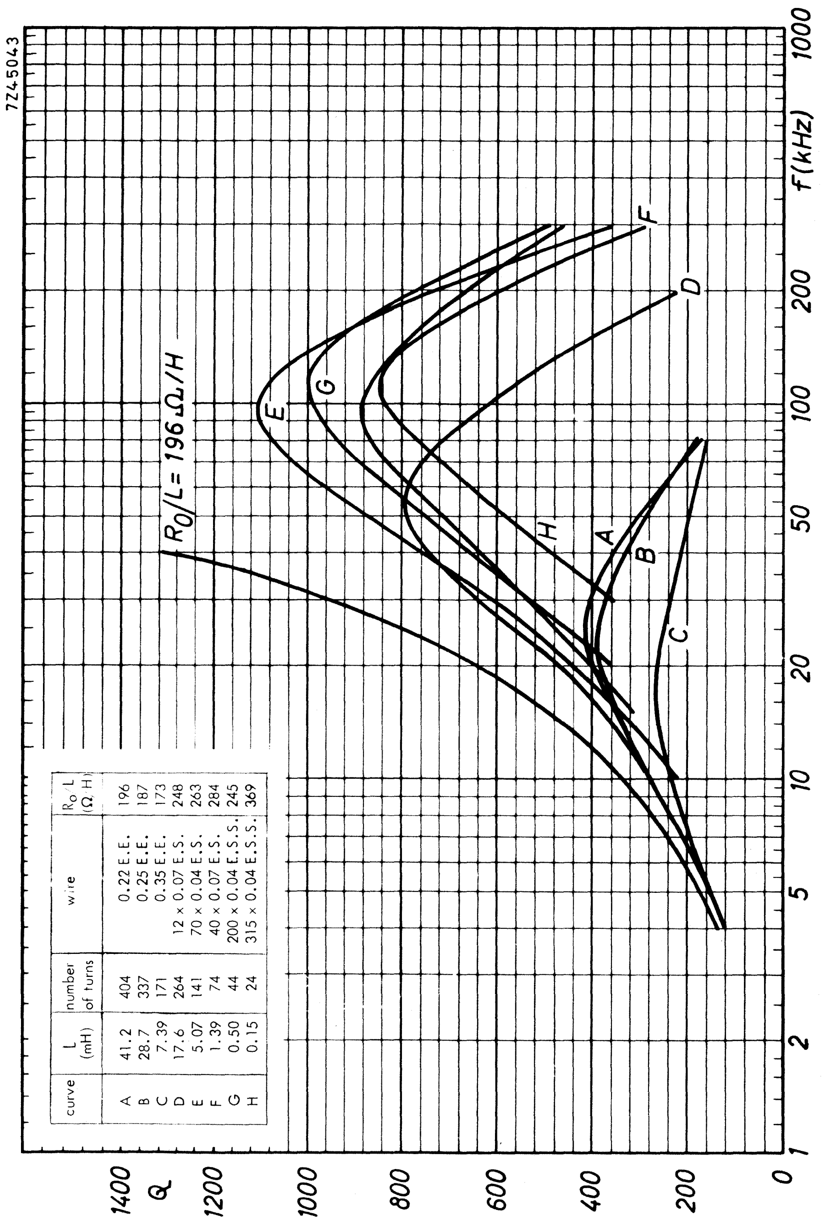
TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1





curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	28.1	404	0.22 E.E.	288
B	19.6	337	0.25 E.E.	276
C	5.03	171	0.35 E.E.	255
D	12.0	264	12 × 0.07 E.S.	365
E	3.45	141	70 × 0.04 E.S.	386
F	0.95	74	40 × 0.07 E.S.	416
G	0.33	44	200 × 0.04 E.S.S.	364
H	0.10	24	315 × 0.04 E.S.S.	545

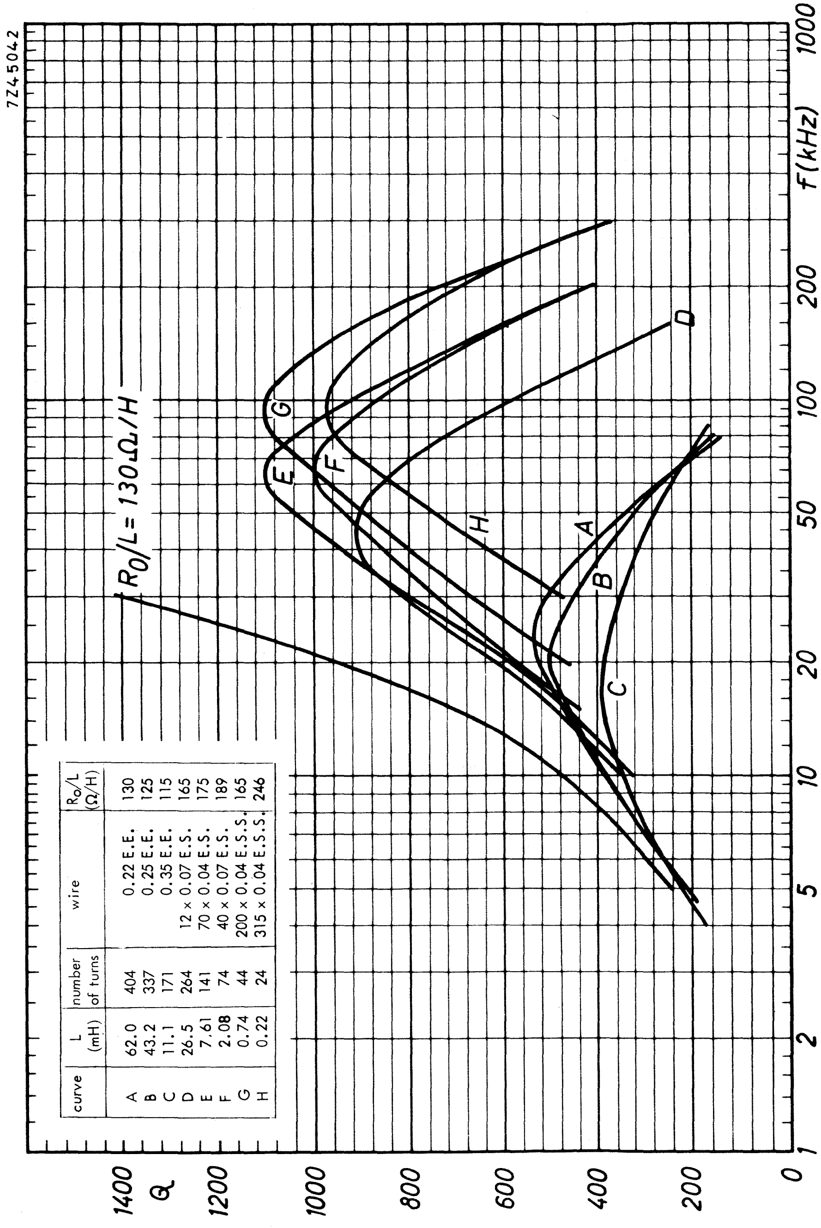
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 68$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	41.2	404	0.22 E.E.	196
B	28.7	337	0.25 E.E.	187
C	7.39	171	0.35 E.E.	173
D	17.6	264	12 × 0.07 E.S.	248
E	5.07	141	70 × 0.04 E.S.	263
F	1.39	74	40 × 0.07 E.S.	284
G	0.50	44	200 × 0.04 E.S.S.	245
H	0.15	24	315 × 0.04 E.S.S.	369

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

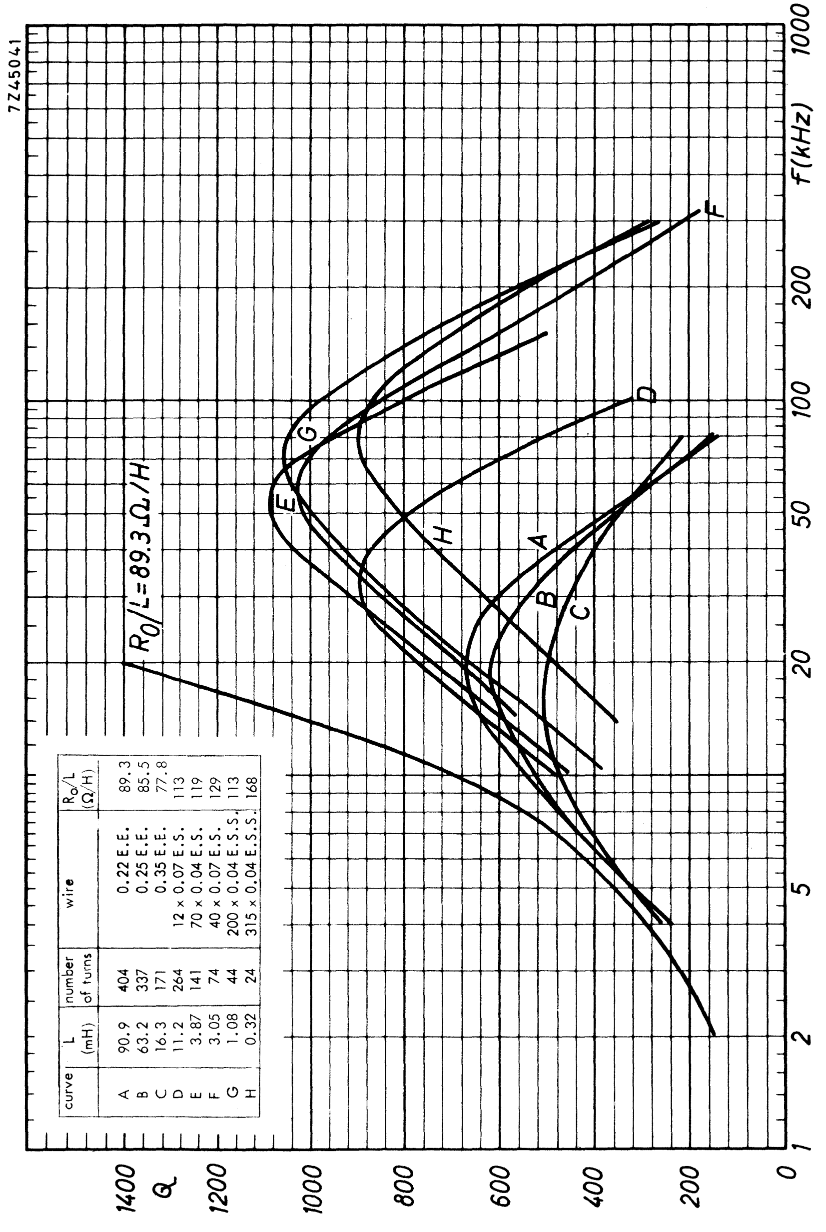
$\mu_e = 100$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	62.0	404	0.22 E.E.	130
B	43.2	337	0.25 E.E.	125
C	11.1	171	0.35 E.E.	115
D	26.5	264	12 × 0.07 E.S.	165
E	7.61	141	70 × 0.04 E.S.	175
F	2.08	74	40 × 0.07 E.S.	189
G	0.74	44	200 × 0.04 E.S.S.	165
H	0.22	24	315 × 0.04 E.S.S.	246

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

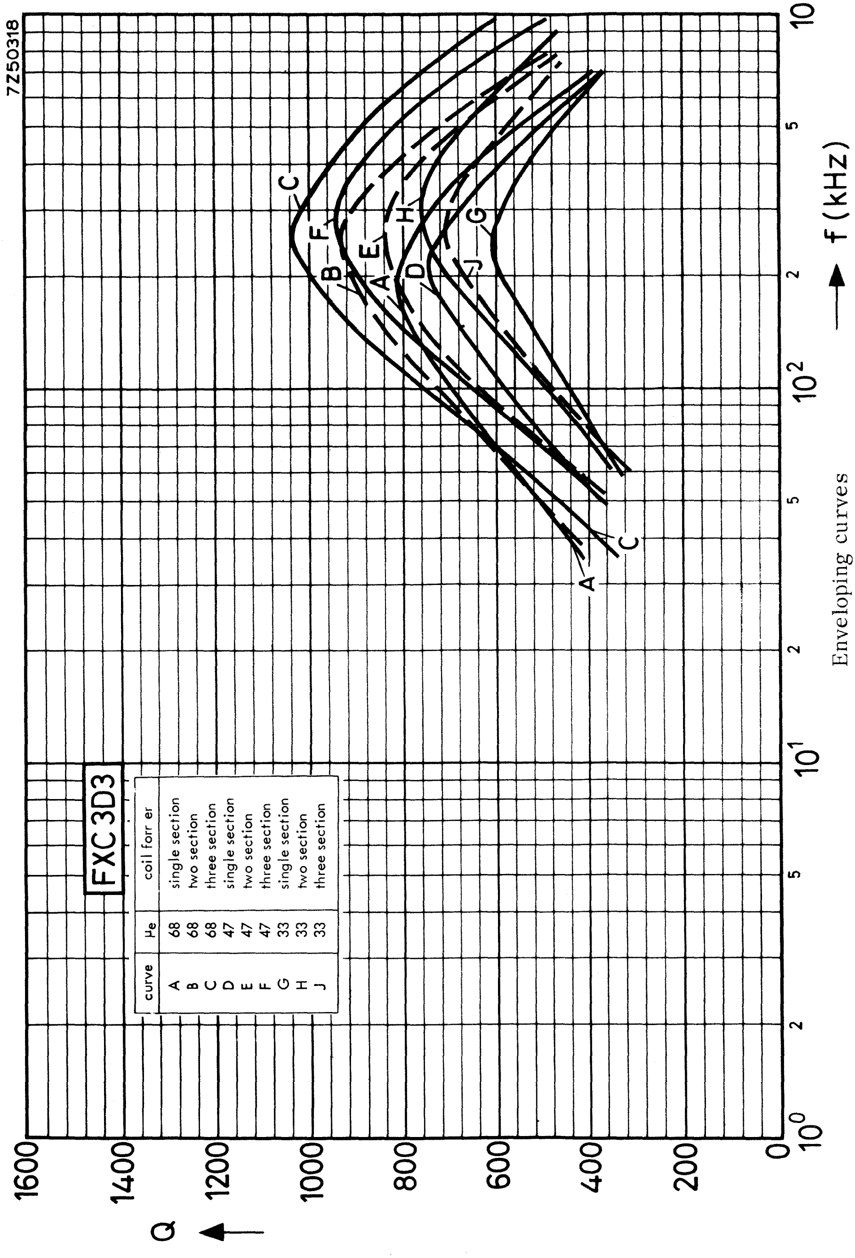
$\mu_e = 150$

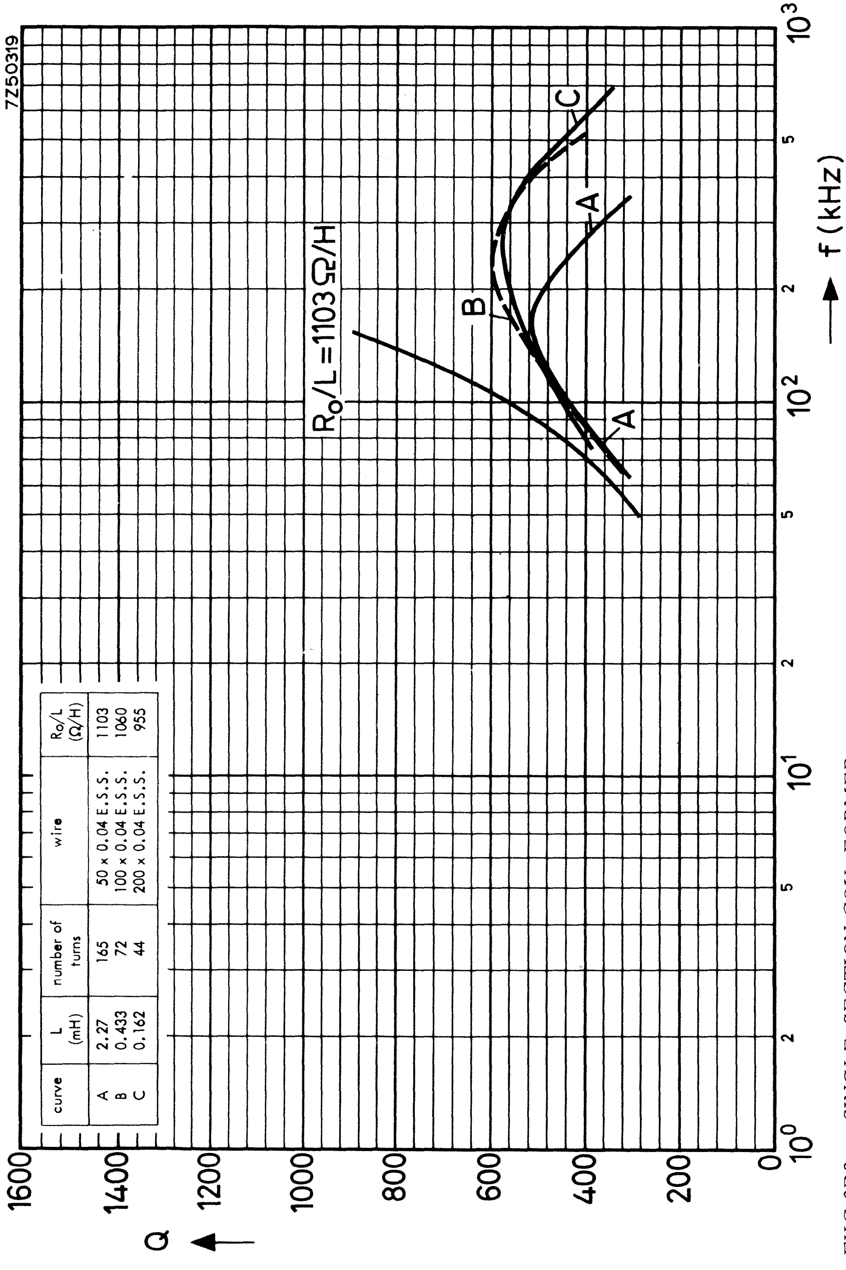


curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	90.9	404	0.22 E.E.	89.3
B	63.2	337	0.25 E.E.	85.5
C	16.3	171	0.35 E.E.	77.8
D	11.2	264	12 × 0.07 E.S.	113
E	3.87	141	70 × 0.04 E.S.	119
F	3.05	74	40 × 0.07 E.S.	129
G	1.08	44	200 × 0.04 E.S.S.	113
H	0.32	24	315 × 0.04 E.S.S.	168

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 220$

TYPICAL Q-CURVES FOR FXC 3D3

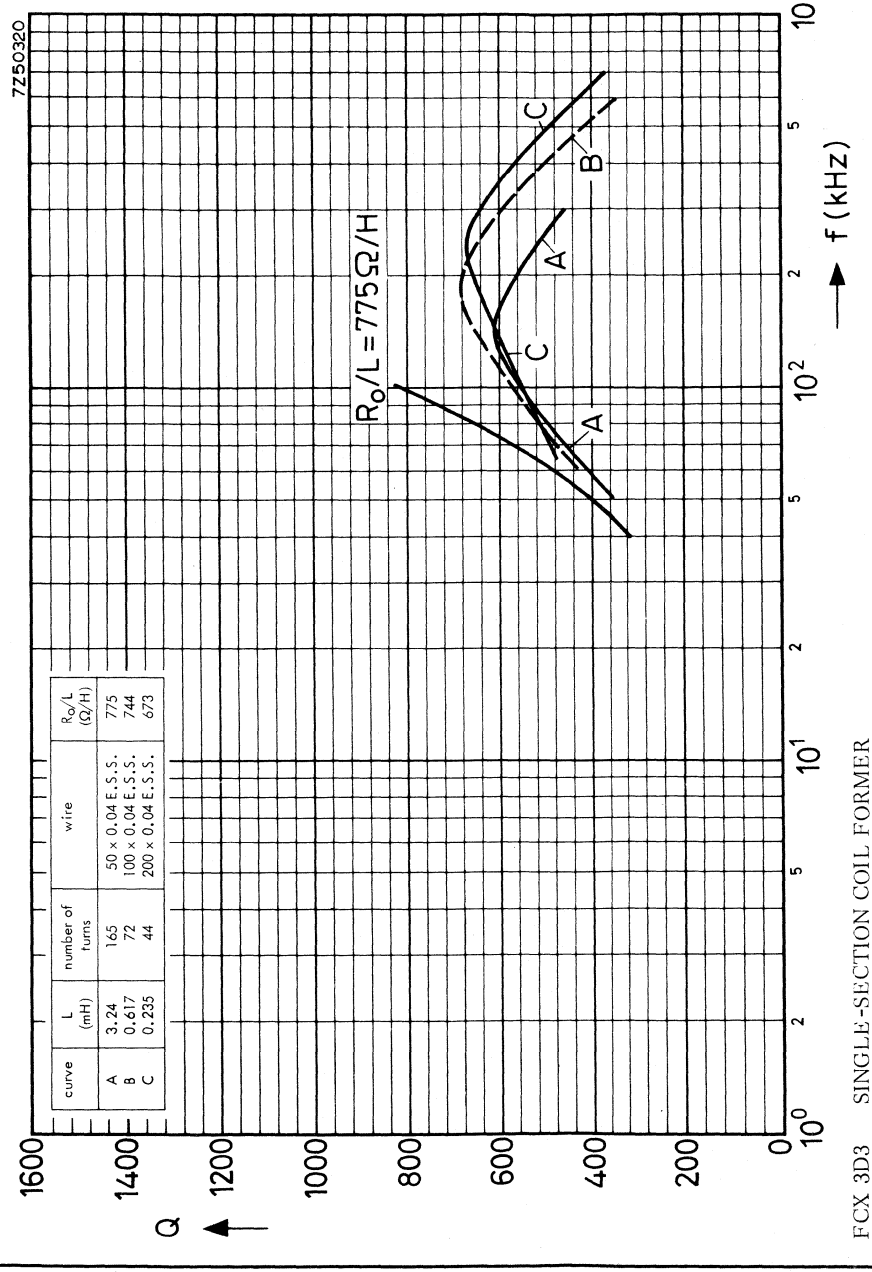




curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	2.27	165	50 × 0.04 E.S.S.	1103
B	0.433	72	100 × 0.04 E.S.S.	1060
C	0.162	44	200 × 0.04 E.S.S.	955

SINGLE-SECTION COIL FORMER

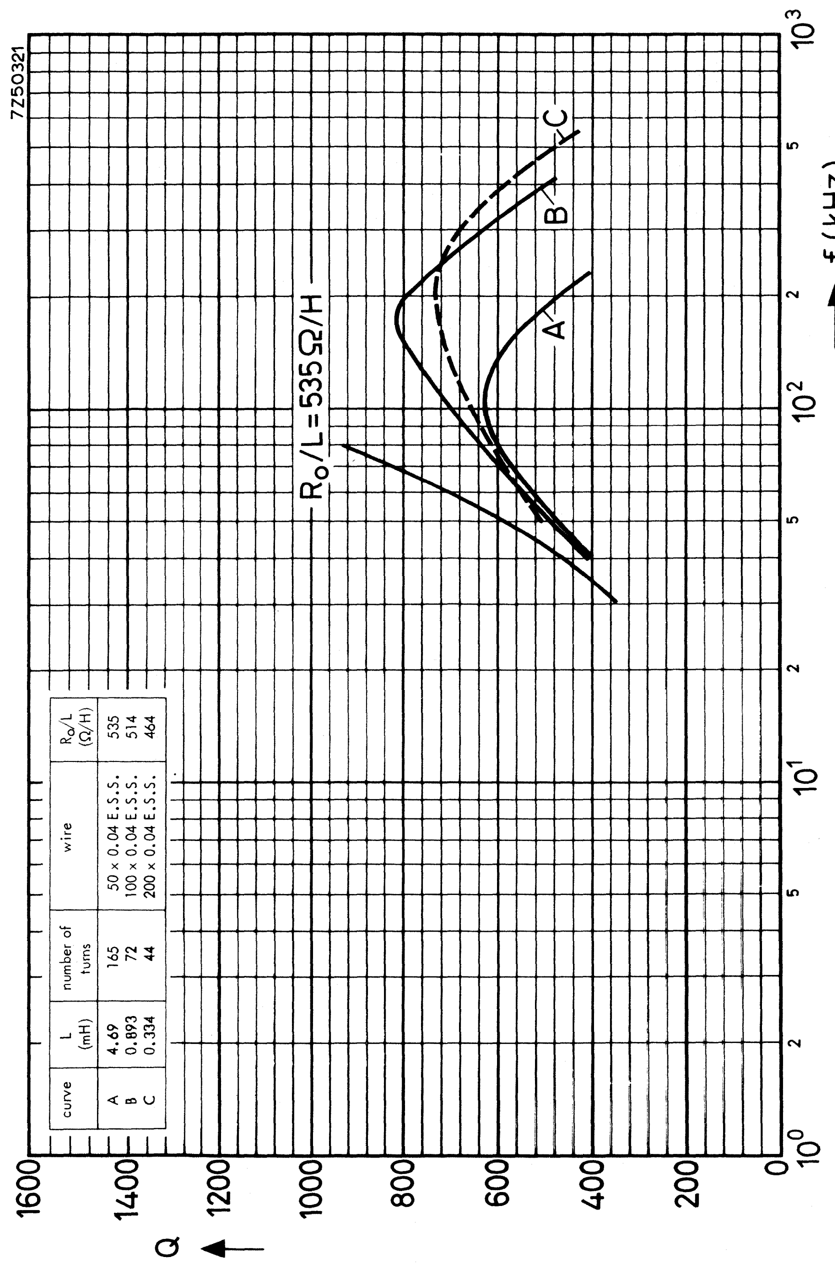
FXC 3D3
$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	3.24	165	50 × 0.04 E.S.S.	775
B	0.617	72	100 × 0.04 E.S.S.	744
C	0.235	44	200 × 0.04 E.S.S.	673

SINGLE-SECTION COIL FORMER

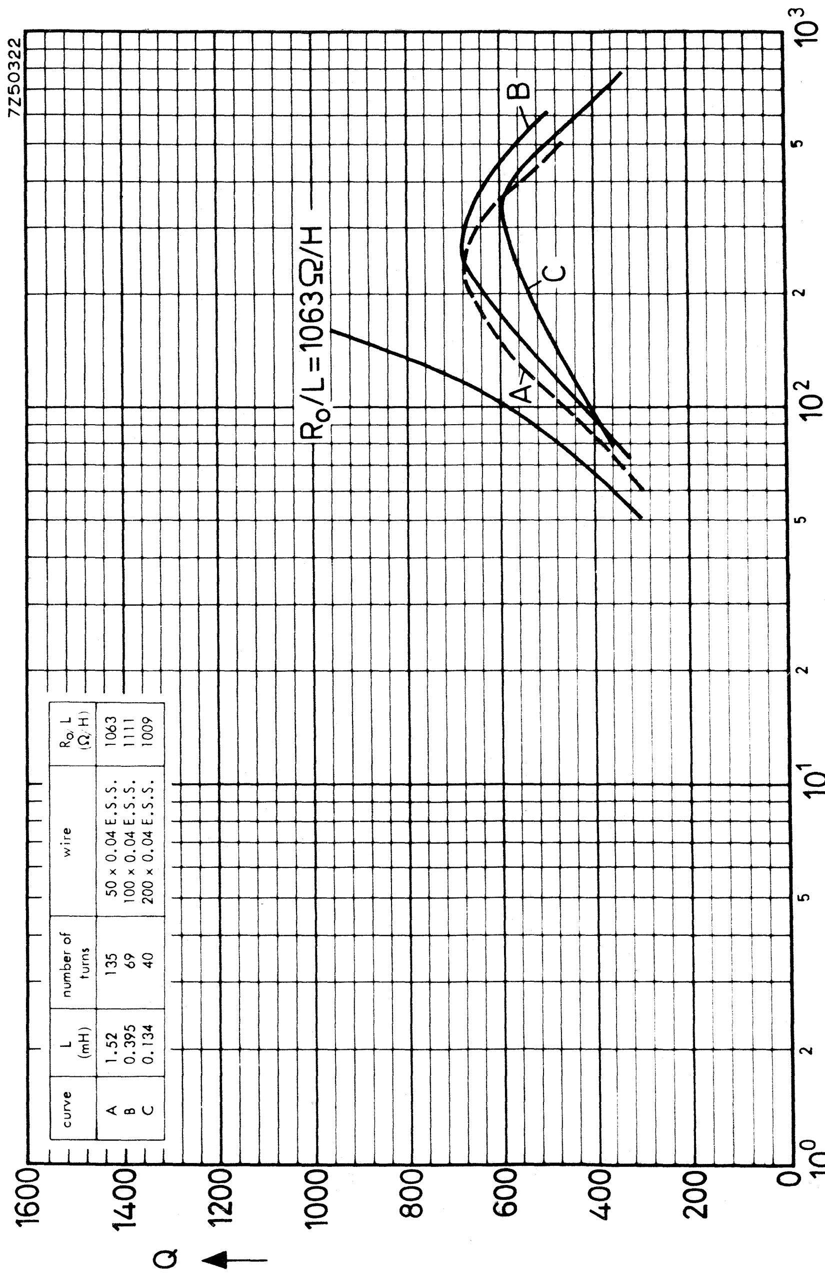
FCX 3D3
$\mu_e = 47$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	4.69	165	50 × 0.04 E.S.S.	535
B	0.893	72	100 × 0.04 E.S.S.	514
C	0.334	44	200 × 0.04 E.S.S.	464

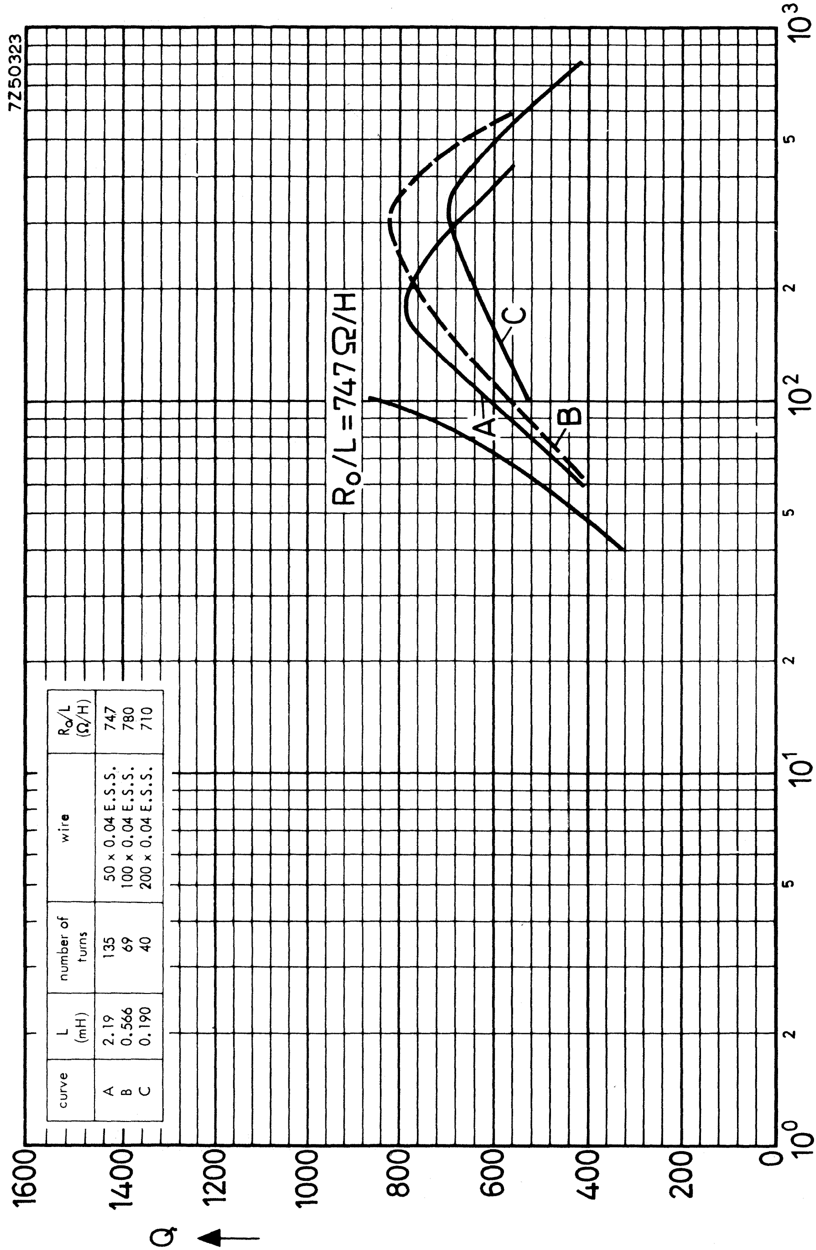
SINGLE-SECTION COIL FORMER

FXC 3D3
$\mu_e = 68$



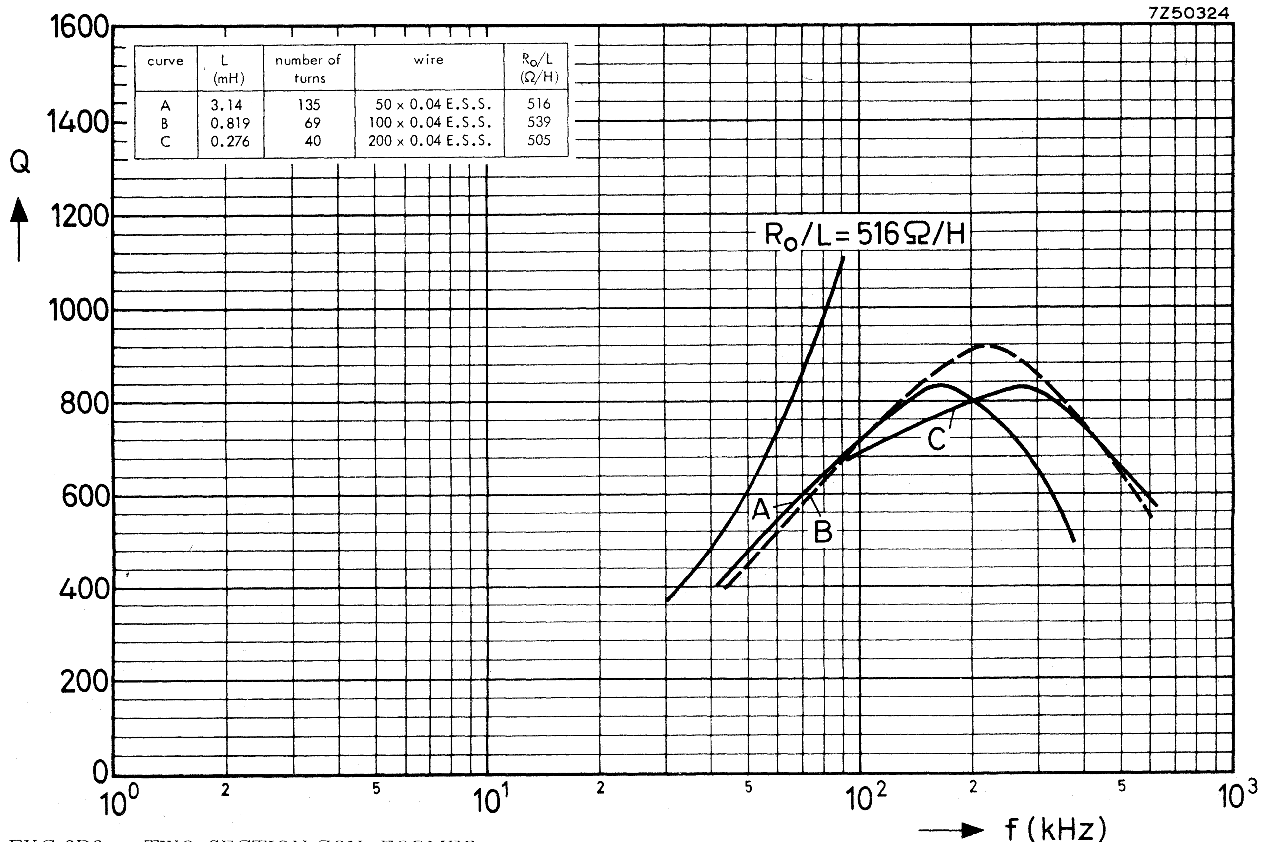
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.52	135	50 × 0.04 E.S.S.	1063
B	0.395	69	100 × 0.04 E.S.S.	1111
C	0.134	40	200 × 0.04 E.S.S.	1009

FXC 3D3 $\mu_e = 33$ TWO-SECTION COIL FORMER



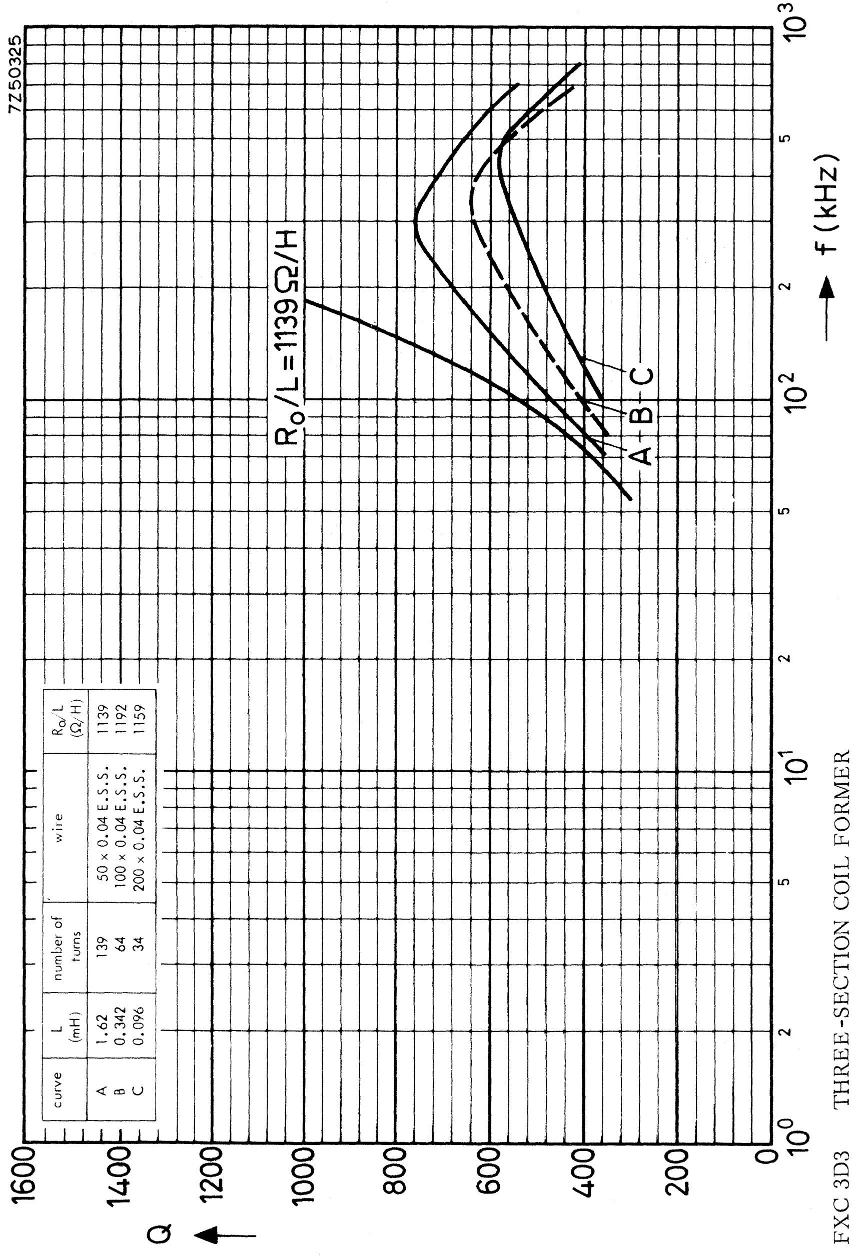
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	2.19	135	50 × 0.04 E.S.S.	747
B	0.566	69	100 × 0.04 E.S.S.	780
C	0.190	40	200 × 0.04 E.S.S.	710

FXC 3D3 TWO-SECTION COIL FORMER
$\mu_e = 47$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	3.14	135	50 × 0.04 E.S.S.	516
B	0.819	69	100 × 0.04 E.S.S.	539
C	0.276	40	200 × 0.04 E.S.S.	505

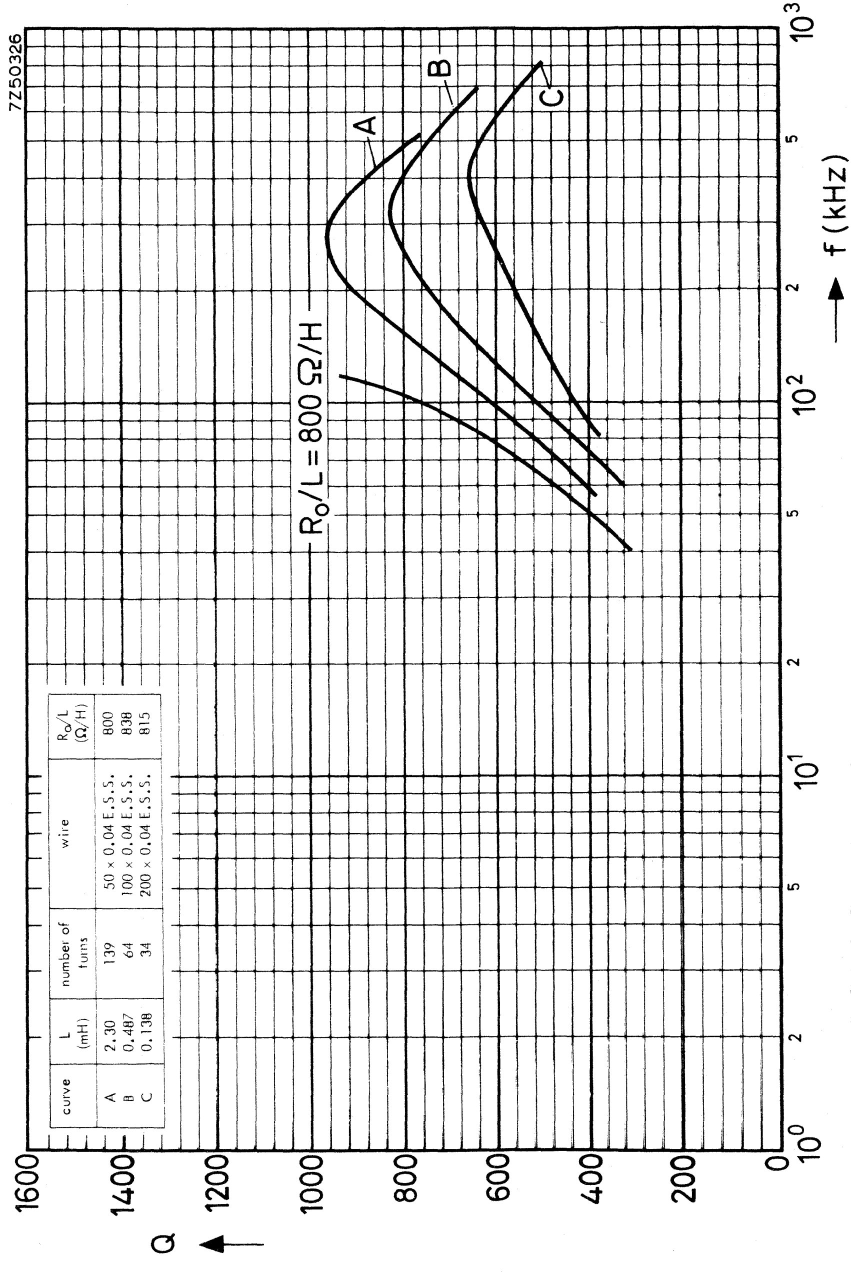
FXC 3D3 TWO-SECTION COIL FORMER
$\mu_e = 68$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	1.62	139	50 × 0.04 E.S.S.	1139
B	0.342	64	100 × 0.04 E.S.S.	1192
C	0.096	34	200 × 0.04 E.S.S.	1159

THREE-SECTION COIL FORMER

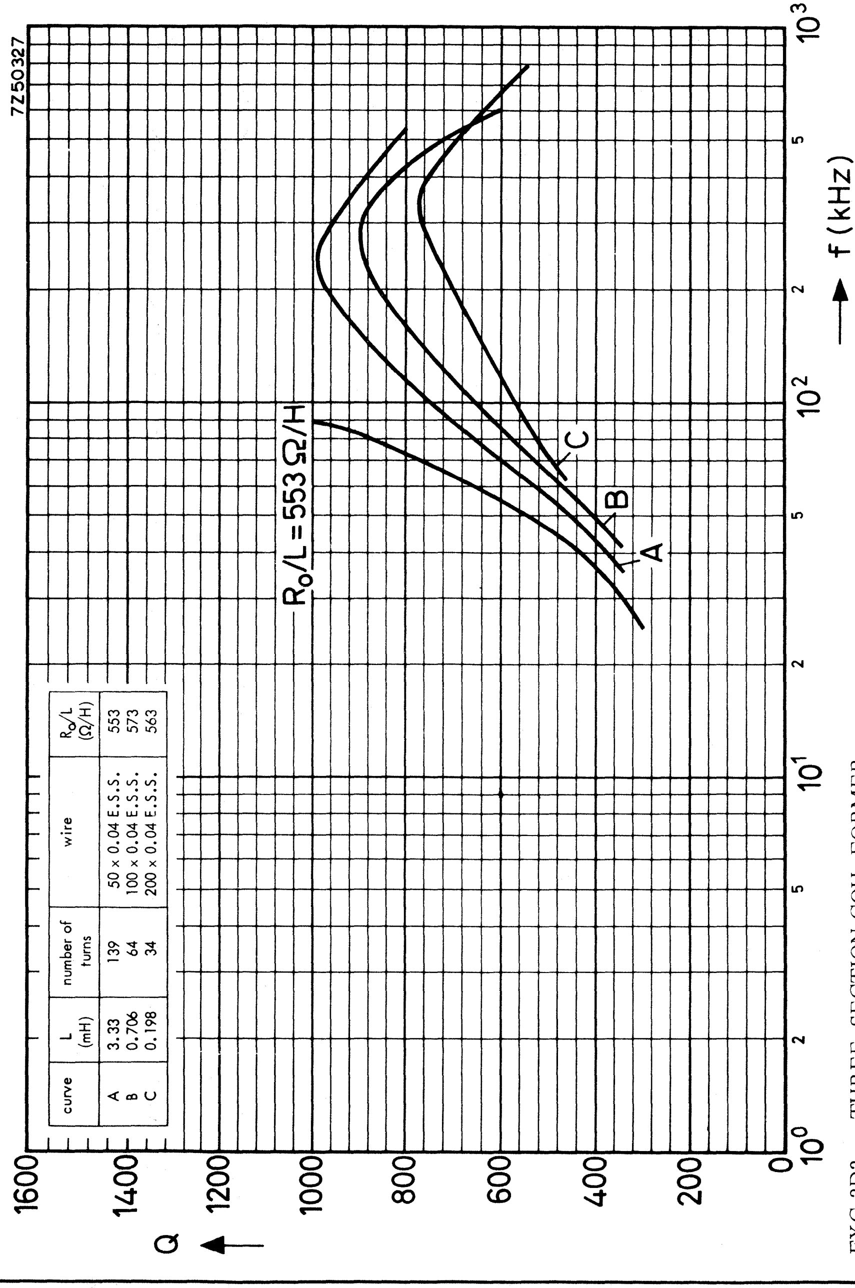
FXC 3D3
$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	2.30	139	50 × 0.04 E.S.S.	800
B	0.487	64	100 × 0.04 E.S.S.	838
C	0.138	34	200 × 0.04 E.S.S.	815

THREE-SECTION COIL FORMER

FXC 3D3
$\mu_e = 47$

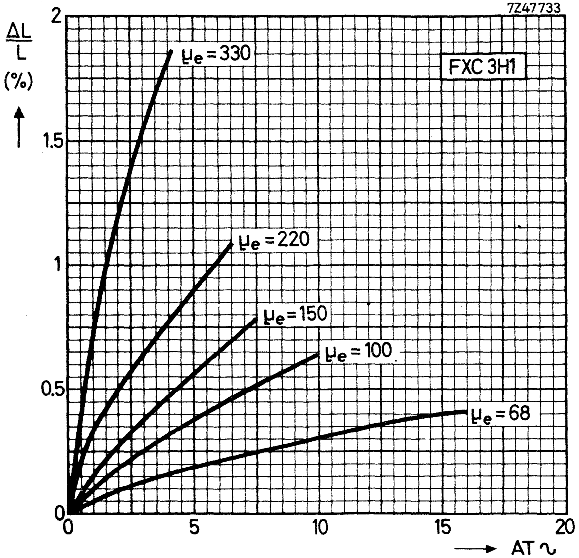


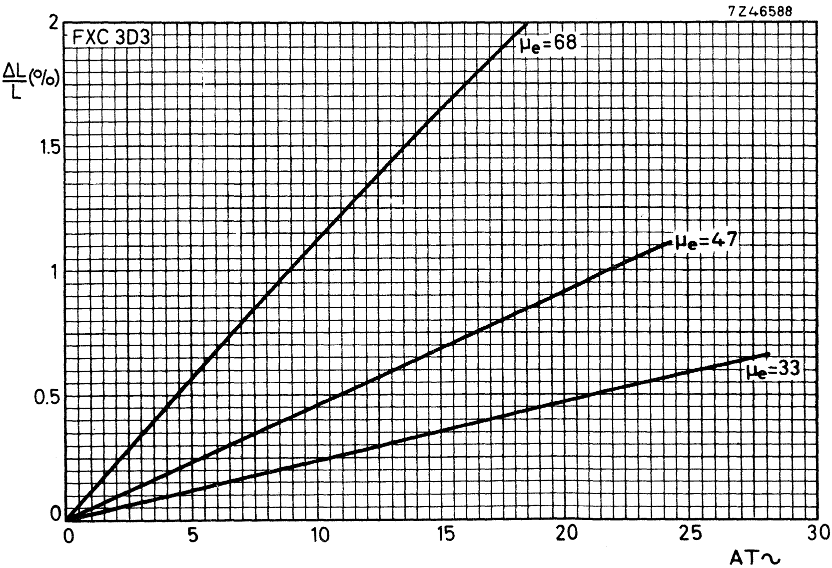
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	3.33	139	50 × 0.04 E.S.S.	553
B	0.706	64	100 × 0.04 E.S.S.	573
C	0.198	34	200 × 0.04 E.S.S.	563

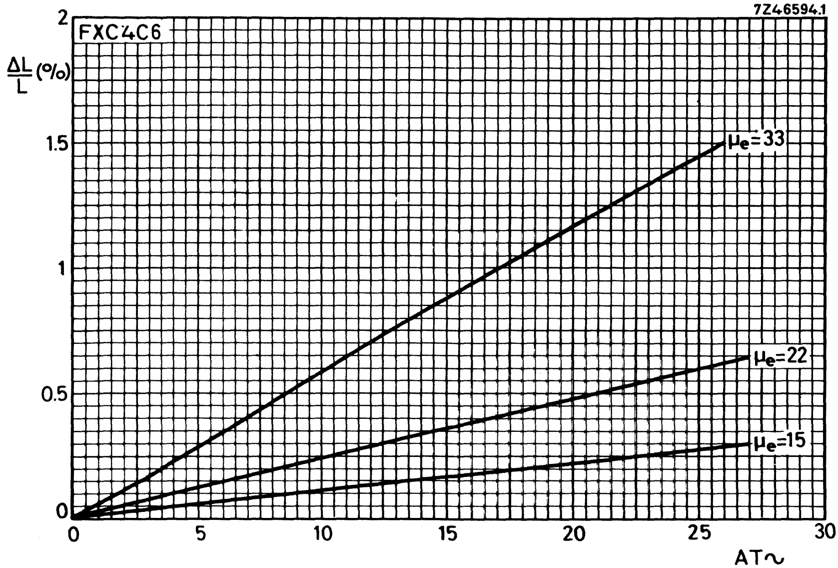
THREE-SECTION COIL FORMER

FXC 3D3
$\mu_e = 68$

INDUCTANCE VARIATION AS A FUNCTION OF AT~

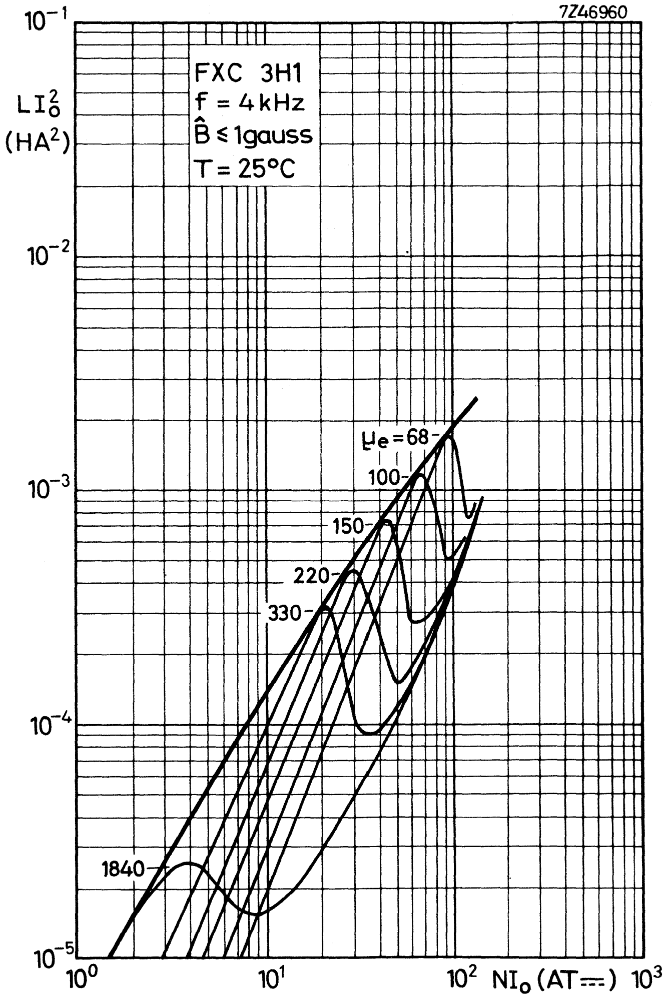




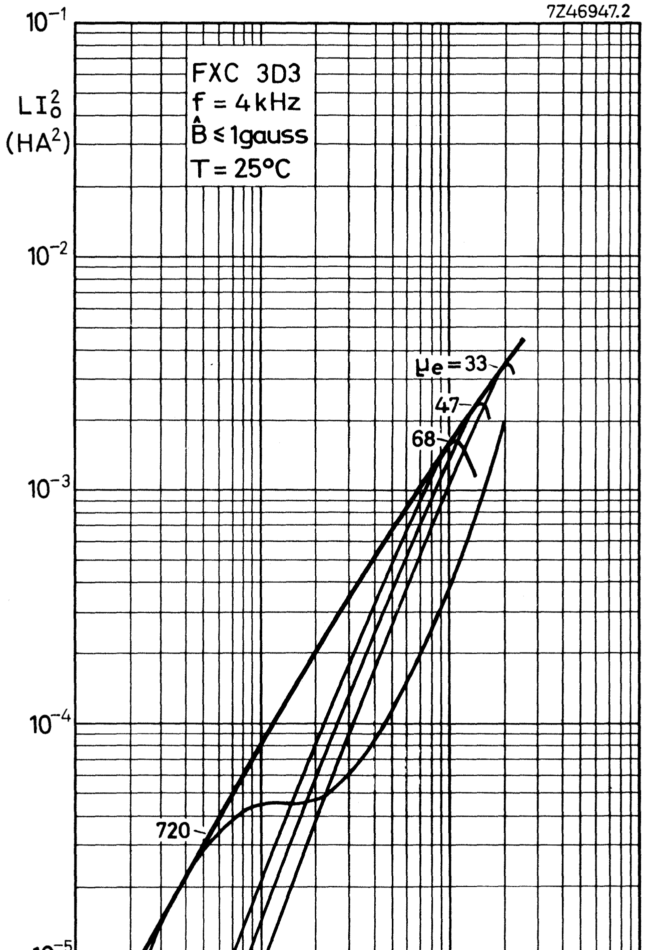

7Z46594.1
FXC4C6
ΔL/L (%)
2
1.5
1
0.5
0
0
5
10
15
20
25
30
AT~
μe=33
μe=22
μe=15

HANNA CURVES

Indicating optimum inductance for a certain μ_e-value and direct current.
Typical values



Typical values



POTCORES

INTRODUCTION

Three types of core can be supplied:

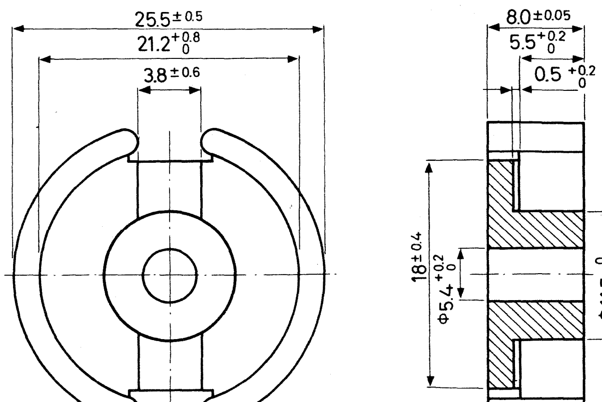
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E_6 range of values or an inductance factor (A_L) in the R_5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).

Potcores and associated parts are ordered by their 12-digit catalog number.
Quantity: a primary pack contains 20 potcore halves or 10 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 22000
3H1	4322 020 22010
3D3	4322 020 22020
improved 3E1	4322 020 22140
4C6	4322 020 22110

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (°C)	grade				
		3B7	3H1	3D3		4C6
T.F. x 10^6	+5 to +23	–	+0.5 to +1.5	–		–2 to +4
	+5 to +55	–	–	–		
	+23 to +55	–	+0.5 to +1.5	–		0 to +6
	+23 to +70	–0.6 to +0.6	1)	0 to 2		–
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 12		≤ 10

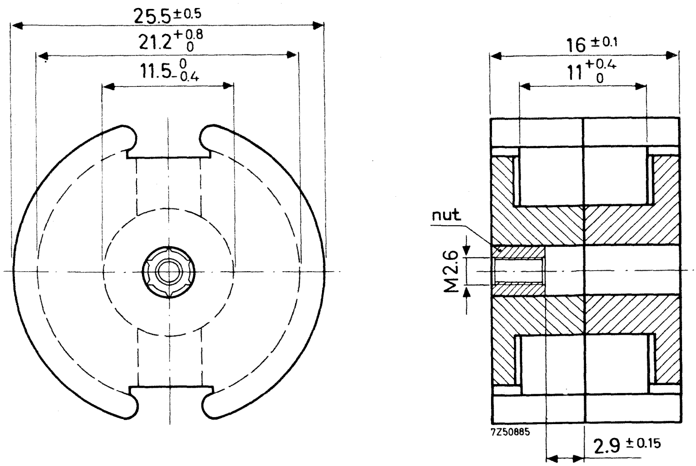
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 200 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II	$\hat{B}$ (Gs)	freq. (MHz)	grade				
			3B7	3H1	3D3	impr. 3E1	4C6
μ_e	≤ 1	0.004	≥ 1430	≥ 1430	–	2300-3825	–
	≤ 1	0.1	–	–	≥ 550	–	≥ 93
A_L	≤ 1	0.004	–	–	–	7250-12000	–
α	≤ 1	0.004	≤ 14.9	≤ 14.9	–	–	–
$\frac{\tan\delta}{\mu_i} \times 10^6$	≤ 1	0.1	–	–	≤ 24.1	–	≤ 58.0
	≤ 1	0.004	≤ 1.2	≤ 1.2	–	≤ 2.5	–
	≤ 1	0.1	≤ 5	≤ 5	≤ 8	≤ 20	–
	≤ 1	0.5	–	–	≤ 14	≤ 200	–
	≤ 1	1	–	–	≤ 35	–	–
	≤ 1	2	–	–	–	–	≤ 40
	≤ 1	10	–	–	–	–	≤ 100
q2-24-100	15-30	0.004	≤ 1.8	≤ 1.4	–	≤ 3.0	–
	3-12	0.1	–	–	≤ 3.0	–	≤ 10

1) For orientation: +1.5 to +1.5.

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 2....
Without nut, catalog number = 4322 022 0....

Weight = 20 g

Effective length l_e = 3.76 cm

$\Sigma \frac{l_e}{A_e}$ = 4.00 cm^{-1}

Effective volume V_e = 3.53 cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 15, grade 4C6, potcore with nut, catalog number = 4322 022 28810
   A_L = 100, grade 3B7, potcore without nut, catalog number = 4322 022 09040
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

Potcores with standard μ_e values [1)]

μ_e	α	tolerance on inductance (%)	catal. No.: 4322 022 2.... with nut 4322 022 0.... without nut 3B7	3H1	3D3	4C6
15	146	± 1	–	–	–	8810
22	120	± 1	–	–	–	8820
33	98.2	± 1	8030	8230	8430	8830
47	82.3	± 1	8040	8240	8440	–
68	68.4	± 1	8050	8250	8450	–
100	56.4	± 1.5	8060	8260	–	–
150	46.1	± 2	8070	8270	–	–
220	38.1	± 3	8080	8280	–	–
330	31.0	± 3	8090	8290	–	–
730	20.8	± 25	–	–	8400 *	–
1910	12.9	± 25	8000*	8200*	–	–

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

Potcores with standard A_L factors [1)]

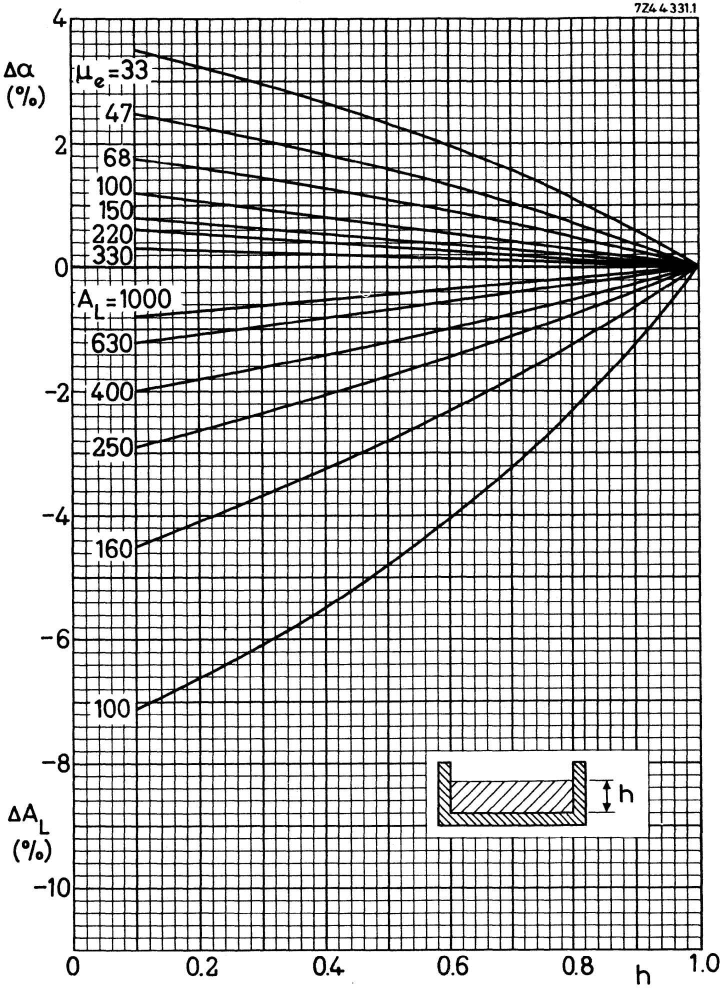
A_L	corresponding μ_e-value	tolerance on inductance (%)	catal. No.: 4322 022 2.... with nut 4322 022 0.... without nut 3B7	3H1	3D3	4C6
63	20	± 1	9030	9230	9430	9830
100	31.8	± 1	9040	9240	9440	9840
160	51	± 1	9050	9250	9450	–
250	79.5	± 1	9060	9260	9460	–
315	100.2	± 1.5	9070	9270	–	–
400	127	± 2	9080	9280	–	–
630	200	± 3	9100	9300	–	–
1000	318	± 3	9110	9310	–	–
1600	510	± 3	9120	9320	–	–

Inductance $L = N^2 A_L$ (in 10^{-9} H)

[1)] See Notes on the previous page.

*) Only available without nut.

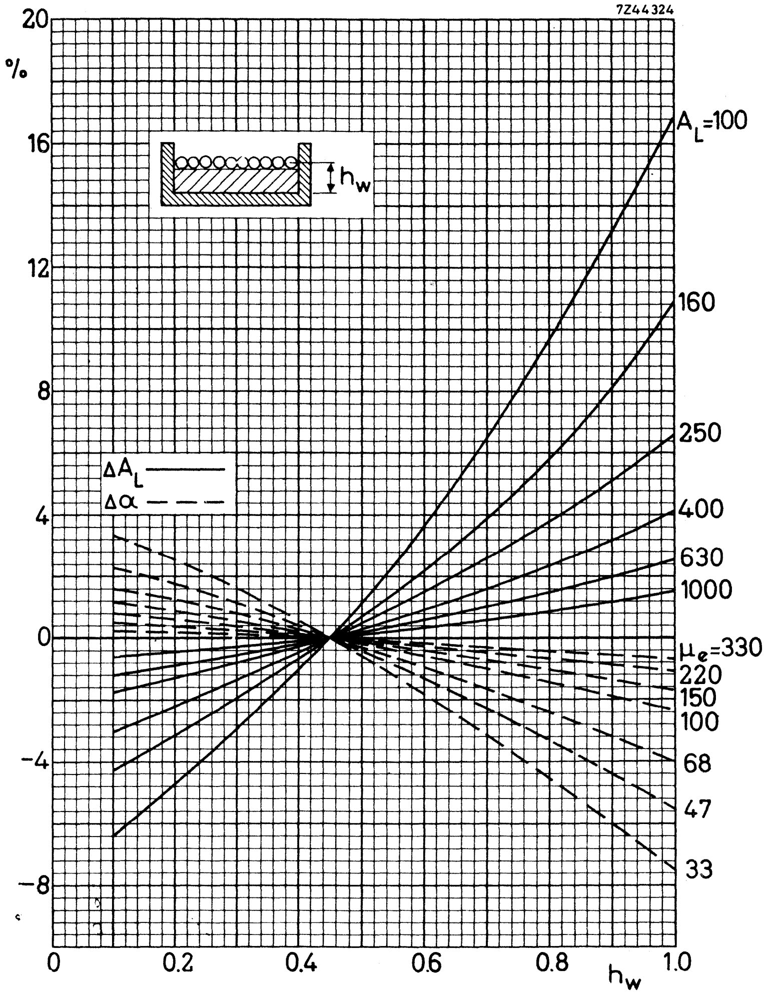
DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former only 0.4 part of the available height is used. A potcore with μ_e = 68 in that case obtains an α factor of 68.4 + 1.25 %.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_w on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3 only.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 68 obtains for that winding an α factor of 68.4 - 1.7 %.

COIL FORMERS

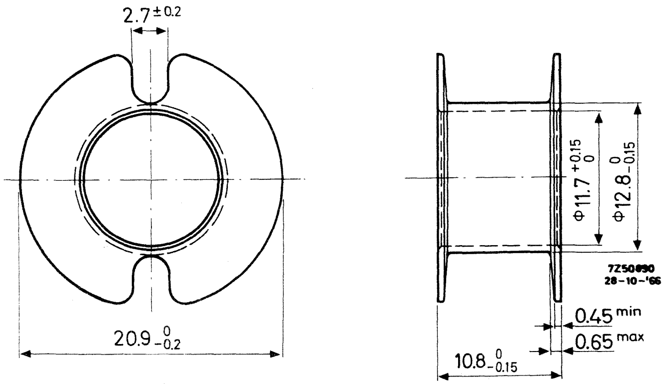
GENERAL

Four types of coil former can be supplied:

- with one section
- with two sections
- with three sections
- with one section and with soldering pins to fit 0.1" and 2.50 mm grid.

The dimensions conform with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-02 (France) and D.I.N. 41 294 (Germany).
The dimensions in the drawings are in mm.

SINGLE-SECTION COIL FORMER



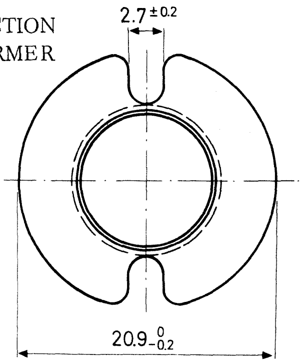
Catalog number	4322 021 30330
Material	glassfibre-reinforced polyacetal
Window area	39 mm^2
Mean length of turn	5.3 cm
Max. temperature	130 °C

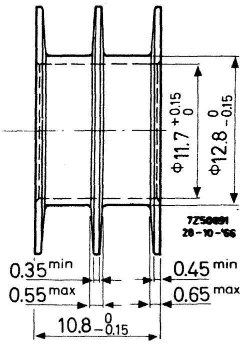
D.C. losses

$$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 7.42 \times 10^3 \ \Omega/H$$

Weight 0.5 g

TWO-SECTION
COIL FORMER





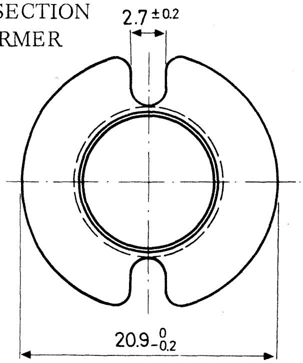
Catalog number	4322 021 30340
Material	glassfibre-reinforced polyacetal
Window area	2 x 19 mm^2
Mean length of turn	5.3 cm
Max. temperature	130 °C

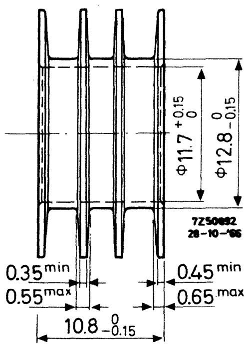
D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 7.79 \times 10^3 \quad \Omega/H$$

Weight 0.6 g

THREE-SECTION
COIL FORMER





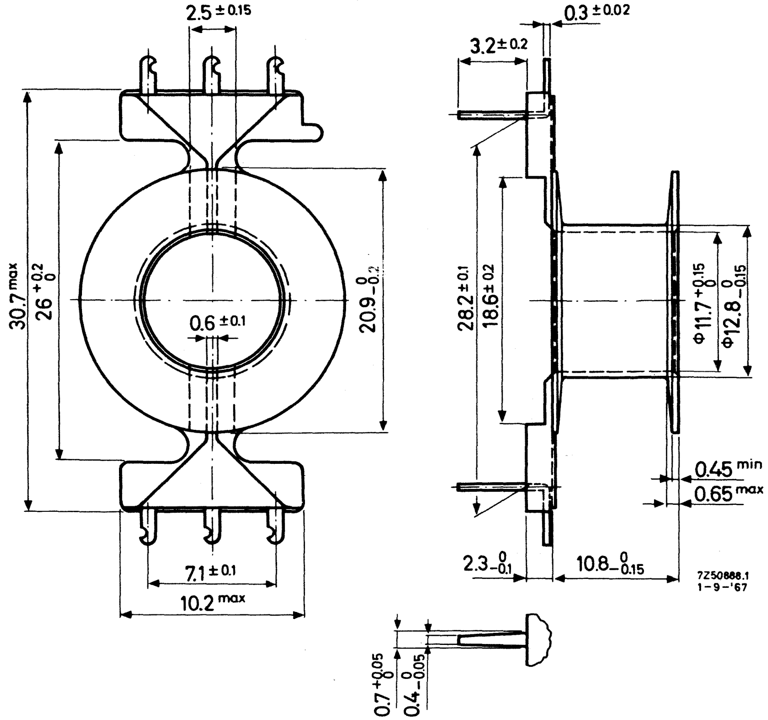
Catalog number	4322 021 30350
Material	glassfibre-reinforced polyacetal
Window area	3 x 12 mm^2
Mean length of turn	5.3 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 8.18 \times 10^3 \quad \Omega/H$$

Weight 0.7 g

SINGLE-SECTION COIL FORMER WITH SOLDERING PINS



Catalog number 4322 021 30130

Material: reinforced polyester with brass dipsoldered pins

Window area 39 mm^2

Mean length of turn 5.3 cm

Max. temperature 180 °C

Solderability according to I.E.C.68-2-20, part 2, test T

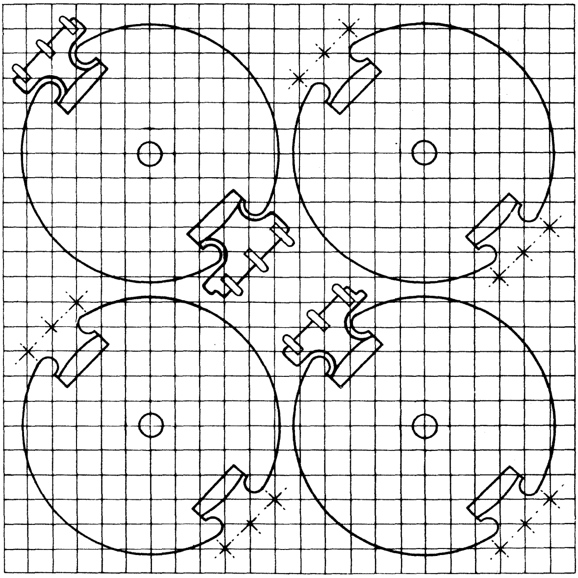
D.C. losses:

$$\frac{R_0}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 7.42 \times 10^3 \ \Omega/H$$

Weight 0.6 g

The coil formers are packed in boxes containing 5 layers of 40 coil formers, so please order in multiples of 40.

The soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes 1.3 ± 0.1 mm diameter. For this coil former the potcore halves must be cemented together, and it is recommended to cement the coil former to the lower potcore half.



7Z47201

INDUCTANCE ADJUSTORS

CONTINUOUS ADJUSTORS

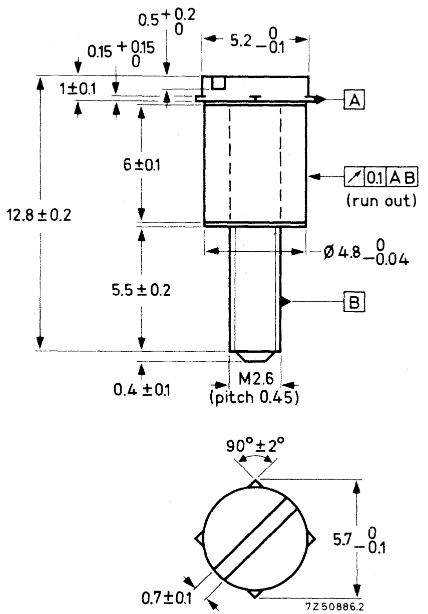


Fig. A

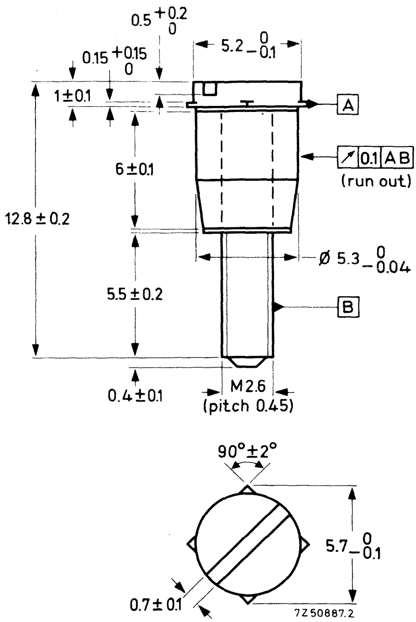


Fig. B

The tolerances on inductance of the pre-adjusted potcores (with adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.
Table II shows the type of adjustor recommended for different potcores.

Table I, types of adjustor

Fig.	colour	catalogue number
A	green	4322 021 30780
A	yellow	4322 021 30790
A	red	4322 021 30800
A	brown	4322 021 30810
B	white	4322 021 30980
B	grey	4322 021 31090

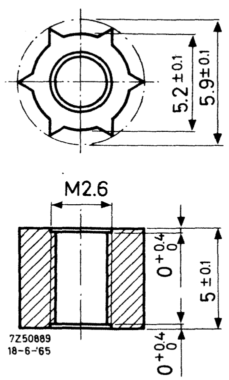
The adjustors are packed in bags of 100, so please order in multiples of 100.

Table II, recommended application

μ_e	A_L	3B7/3H1/3D3	4C6
		catal. No. 4322 021	
15		–	30780
22		–	30780
	63	–	30780
33		30780	30790
	100	30780	30790
47		30800	
	160	30800	
68		30980	
	250	30980	
100	315	30980	
150		30810	
	400	30810	
220		30810	
	630	30810	
330		31090	
	1000	31090	

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

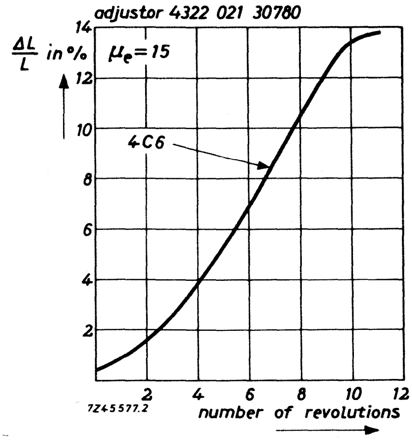


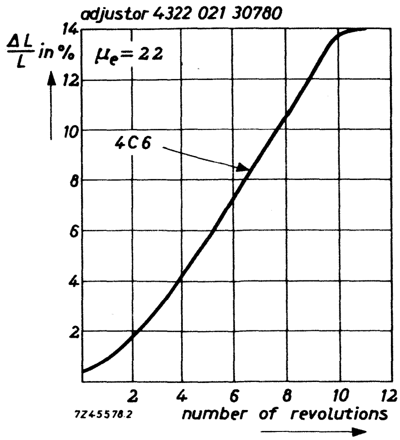
Catalogue number	4322 021 30160
Material	polycarbonate
Max. impregnation temperature for 24 hours	120 °C
Recommended distance from mating surface to nut	2.9 ± 0.15 mm

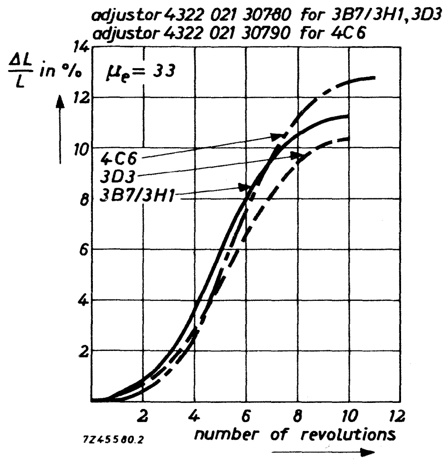
For more information see Potcores General, Mounting data

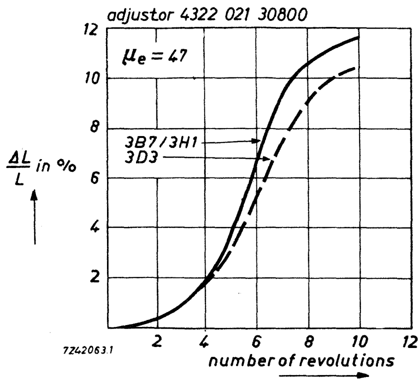
The nuts are packed in bags of 100, so please order in multiples of 100.

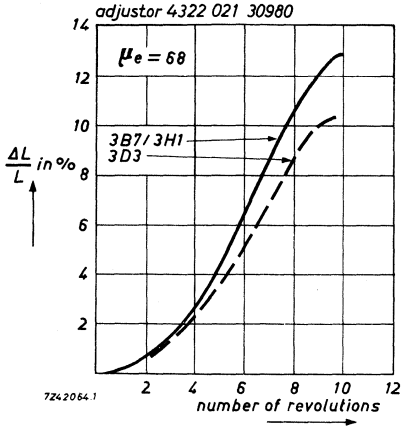
ADJUSTMENT CURVES

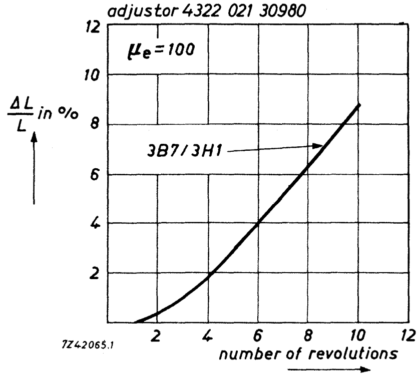


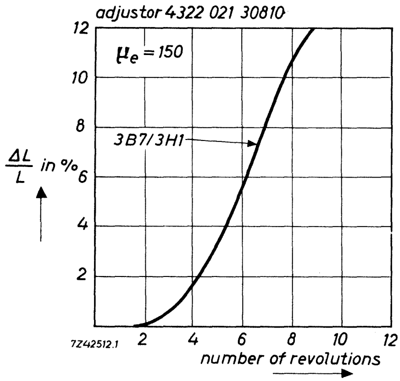


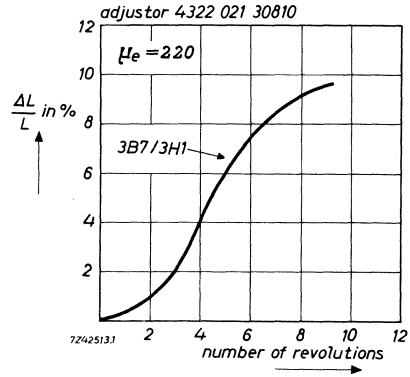


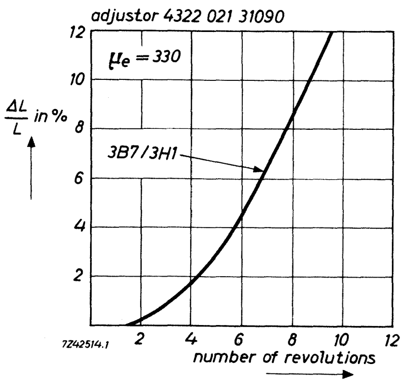



adjustor 4322 021 30980
$\mu_e = 68$
3B7/3H1
3D3
$\frac{\Delta L}{L}$ in %
number of revolutions
7Z42064.1


adjustor 4322 021 30980
$\mu_e = 100$
3B7/3H1
$\frac{\Delta L}{L}$ in %
number of revolutions
7Z42065.1


adjustor 4322 021 30810
$\mu_e = 150$
3B7/3H1
$\frac{\Delta L}{L}$ in %
number of revolutions
7Z42512.1

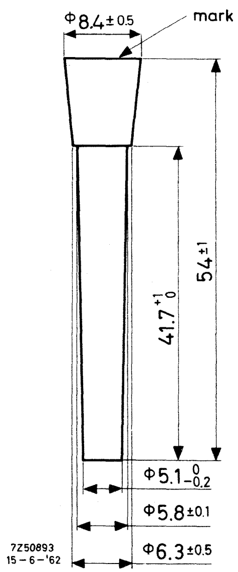

adjustor 4322 021 30810
$\mu_e = 220$
3B7/3H1
$\frac{\Delta L}{L}$ in %
number of revolutions
7Z42513.1

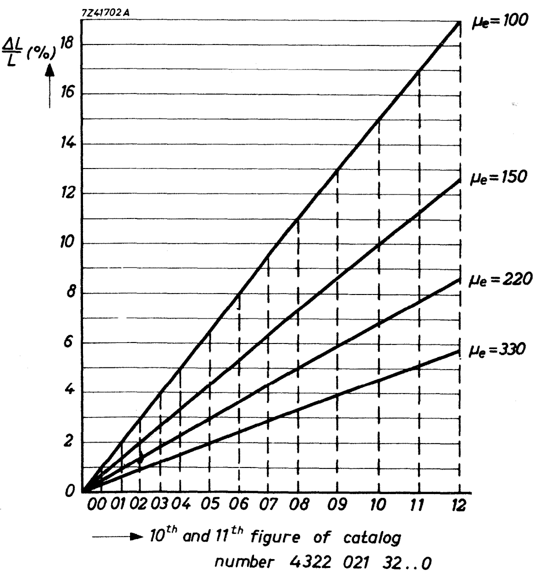

adjustor 4322 021 31090
$\mu_e = 330$
3B7/3H1
$\frac{\Delta L}{L}$ in %
number of revolutions
7Z42514.1

STEP-BY-STEP ADJUSTORS

These adjustors are used when a continuous adjustment of the inductance is not necessary. For instance, they are applied in loading coils to bring the inductance within a certain tolerance field. They are not suitable for adjusting the inductance to an exact value, as is usually necessary in filters. The increment of the losses caused by these adjustors is negligible.
A range of 13 flexible conical adjustors is available under the catalog numbers 4322 021 32000 up to ..32120. Each adjustor causes an increase in the inductance; the higher the catalog number, the greater the effect. The influence of each adjustor on the inductance at different μ_e values of the potcore can be found from the graph.
The 10th and 11th figure of the catalog number are indicated on the head of the adjustor. It should be borne in mind that, when using these adjustors, the inductance of the coil should initially be lower than the wanted value.
When the correct adjustor has been found, it is inserted in the centre hole of the pot. An adhesive (for instance Pliobond of Good Year) is used as sliding and fixing material. After fixing the protruding ends are cut off.

The maximum impregnation temperature is 150 °C.
The maximum working temperature is 90 °C.
Material: rubber with powder iron.

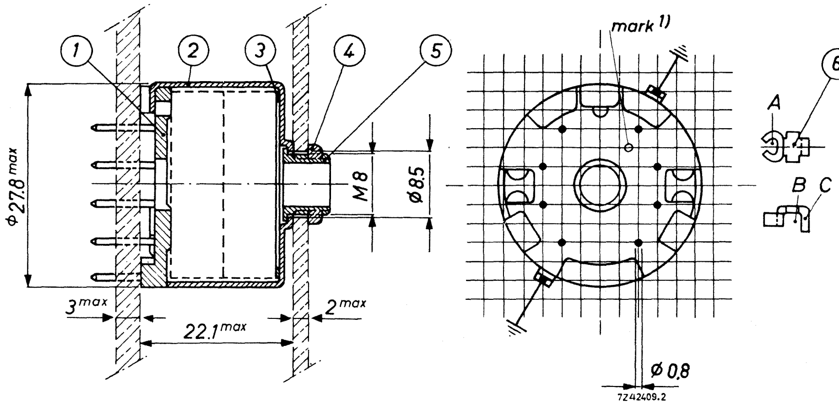




Dimensions in mm

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30470	(4) nut	4322 021 30710
(2) brass container	4322 021 30550	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30660	(6) soldering spring	4322 021 30700 (8x)

The core is suitable for mounting on printed-wiring boards and on conventional panels.

The parts 1, 2, 3 (and 6) are sufficient to construct an assembly for use in combination with printed wiring.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The eight soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3 + 0.1 mm diameter.

If one-hole mounting is preferred, the parts 4 and 5 should be added. The coil assembly may then be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

1) There is another mark hole in a similar position on the top of the container.

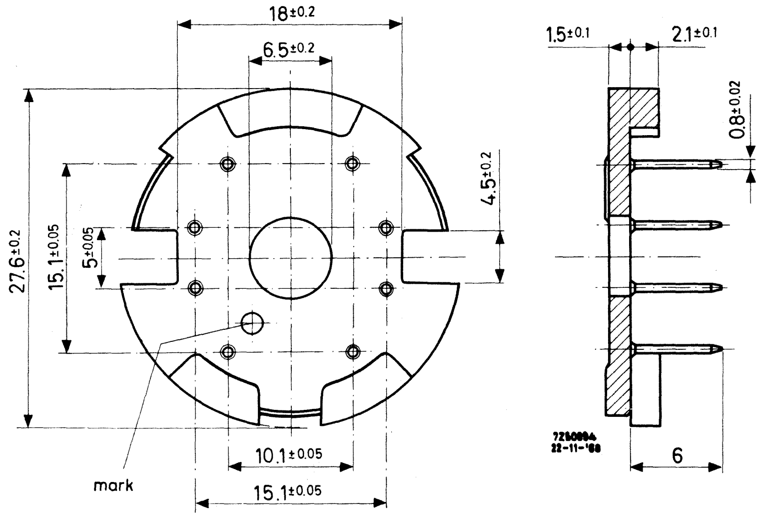
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.
Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 200 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

(1) Tag plate 4322 021 30470

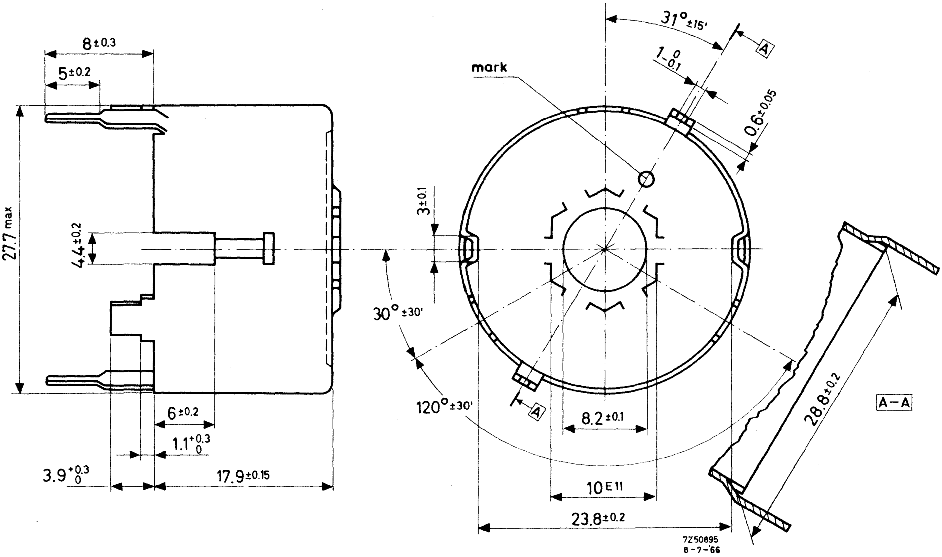
Plate: reinforced polyester

Pins : phosphorbronze, dipsoldered



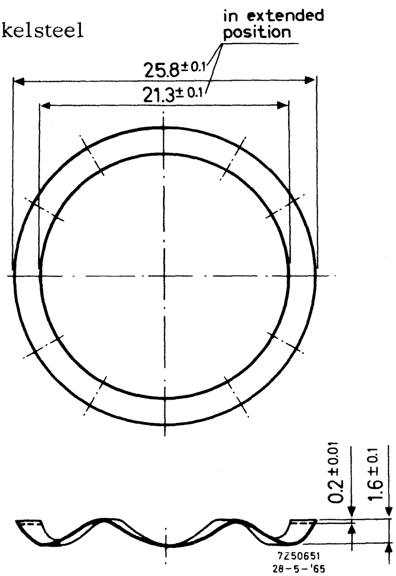
(2) Container 4322 021 30550

Material: brass, nickel plated



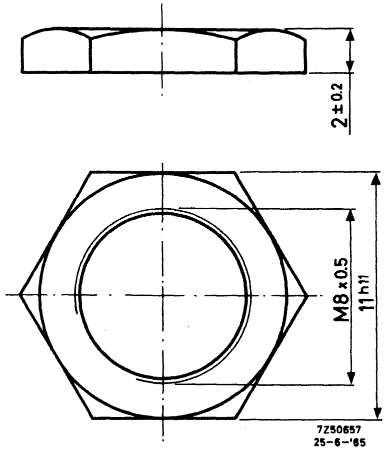
(3) Spring 4322 021 30660

Material: chrome-nickelsteel



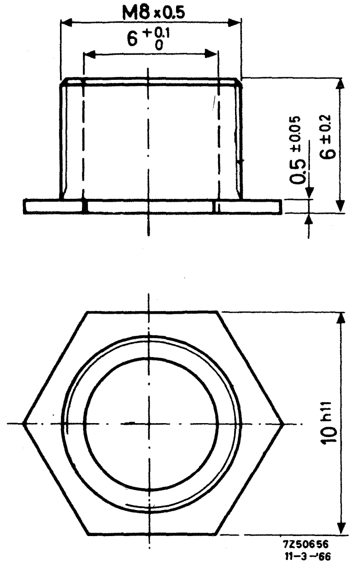
(4) Nut 4322 021 30710

Material: brass, nickel plated



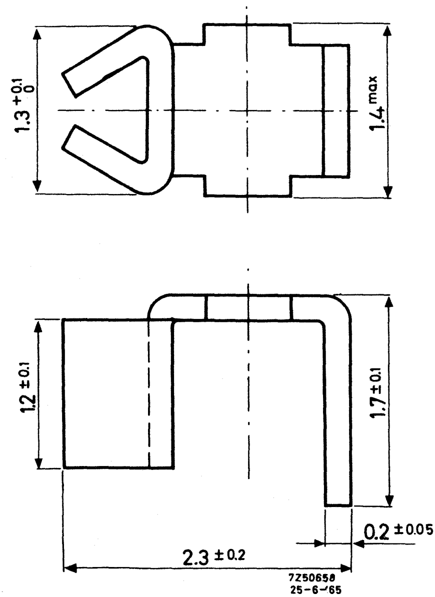
(5) Fixing bush 4322 021 30720

Material: brass, nickel plated



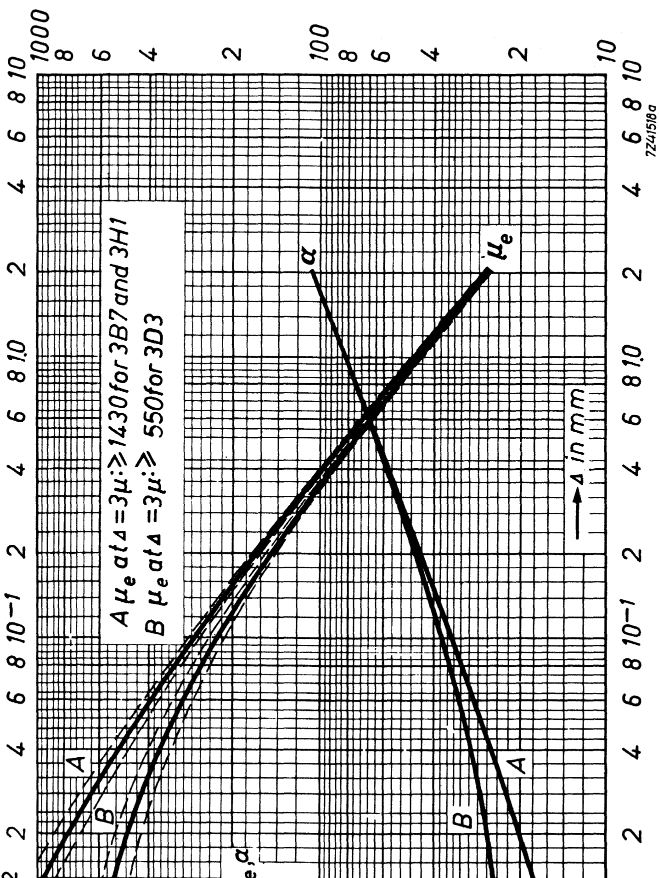
(6) Soldering spring 4322 021 30700

Material : brass, dipsoldered



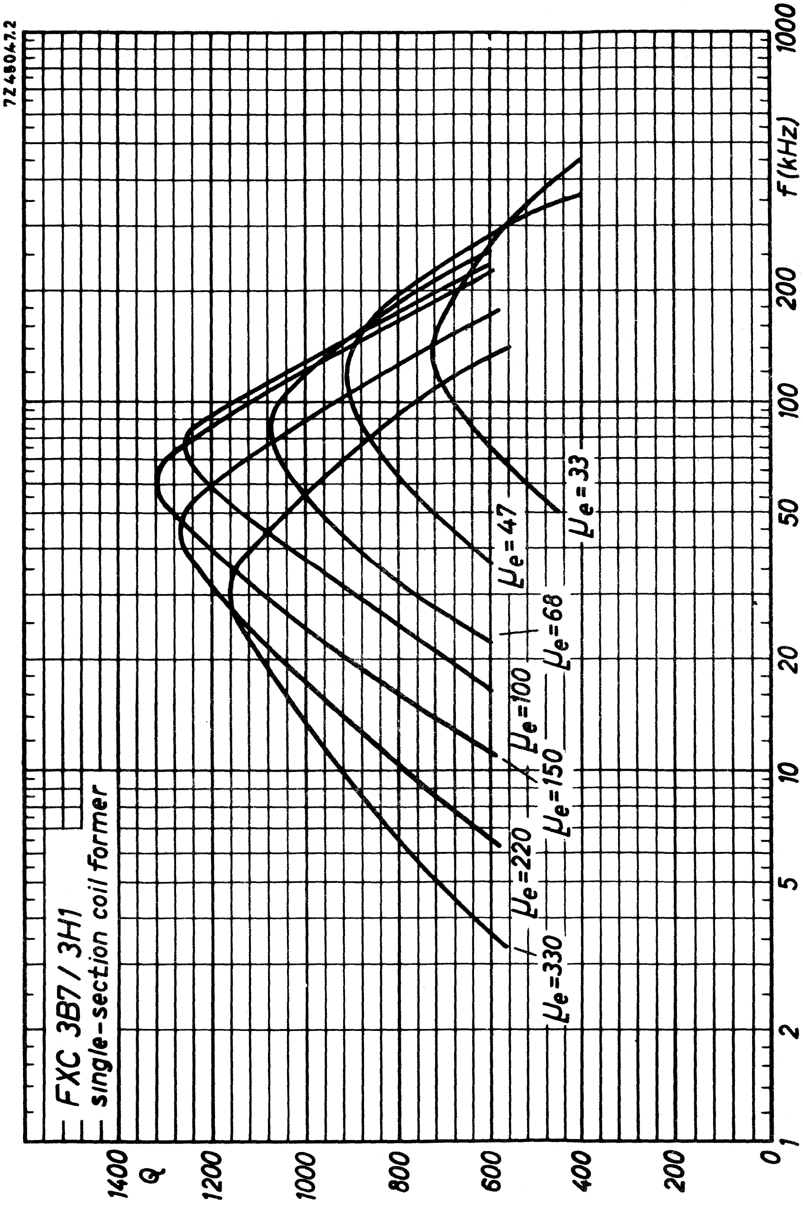
CHARACTERISTIC CURVES

μ_e - α CURVES

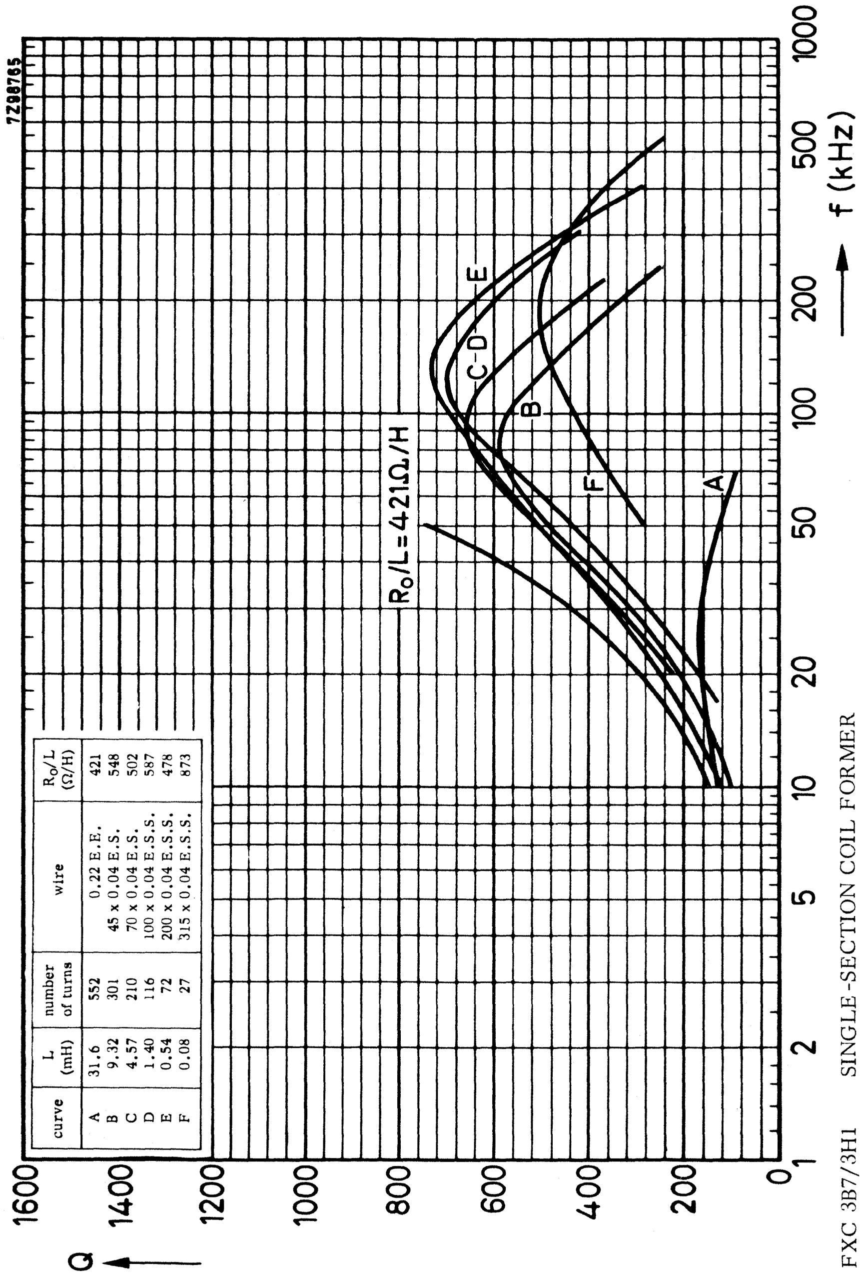


Relative effective permeability and turn factor for 1 mH as a function of the air-gap length.

TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1



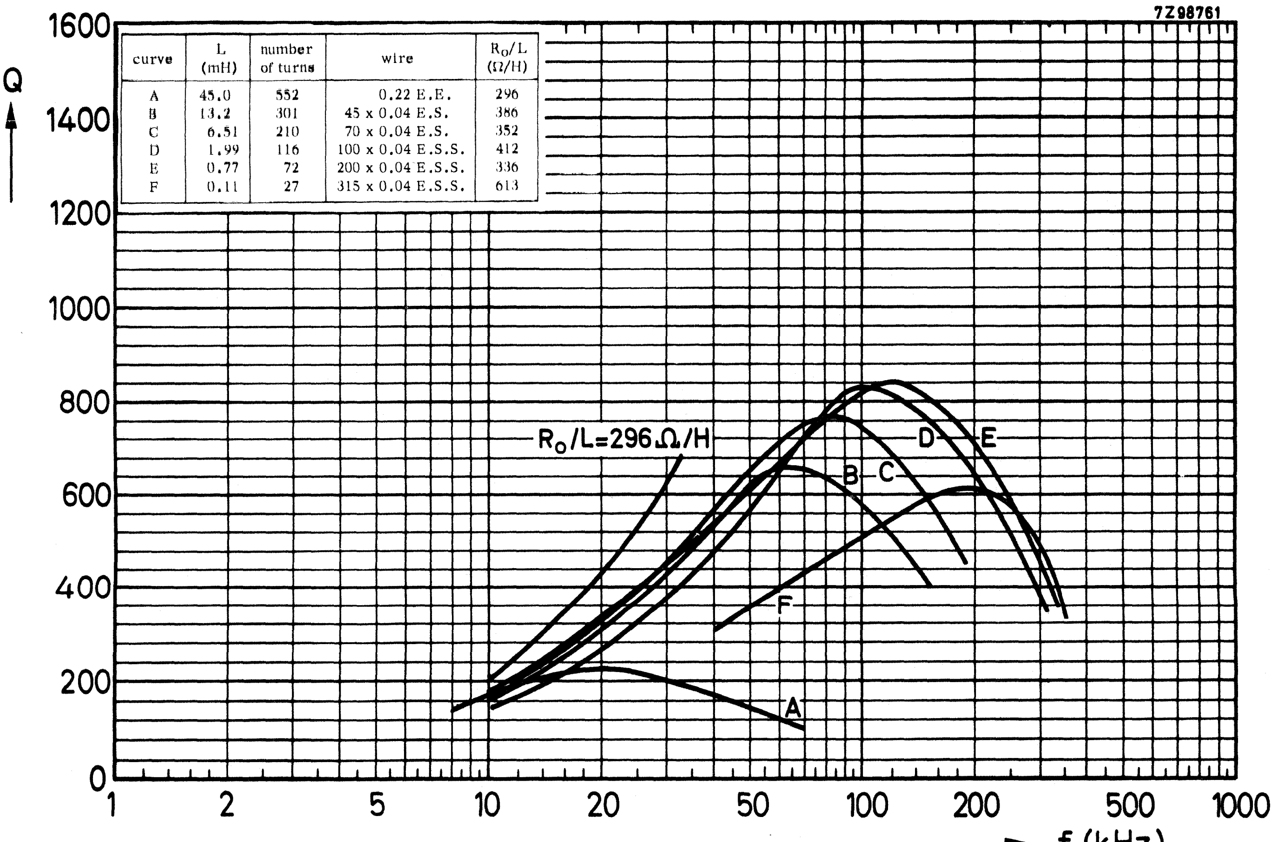
Enveloping curves



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	31.6	552	0.22 E.E.	421
B	9.32	301	45 x 0.04 E.S.	548
C	4.57	210	70 x 0.04 E.S.	502
D	1.40	116	100 x 0.04 E.S.S.	587
E	0.54	72	200 x 0.04 E.S.S.	478
F	0.08	27	315 x 0.04 E.S.S.	873

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

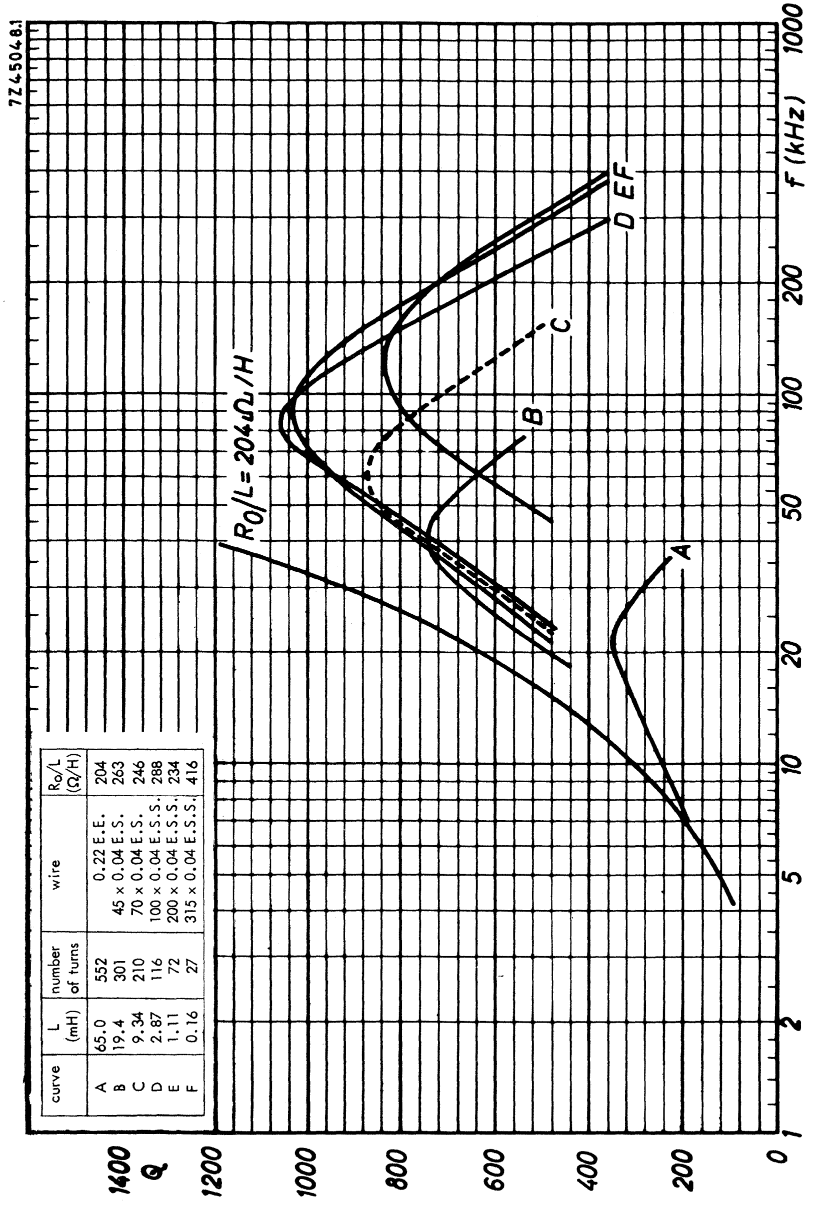
$\mu_e = 33$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	45.0	552	0.22 E.E.	296
B	13.2	301	45 x 0.04 E.S.	386
C	6.51	210	70 x 0.04 E.S.	352
D	1.99	116	100 x 0.04 E.S.S.	412
E	0.77	72	200 x 0.04 E.S.S.	336
F	0.11	27	315 x 0.04 E.S.S.	613

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

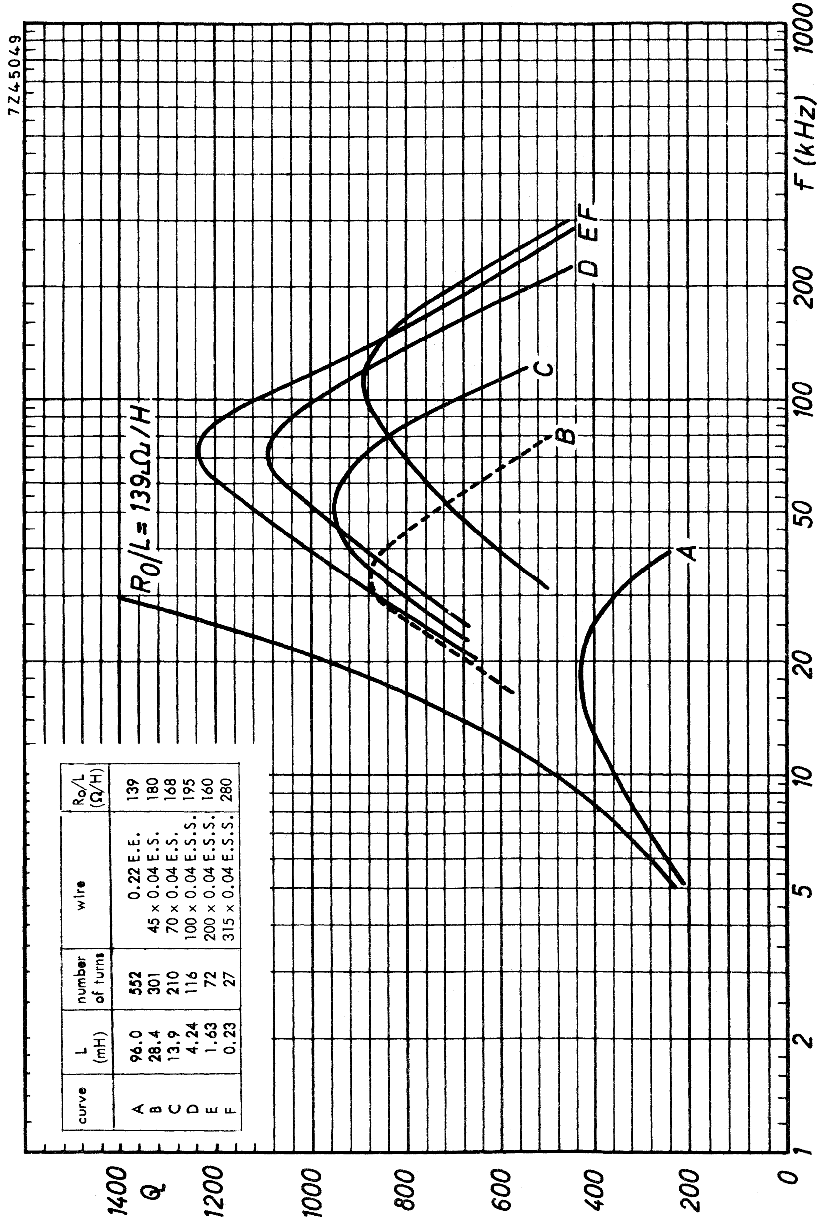
μ_e = 47



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	65.0	552	0.22 E.E.	204
B	19.4	301	45 × 0.04 E.S.	263
C	9.34	210	70 × 0.04 E.S.	246
D	2.87	116	100 × 0.04 E.S.S.	288
E	1.11	72	200 × 0.04 E.S.S.	234
F	0.16	27	315 × 0.04 E.S.S.	416

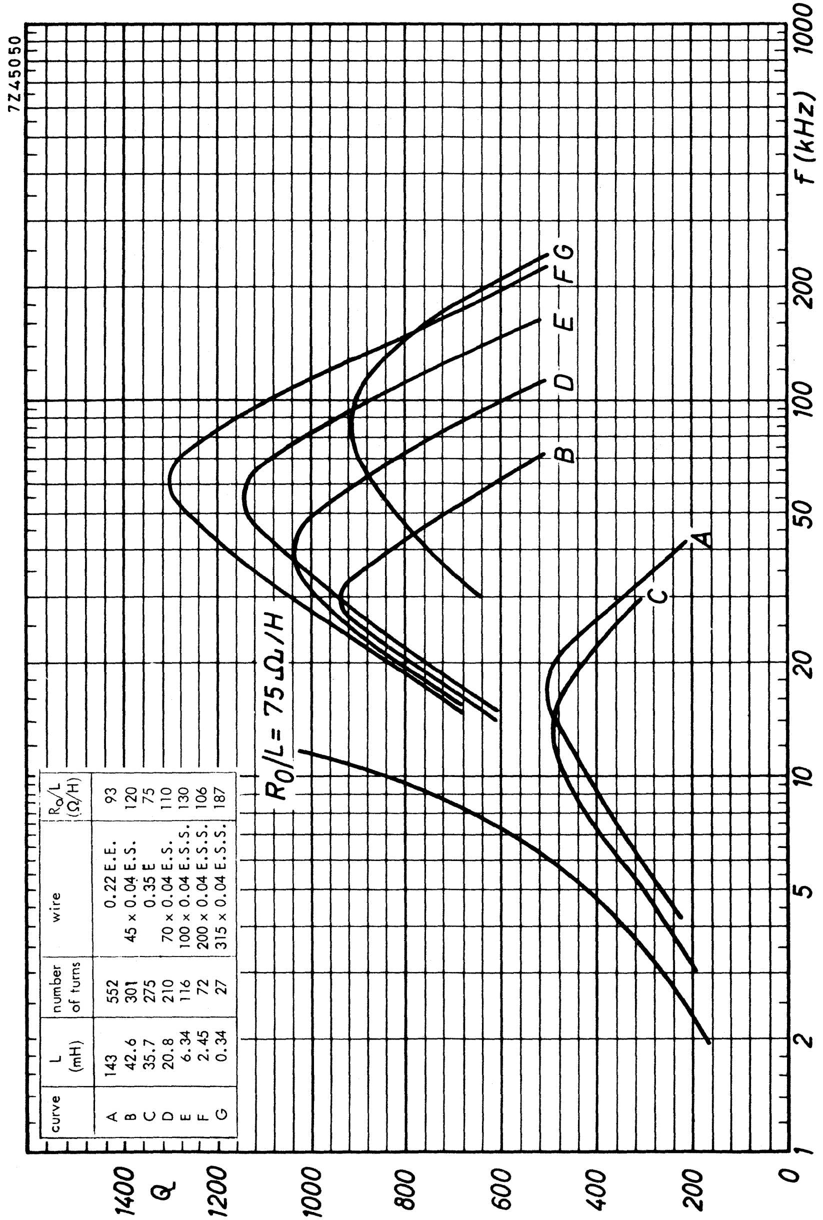
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 68$



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	96.0	552	0.22 E.E.	139
B	28.4	301	45 × 0.04 E.S.	180
C	13.9	210	70 × 0.04 E.S.	168
D	4.24	116	100 × 0.04 E.S.S.	195
E	1.63	72	200 × 0.04 E.S.S.	160
F	0.23	27	315 × 0.04 E.S.S.	280

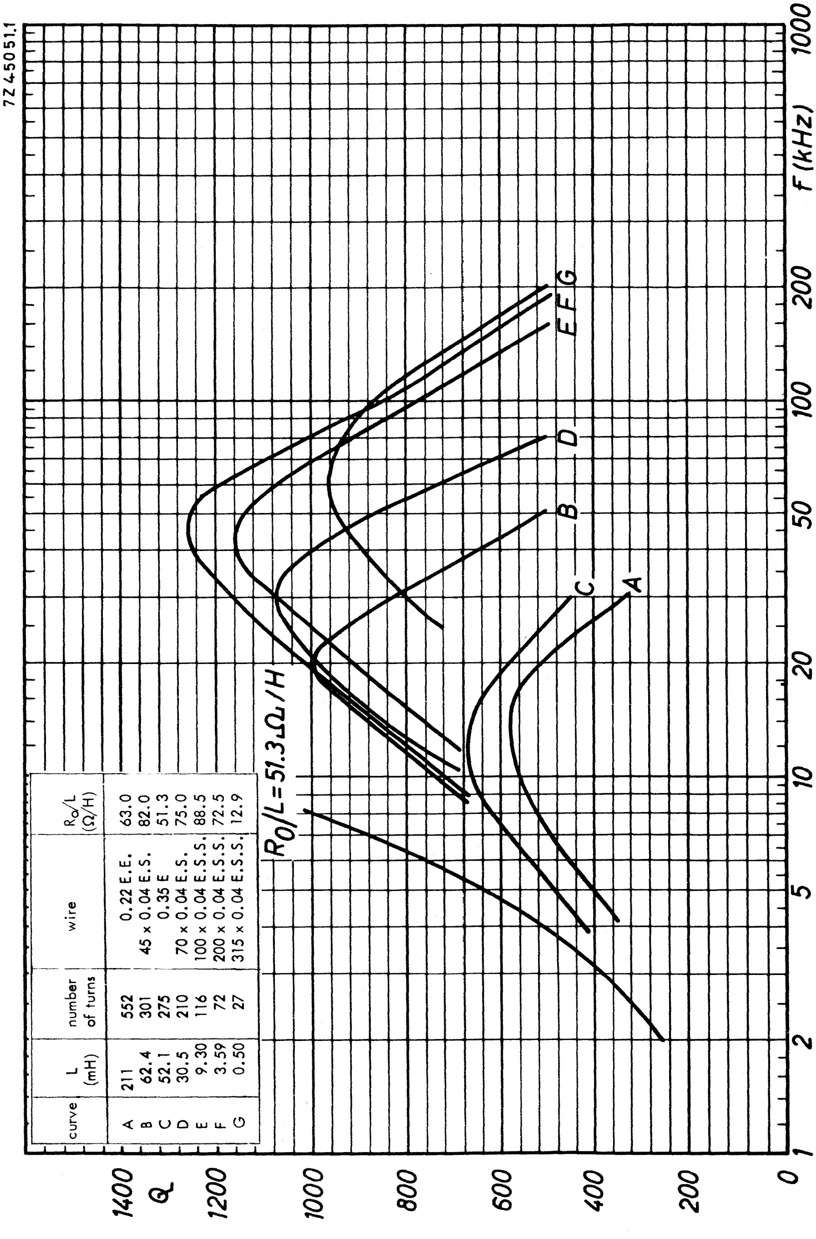
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 100$



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	143	552	0.22 E.E.	93
B	42.6	301	45 × 0.04 E.S.	120
C	35.7	275	0.35 E	75
D	20.8	210	70 × 0.04 E.S.	110
E	6.34	116	100 × 0.04 E.S.S.	130
F	2.45	72	200 × 0.04 E.S.S.	106
G	0.34	27	315 × 0.04 E.S.S.	187

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

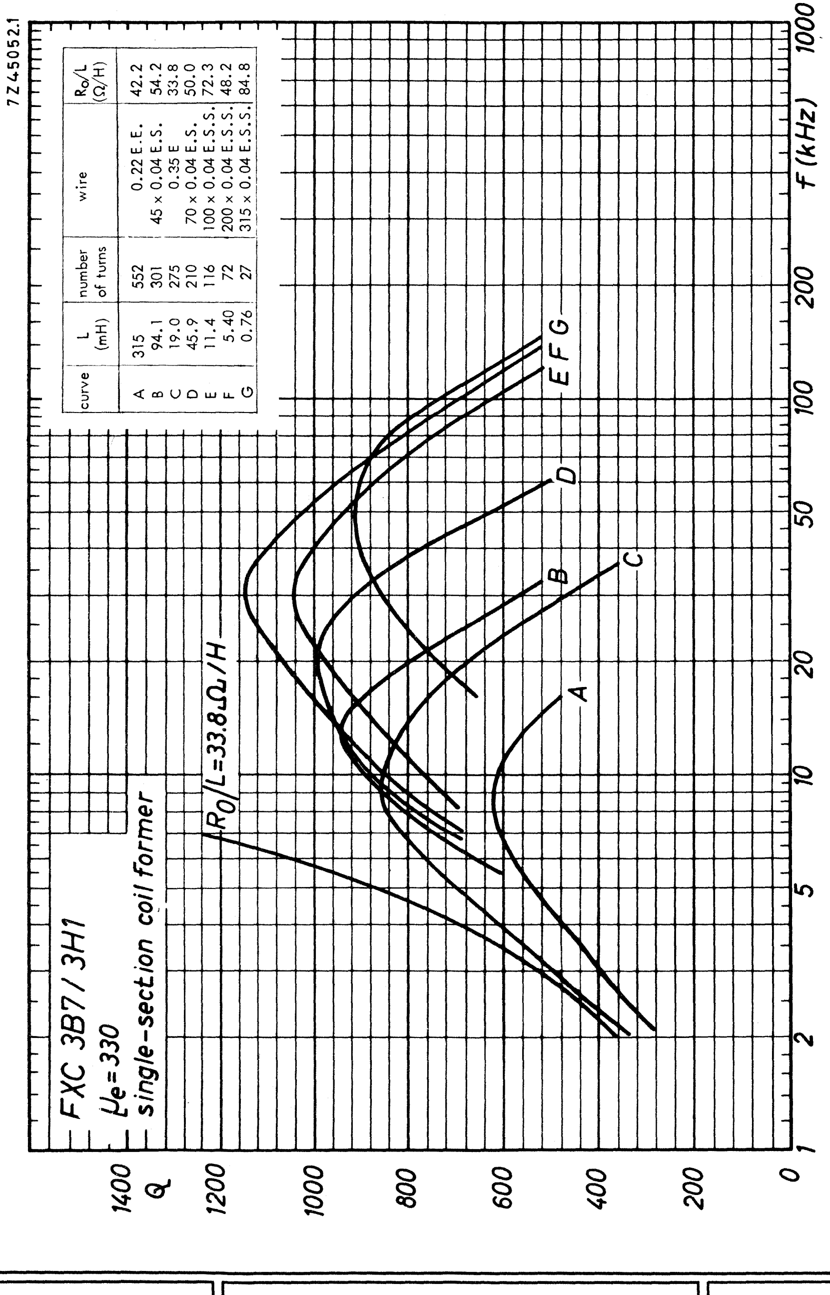
$\mu_e = 150$



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	211	552	0.22 E.E.	63.0
B	62.4	301	45 × 0.04 E.S.	82.0
C	52.1	275	0.35 E	51.3
D	30.5	210	70 × 0.04 E.S.	75.0
E	9.30	116	100 × 0.04 E.S.S.	88.5
F	3.59	72	200 × 0.04 E.S.S.	72.5
G	0.50	27	315 × 0.04 E.S.S.	12.9

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

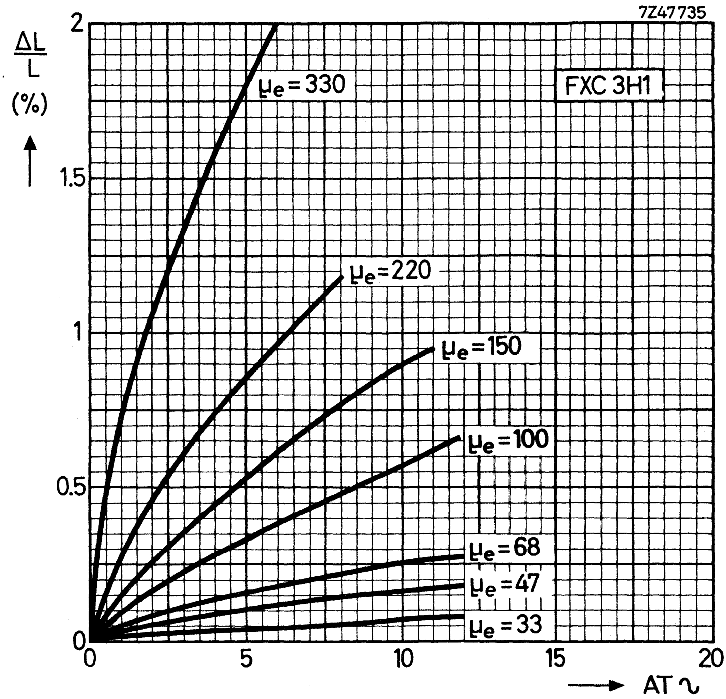
$\mu_e = 220$

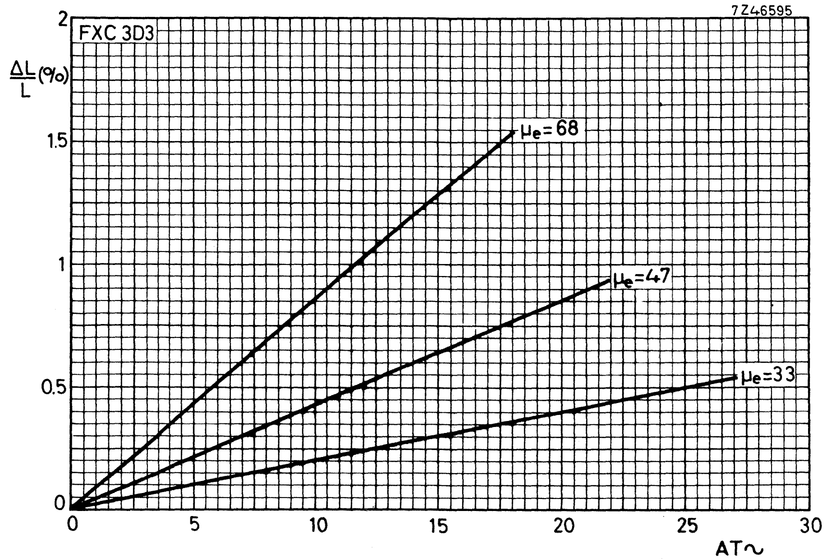


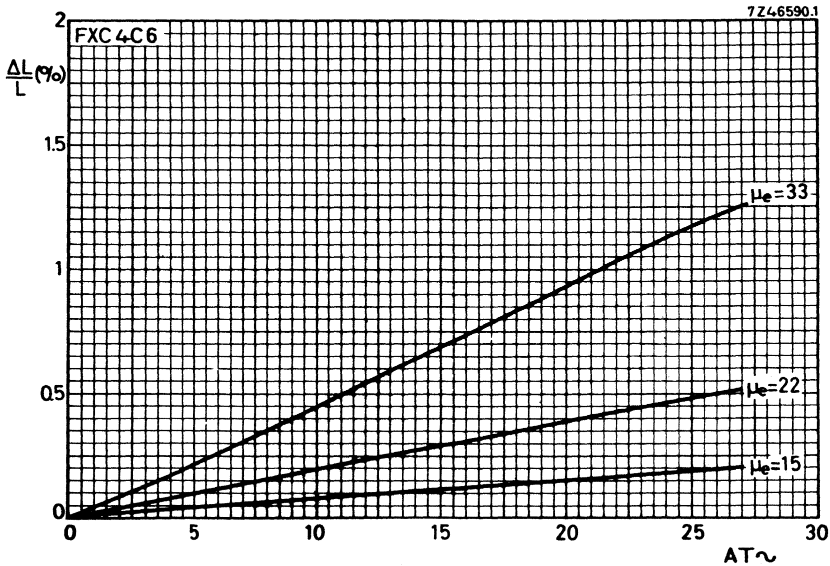
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	315	552	0.22 E.E.	42.2
B	94.1	301	45 × 0.04 E.S.	54.2
C	19.0	275	0.35 E	33.8
D	45.9	210	70 × 0.04 E.S.	50.0
E	11.4	116	100 × 0.04 E.S.S.	72.3
F	5.40	72	200 × 0.04 E.S.S.	48.2
G	0.76	27	315 × 0.04 E.S.S.	84.8

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
μ_e = 330

INDUCTANCE VARIATION AS A FUNCTION OF AT ~

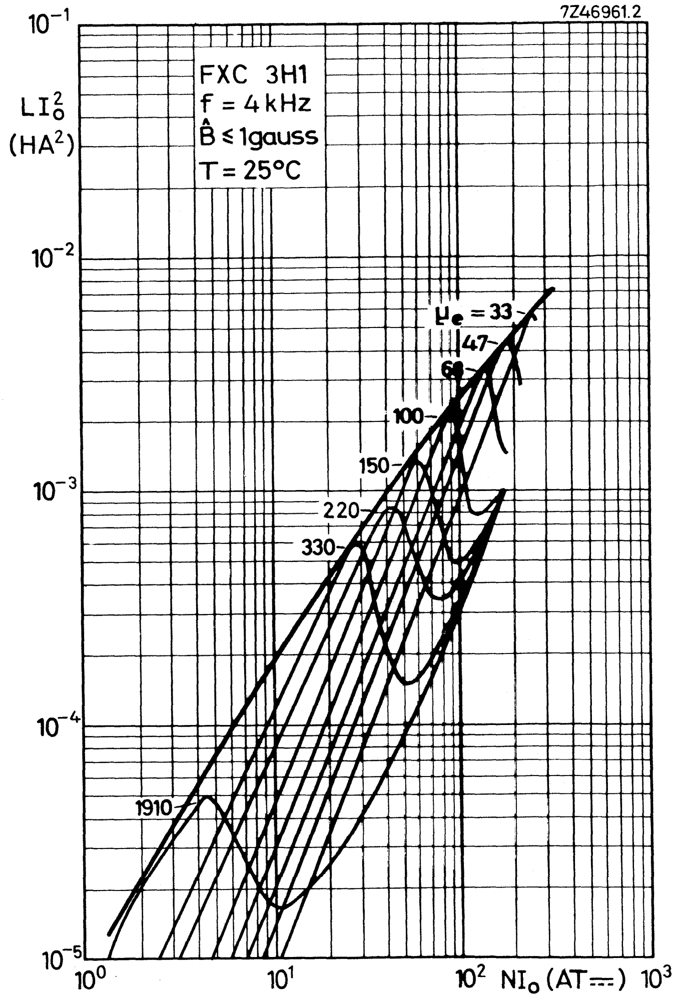



7Z46595
FXC 3D3
ΔL/L (%)
2
1.5
1
0.5
0
μe = 68
μe = 47
μe = 33
0
5
10
15
20
25
30
AT~

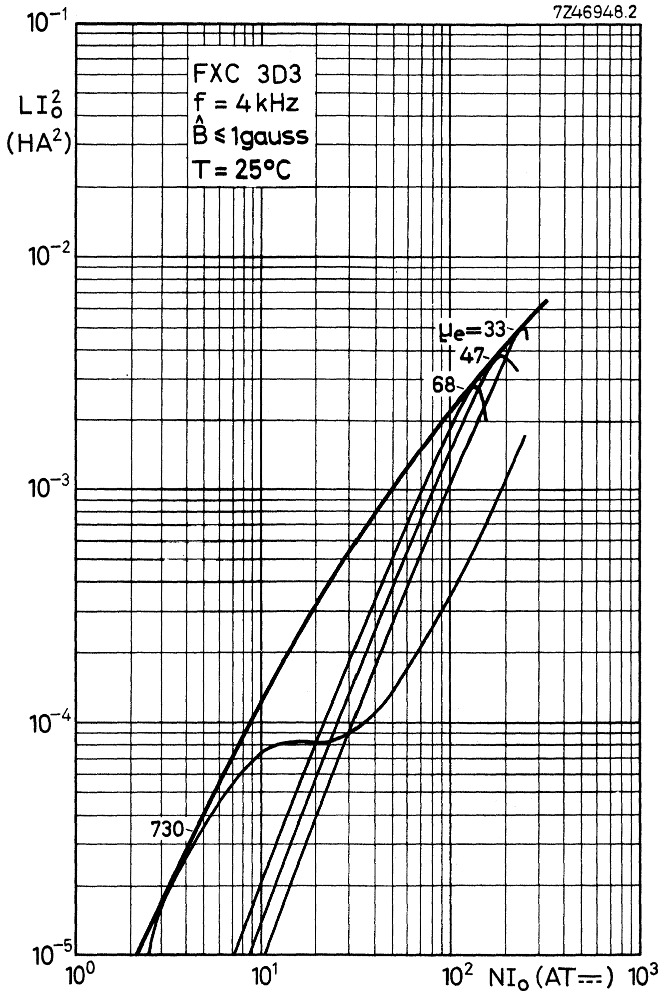

7Z46590.1
FXC 4C6
ΔL/L (%)
2
1.5
1
0.5
0
μe = 33
μe = 22
μe = 15
0
5
10
15
20
25
30
AT~

HANNA CURVES

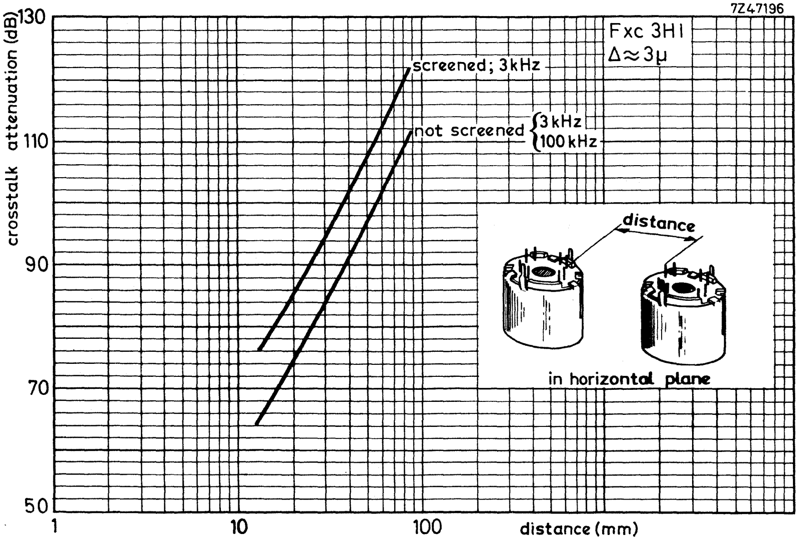
Indicating the optimum inductance for a certain μ_e-value and direct current.
Typical values.

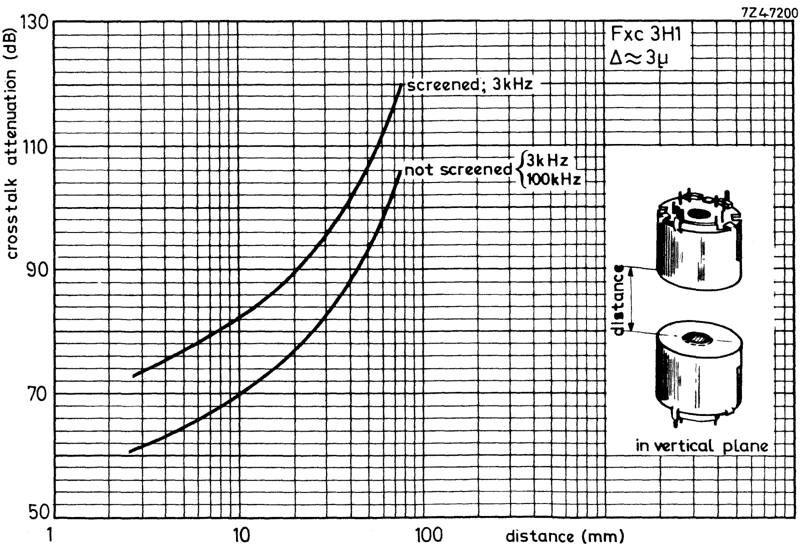


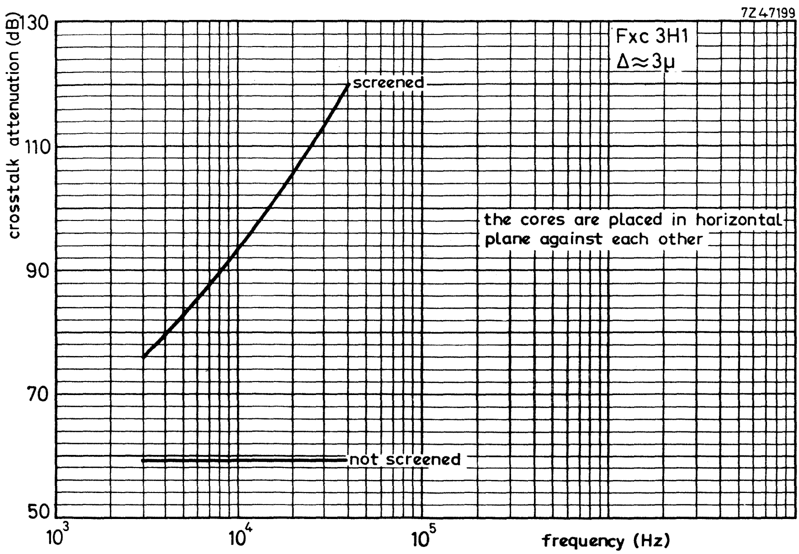
Typical values



CROSSTALK ATTENUATION






7Z47199
Fxc 3H1
Δ≈3μ
screened
not screened
the cores are placed in horizontal plane against each other
crosstalk attenuation (dB)
130
110
90
70
50
10^3
10^4
10^5
frequency (Hz)

POTCORES

INTRODUCTION

Three types of core can be supplied:

- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E6 range of values or an inductance factor (A_L) in the R5 range.
- Pre-adjusted potcores without nut.

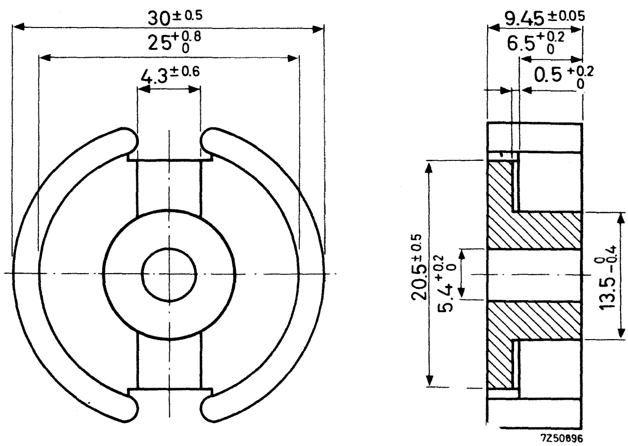
The dimensions of the potcores are in accordance with the following specifications: **I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).**

Potcores and associated parts are ordered by their 12-digit catalog number.

Quantity: a primary pack contains 10 potcore halves or 5 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 22250
3H1	4322 020 22260
3D3	4322 020 22270
improved 3E1	4322 020 22300

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (^oC)	grade			
		3B7	3H1	3D3	impr. 3E1
T.F. x 10^6	+5 to +23	–	+0.5 to +1.5	–	
	+23 to +55	–	+0.5 to +1.5	–	
	+23 to +70	-0.6 to +0.6	+0.5 to +1.5*	0 to +2	
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 12	

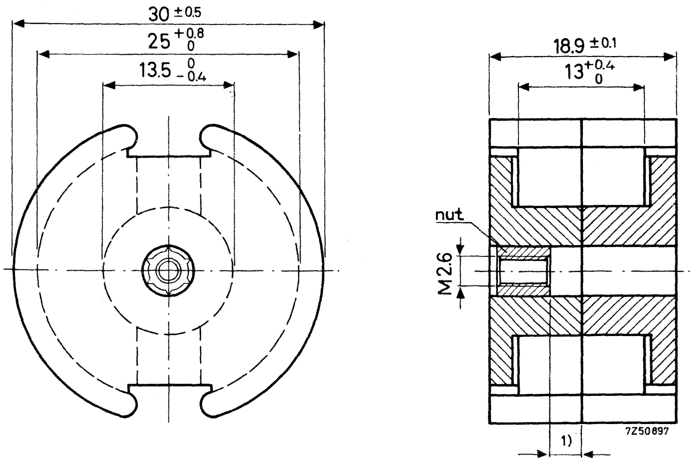
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 250 Newton, the values in Table II are guaranteed at 25 ± 10 ^oC.

Table II	$\hat{B}$ (Gs)	freq. (kHz)	grade			
			3B7	3H1	3D3	impr. 3E1
μ_e	≤ 1	4	≥ 1490	≥ 1490	–	2400-4000
	≤ 1	100	–	–	≥ 555	–
α	≤ 1	4	≤ 13.3*	≤ 13.3*	–	–
	≤ 1	100	–	–	≤ 21.7*	–
A_L	≤ 1	4	–	–	–	9000-15 225
$\frac{\tan\delta}{\mu_i}$ x 10^6	≤ 1	4	≤ 1.2	≤ 1.2	–	≤ 2.5
	≤ 1	100	≤ 6	≤ 6	≤ 8	≤ 20
	≤ 1	500	–	–	≤ 16	–
	≤ 1	1000	–	–	≤ 40	–
$q_{2-24-100}$	15-30	4	≤ 1.8	≤ 1	–	≤ 3.0
	3-12	100	–	–	≤ 3.0	–

*) For guidance only.

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 3. . . .
Without nut, catalog number = 4322 022 1. . . .

Weight = 34 g

Effective length l_e = 4.52 cm

$\Sigma \frac{l_e}{A_e}$ = 3.30 cm^{-1}

Effective volume V_e = 6.19 cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 33, grade 3D3, potcore with nut, catalog number = 4322 022 30430
   A_L = 400, grade 3B7 , potcore without nut, catalog number = 4322 022 11080
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

1) For this distance see adjustment curves under Inductance Adjustment.

Potcores with standard μ_e values [1])

μ_e	α	tolerance on inductance (%)	catal. No. 4322 022 3.... with nut / 4322 022 1.... without nut		
			3B7	3H1	3D3
33	89.2	± 1	0030	0230	0430
47	74.7	± 1	-	-	0440
68	62.1	± 1	0050	0250	0450
100	51.3	± 1.5	0060	0260	-
150	41.8	± 2	0070	0270	-
220	34.6	± 3	0080	0280	-
330	28.2	± 3	0090	0290	-
740	18.9	± 25	-	-	0400*
1990	11.5	± 25	0000*	0200*	-

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

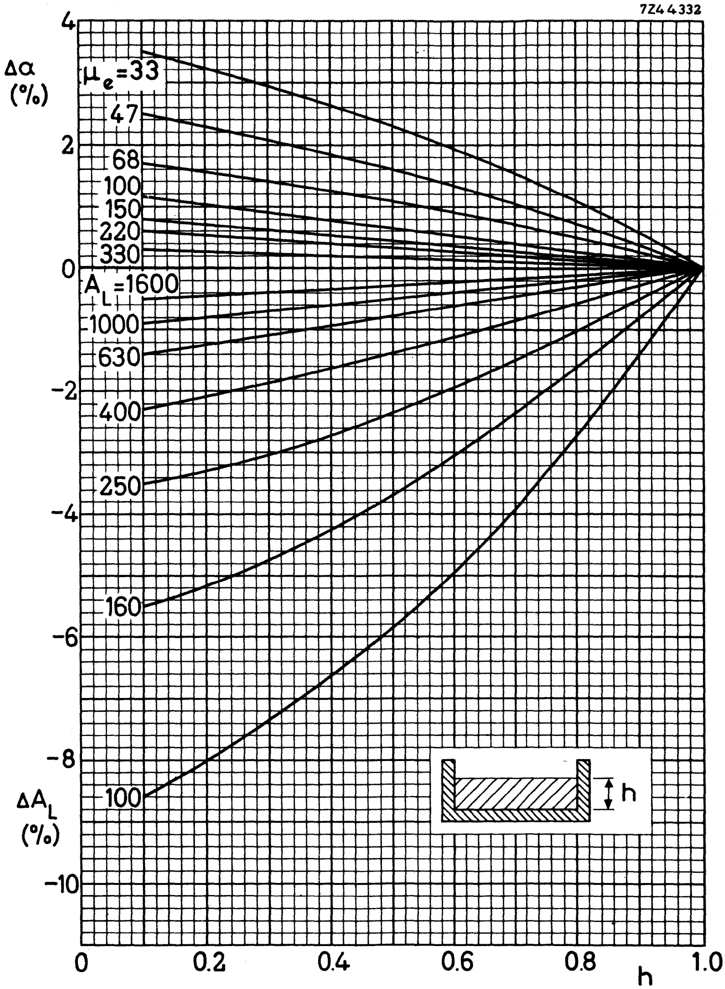
Potcores with standard A_L factors [1])

A_L	corresponding μ_e-value	tolerance on inductance (%)	catal. No. 4322 022 3.... with nut / 4322 022 1.... without nut		
			3B7	3H1	3D3
100	26.2	± 1	-	-	1440
160	42	± 1	-	-	1450
250	65.5	± 1	1060	1260	1460
400	105	± 1.5	1080	1280	-
630	165	± 2	1100	1300	-
1000	263	± 3	1110	1310	-
1600	420	± 3	1120	1320	-

Inductance $L = N^2 A_L$ (in 10^{-9} H)

[1]) See notes on the previous page.
*) Only available without nut.

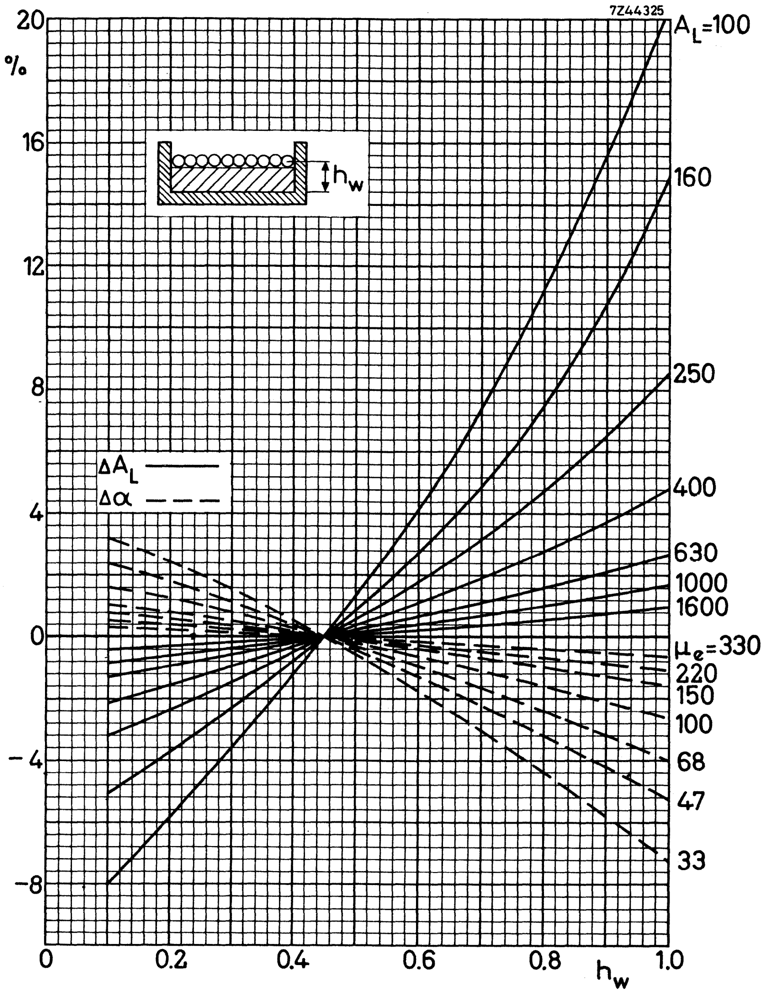
DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3.

Example: On a single-section coil former only 0.4 part of the available height is used. A potcore with μ_e = 68 in that case obtains an α factor of 62.1 + 1.25%.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_W on a single-section coil former.
Valid for ferroxcube 3B7, 3H1 and 3D3.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 68 obtains for that winding an α factor of 62.1 - 1.6%.

COIL FORMERS

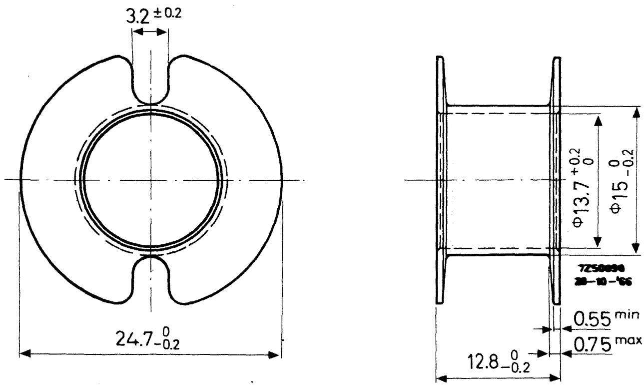
GENERAL

Three types of coil former can be supplied:

- with one section
- with two sections
- with three sections

The dimensions conform with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-02 (France) and D.I.N. 41 294 (Germany).
The dimensions in the drawings are in mm.

SINGLE-SECTION COIL FORMER



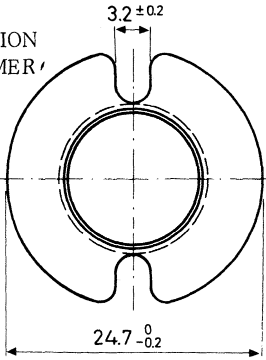
Catalog number	4322 021 30360
Material	glassfibre-reinforced polyacetal
Window area	55 mm^2
Mean length of turn	6.2 cm
Max. temperature	130 °C

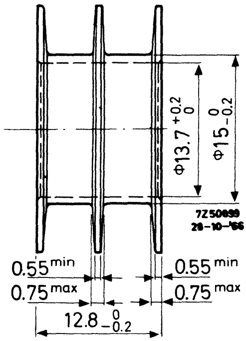
D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 5.07 \times 10^3 \ \Omega/H$$

Weight 0.75 g

TWO-SECTION
COIL FORMER





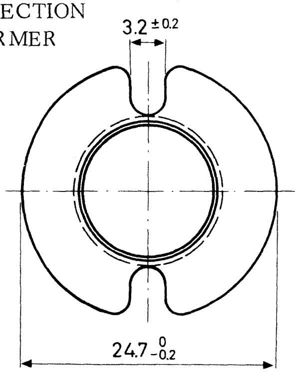
Catalog number	4322 021 30370
Material	glassfibre-reinforced polyacetal
Window area	2 x 26 mm^2
Mean length of turn	6.2 cm
Max. temperature	130 °C

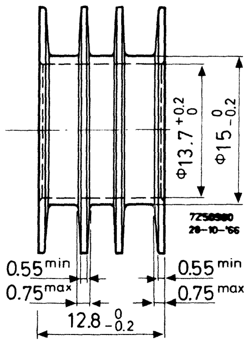
D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 5.38 \times 10^3 \ \Omega/H$$

Weight 1.0 g

THREE-SECTION
COIL FORMER





Catalog number	4322 021 30380
Material	glassfibre-reinforced polyacetal
Window area	3 x 16 mm^2
Mean length of turn	6.2 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 5.74 \times 10^3 \ \Omega/H$$

Weight 1.2 g

INDUCTANCE ADJUSTORS

CONTINUOUS ADJUSTORS

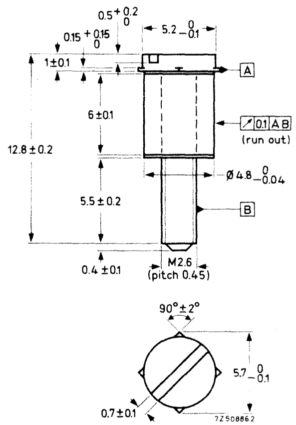


Fig. A

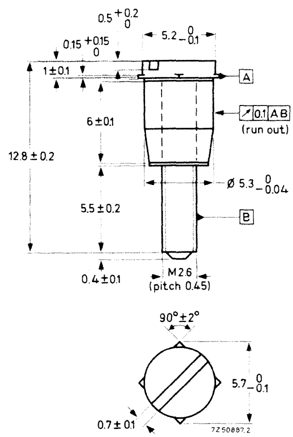


Fig. B

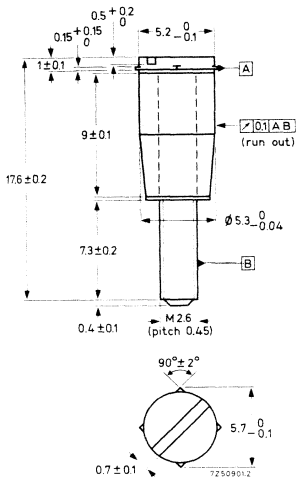


Fig. C

The tolerances on inductance of the pre-adjusted potcores (with adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.

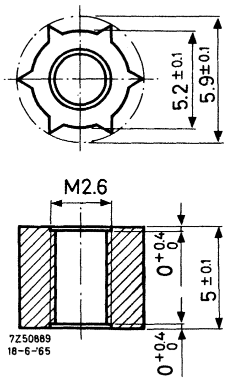
Types of adjustor and recommended applications.

Fig.	colour	catalogue number 4322 021	potcore	
			μ_e	A_L
A	green	30780	33	100
A	red	30800	47	160
B	white	30980	68	250
B	white	30980	100	400
A	brown	30810	150	630
B	grey	31090	220	1000
C	black	31120	330	1600

The adjustors are packed in bags of 100, so please order in multiples of 100.

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

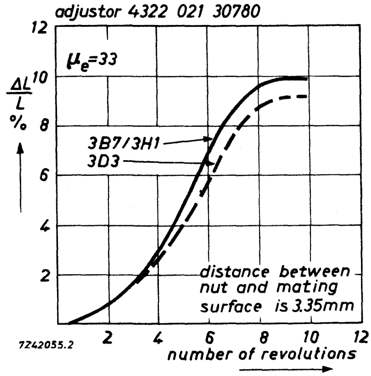


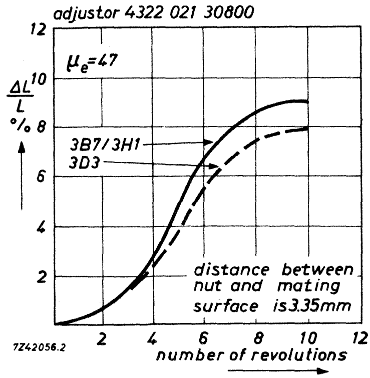
Catalogue number	4322 021 30160
Material	polycarbonate
Max. impregnation temperature for 24 hours	120 °C
Recommended distance from mating surface to nut (see Adjustment curves)	3.35 ± 0.15 mm or 4.35 ± 0.15 mm

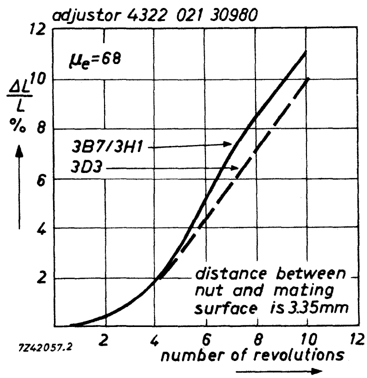
For more information see Potcores General, Mounting data.

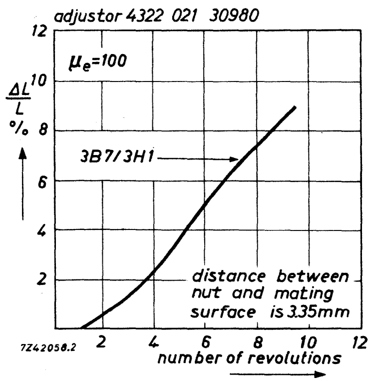
The nuts are packed in bags of 100, so please order in multiples of 100

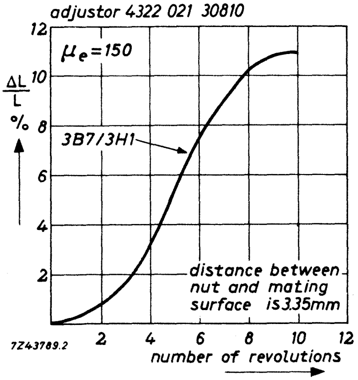
ADJUSTMENT CURVES

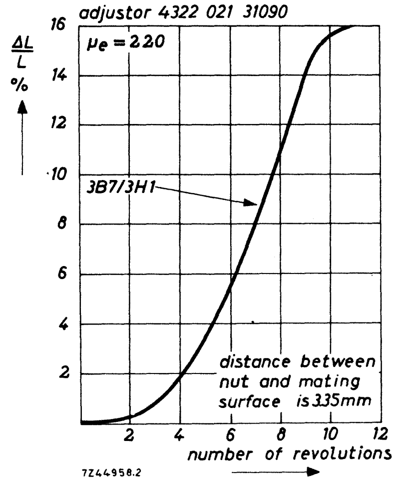


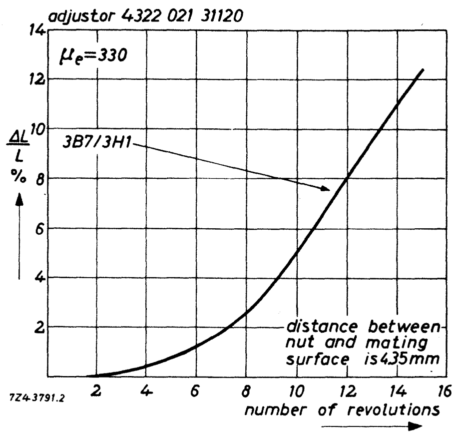







adjustor 4322 021 30810
μ_e=150
ΔL/L %
3B7/3H1
distance between nut and mating surface is 3.35mm
number of revolutions
7Z43789.2

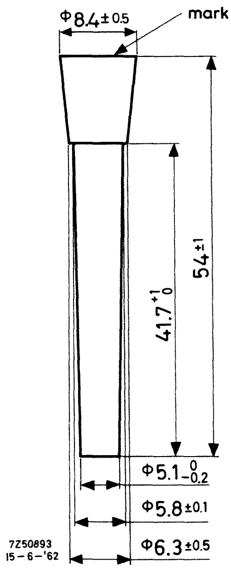

adjustor 4322 021 31090
μ_e=220
ΔL/L %
3B7/3H1
distance between nut and mating surface is 3.35mm
number of revolutions
7Z44958.2

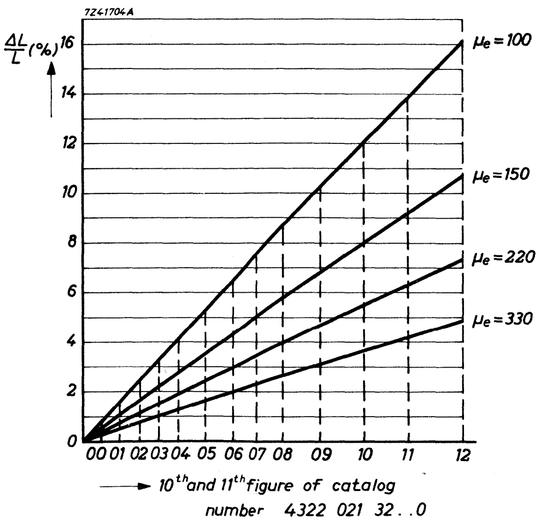

adjustor 4322 021 31120
μ_e=330
ΔL/L %
3B7/3H1
distance between nut and mating surface is 4.35mm
number of revolutions
7Z43791.2

STEP-BY-STEP ADJUSTORS

These adjustors are used when a continuous adjustment of the inductance is not necessary. For instance, they are applied in loading coils to bring the inductance within a certain tolerance field. They are not suitable for adjusting the inductance to an exact value, as is usually necessary in filters. The increment of the losses caused by these adjustors is negligible.
A range of 13 flexible conical adjustors is available under the catalog numbers 4322 021 32000 up to 021 32120. Each adjustor causes an increase in the inductance; the higher the catalog number, the greater the effect. The influence of each adjustor on the inductance at different μ_e values of the potcore can be found from the graph.
The 10th and 11th figure of the catalog number are indicated on the head of the adjustor. It should be borne in mind that, when using these adjustors, the inductance of the coil should initially be lower than the wanted value.
When the correct adjustor has been found, it is inserted in the centre hole of the pot. An adhesive (for instance Pliobond of Good Year) is used as sliding and fixing material. After fixing the protruding ends are cut off.

The maximum impregnation temperature is 150 °C.
The maximum working temperature is 90 °C.
Material: rubber with powder iron.

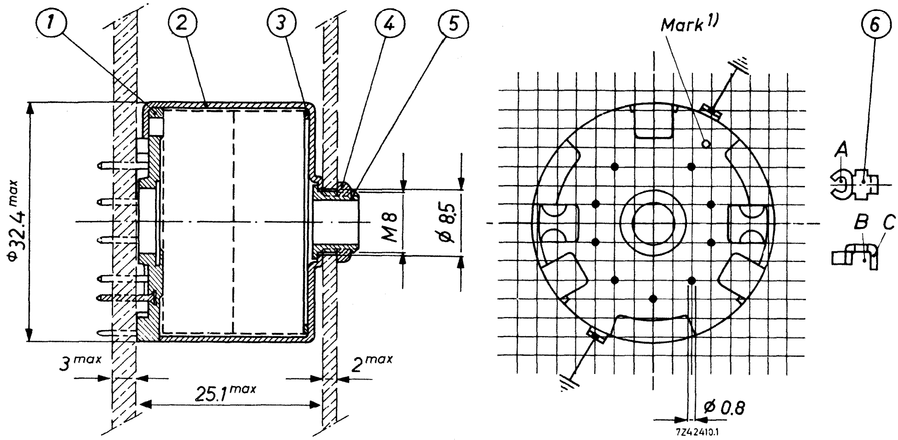




Dimensions in mm

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30480	(4) nut	4322 021 30710
(2) brass container	4322 021 30560	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30670	(6) soldering spring	4322 021 30700 (9x)

The core is suitable for mounting on printed-wiring boards and on conventional panels.

The parts 1, 2, 3 (and 6) are sufficient to construct an assembly for use in combination with printed wiring.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin: then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The nine soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3 ± 0.1 mm diameter.

[1]) There is another mark in a similar position on the top of the container.

If one-hole mounting is preferred, the parts 4 and 5 should be added. The coil assembly may then be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

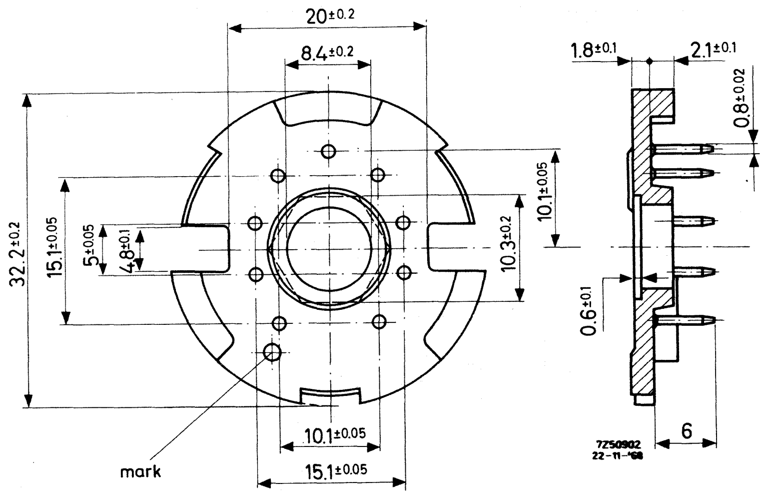
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 250 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

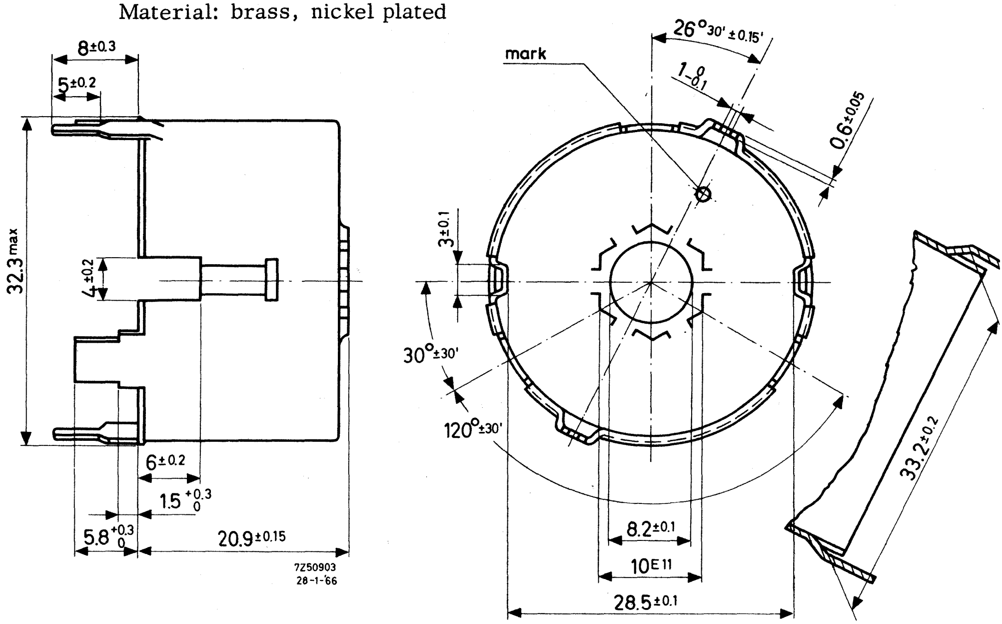
(1) Tag plate 4322 021 30480

Plate: reinforced polyester
Pins : phosphorbronze, dipsoldered



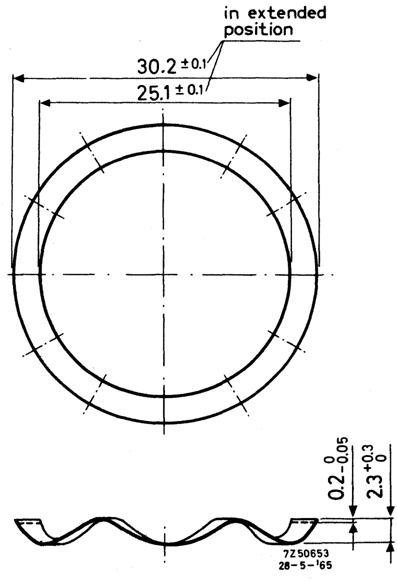
(2) Container 4322 021 30560

Material: brass, nickel plated



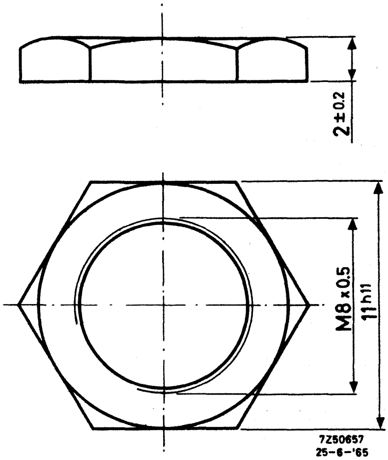
(3) Spring 4322 021 30670

Material: steel



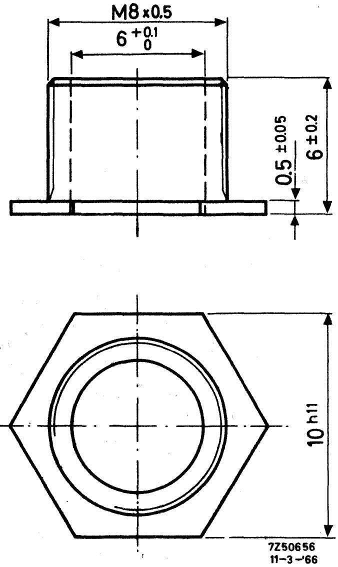
(4) Nut 4322 021 30710

Material: brass, nickel plated



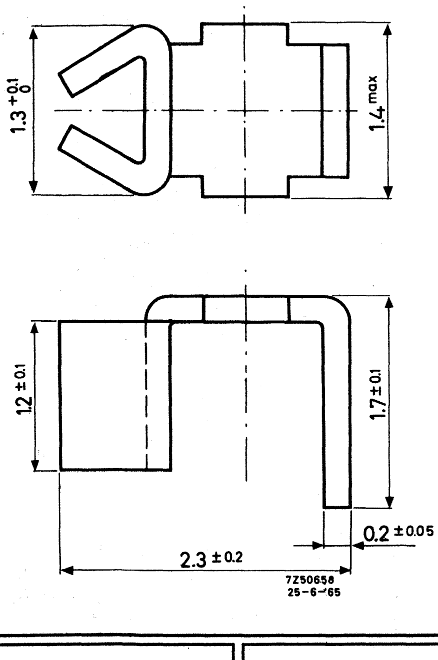
(5) Fixing bush 4322 021 30720

Material: brass, nickel plated



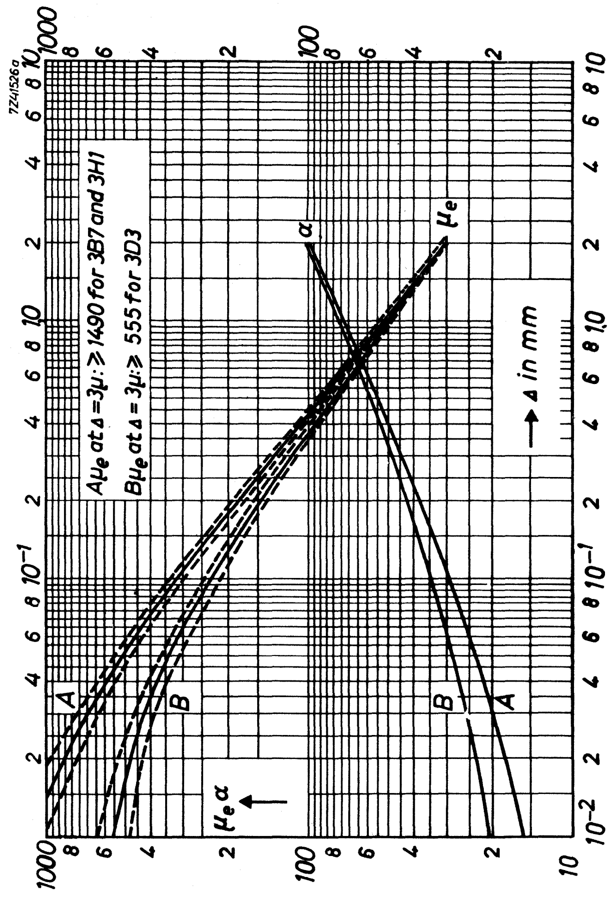
(6) Soldering spring 4322 021 30700

Material: brass, dipsoldered



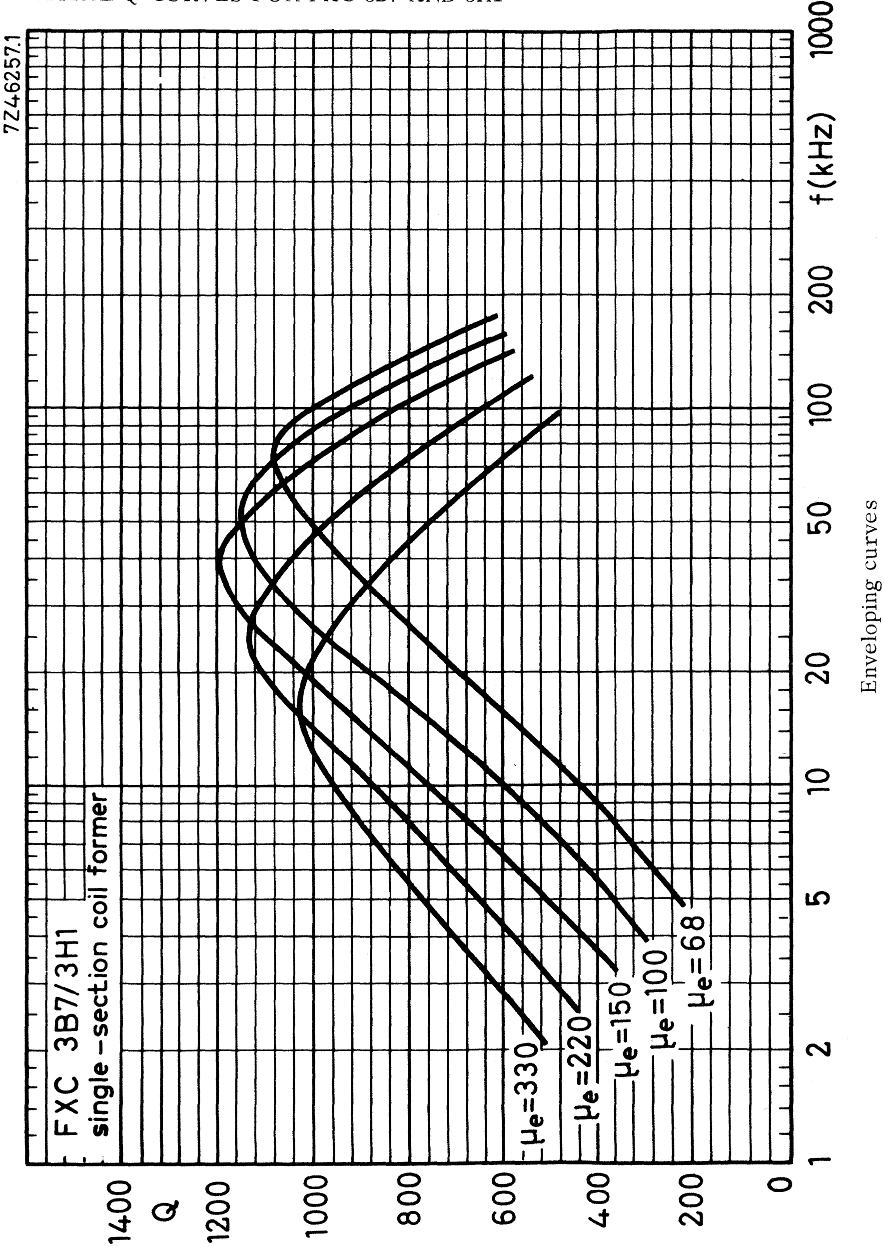
CHARACTERISTIC CURVES

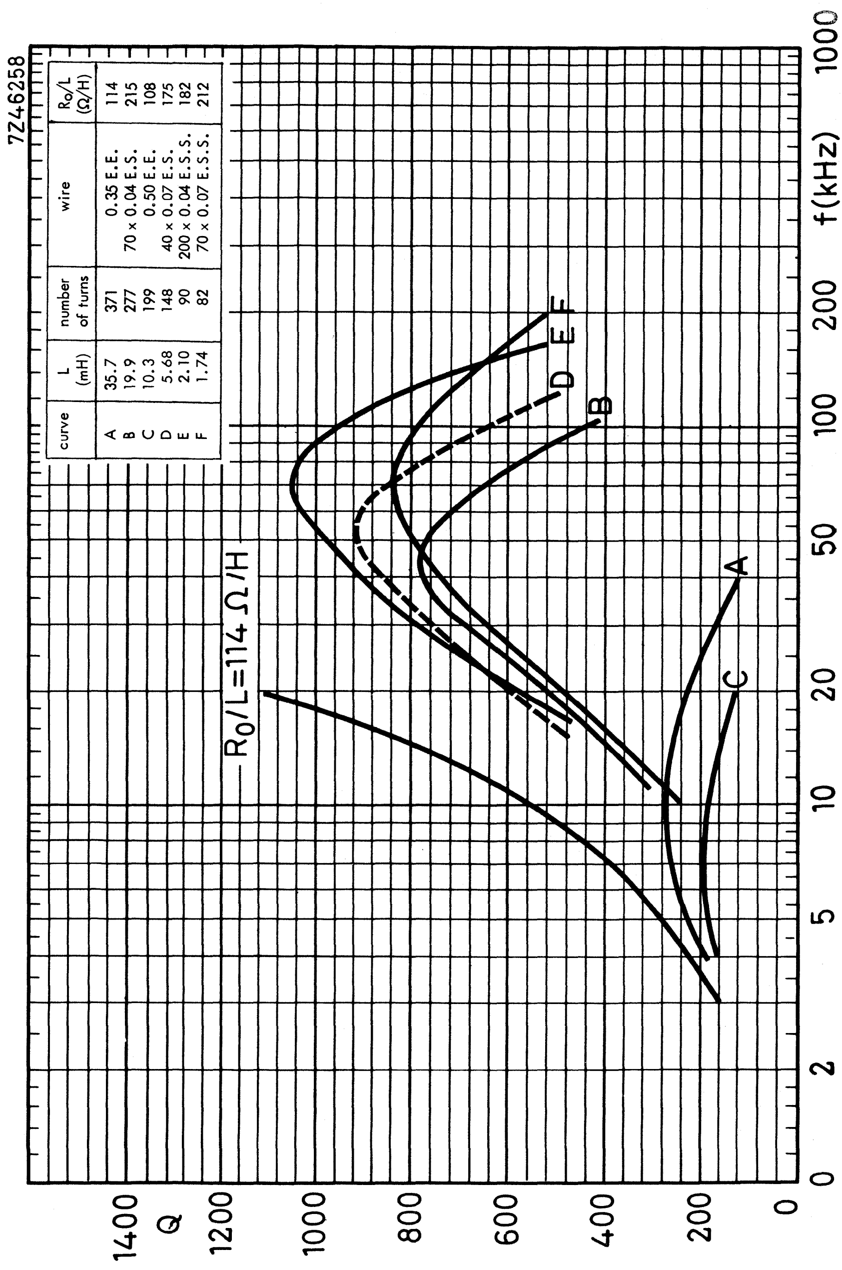
μ_e-α CURVES



Relative effective permeability and turn factor for 1 mH as a function of the air gap length.

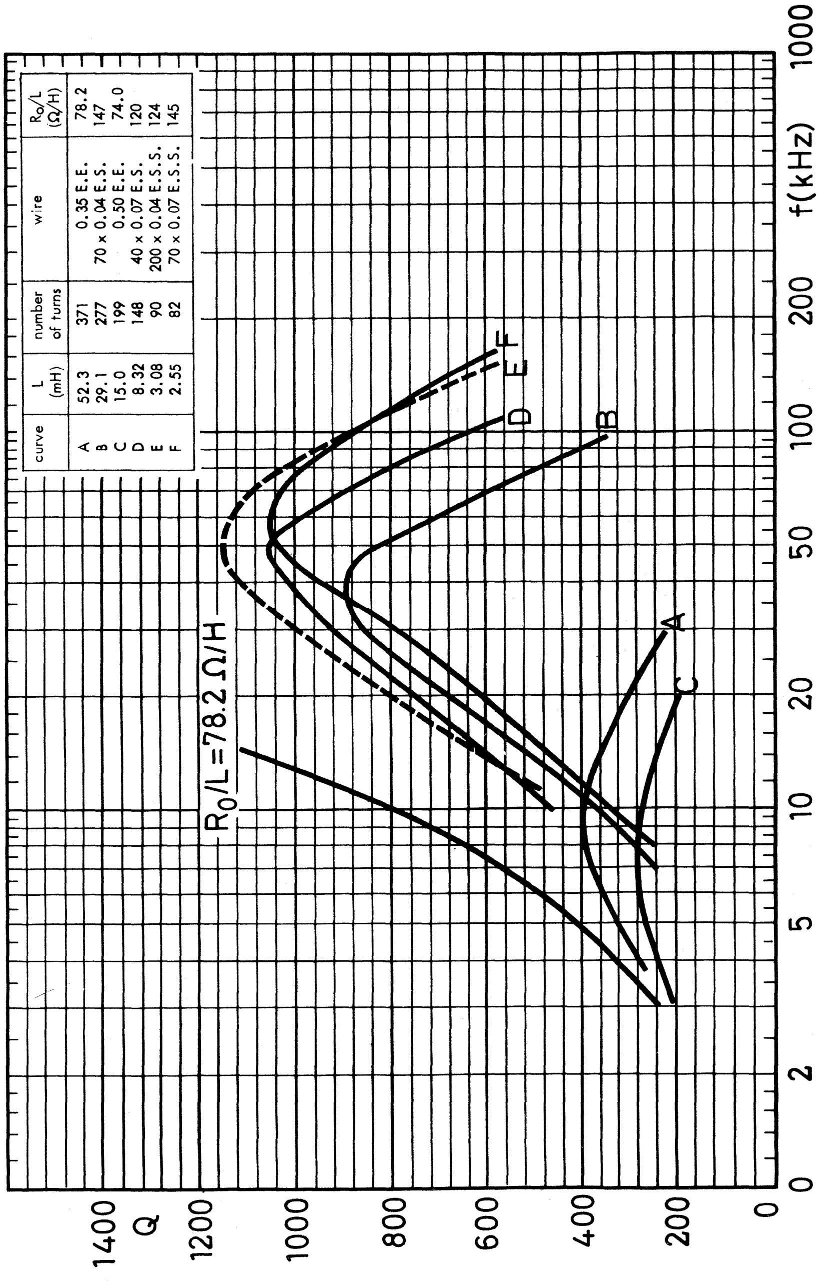
TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1





curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	35.7	371	0.35 E.E.	114
B	19.9	277	70 × 0.04 E.S.	215
C	10.3	199	0.50 E.E.	108
D	5.68	148	40 × 0.07 E.S.S.	175
E	2.10	90	200 × 0.04 E.S.S.	182
F	1.74	82	70 × 0.07 E.S.S.	212

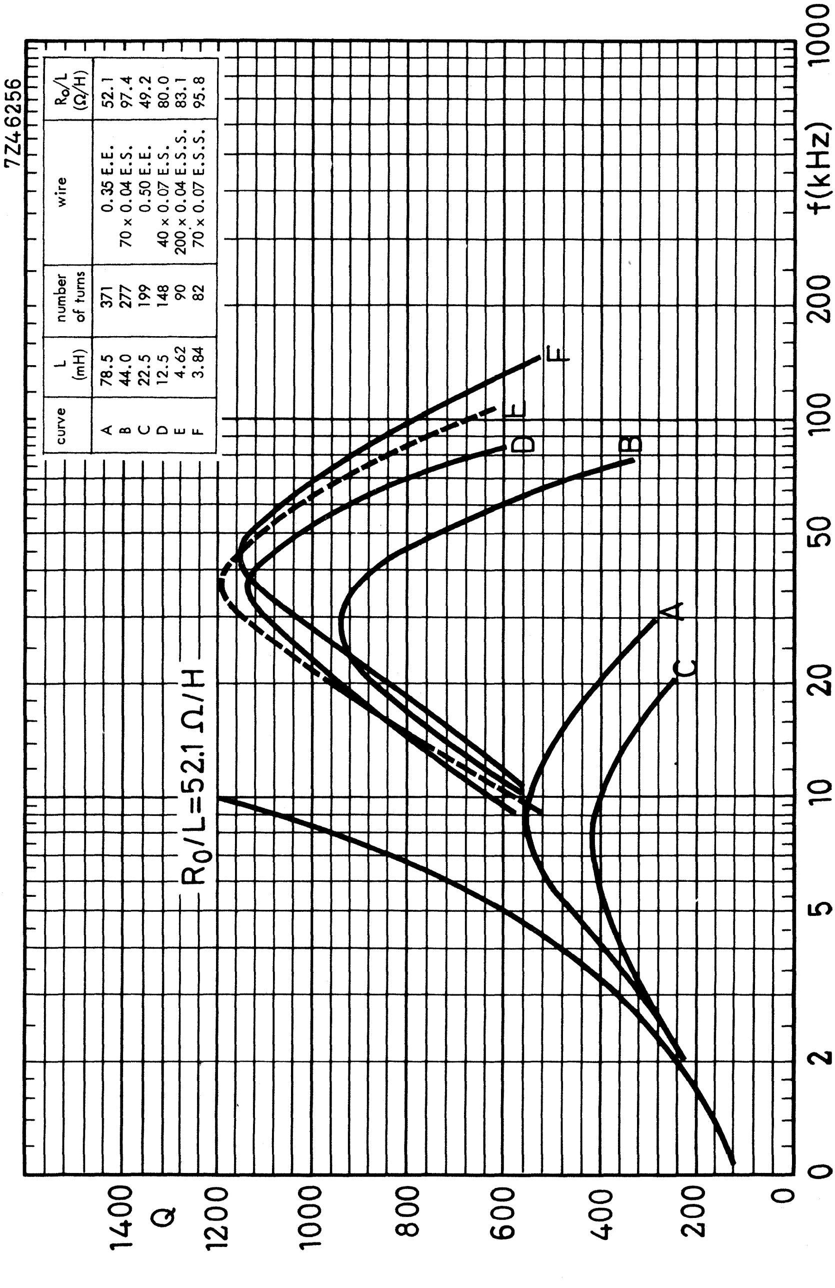
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 68$



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	52.3	371	0.35 E.E.	78.2
B	29.1	277	70 × 0.04 E.S.	147
C	15.0	199	0.50 E.E.	74.0
D	8.32	148	40 × 0.07 E.S.	120
E	3.08	90	200 × 0.04 E.S.S.	124
F	2.55	82	70 × 0.07 E.S.S.	145

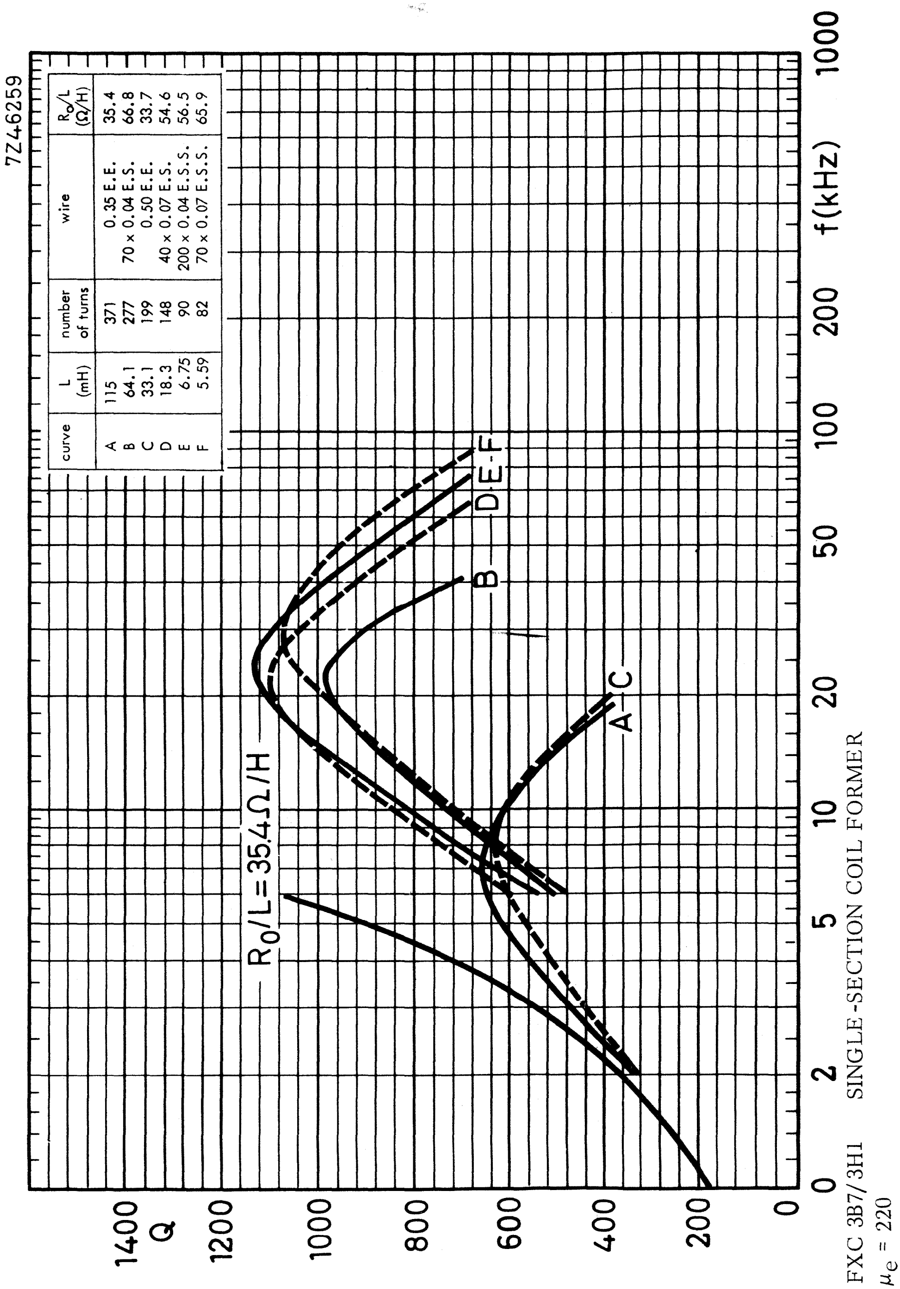
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 100$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	78.5	371	0.35 E.E.	52.1
B	44.0	277	70 × 0.04 E.S.	97.4
C	22.5	199	0.50 E.E.	49.2
D	12.5	148	40 × 0.07 E.S.	80.0
E	4.62	90	200 × 0.04 E.S.S.	83.1
F	3.84	82	70 × 0.07 E.S.S.	95.8

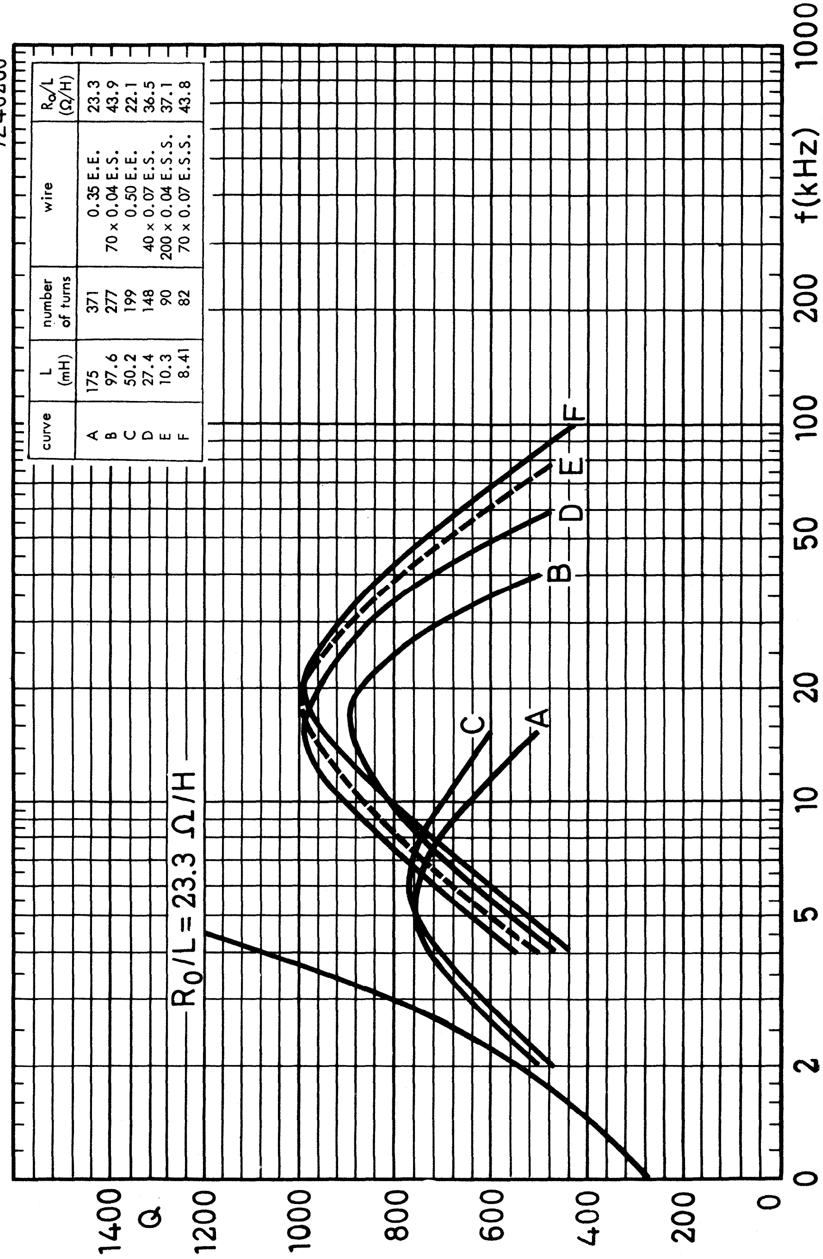
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
μ_e = 150



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	115	371	0.35 E.E.	35.4
B	64.1	277	70 × 0.04 E.S.	66.8
C	33.1	199	0.50 E.E.	33.7
D	18.3	148	40 × 0.07 E.S.	54.6
E	6.75	90	200 × 0.04 E.S.S.	56.5
F	5.59	82	70 × 0.07 E.S.S.	65.9

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

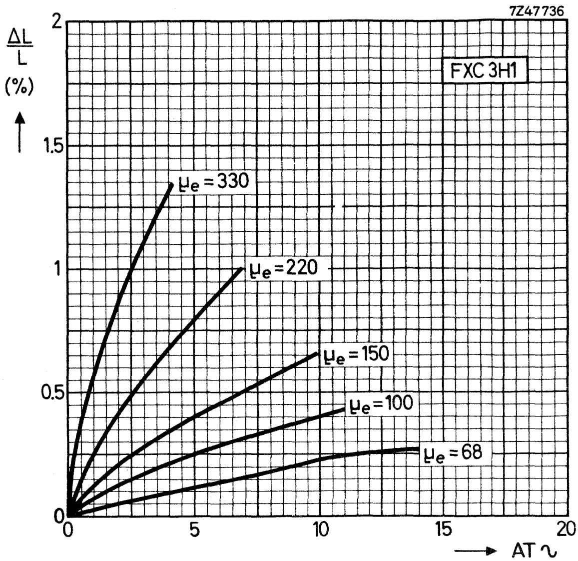
$\mu_e = 220$

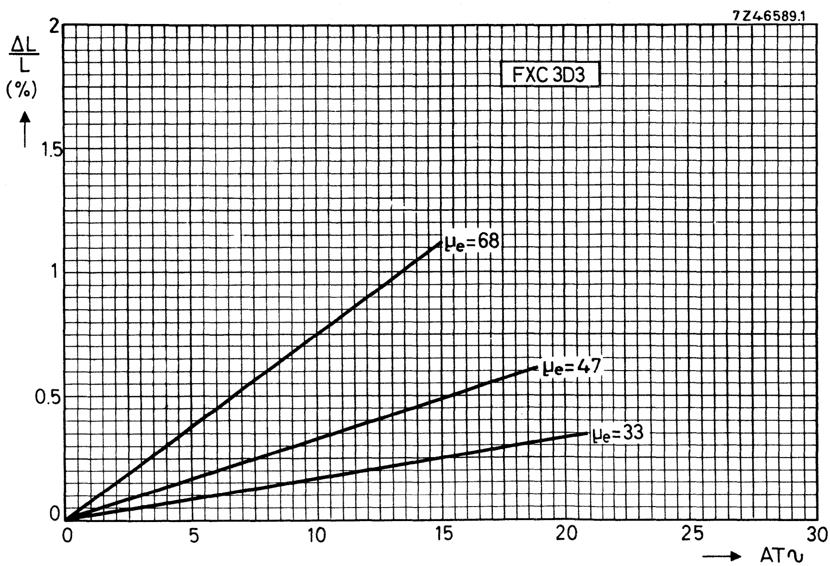


curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	175	371	0.35 E.E.	23.3
B	97.6	277	70 × 0.04 E.S.	43.9
C	50.2	199	0.50 E.E.	22.1
D	27.4	148	40 × 0.07 E.S.	36.5
E	10.3	90	200 × 0.04 E.S.S.	37.1
F	8.41	82	70 × 0.07 E.S.S.	43.8

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 330$

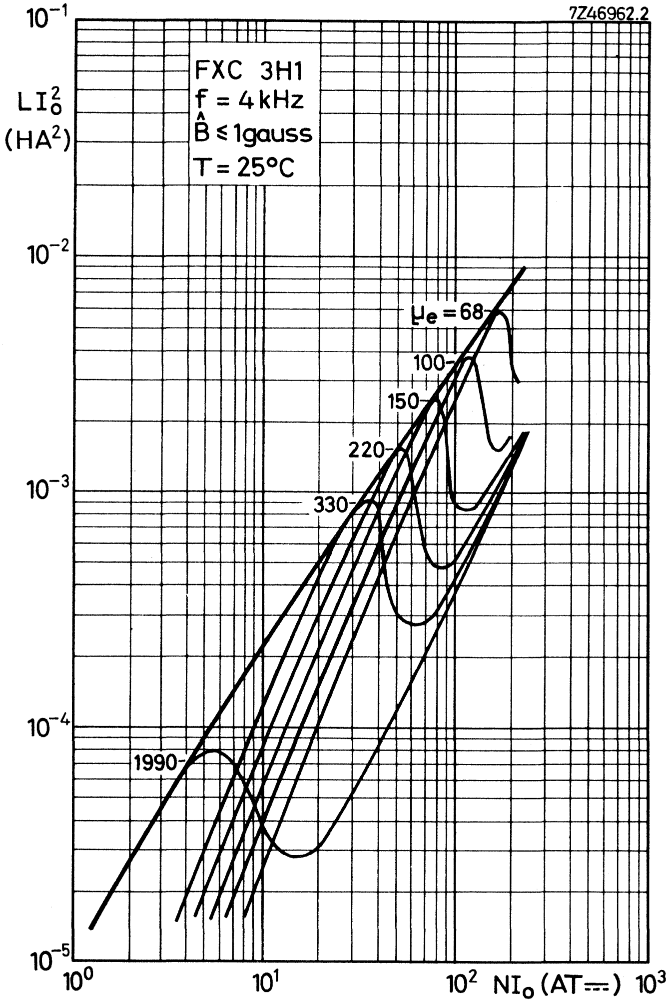
INDUCTANCE VARIATION AS A FUNCTION OF AT~

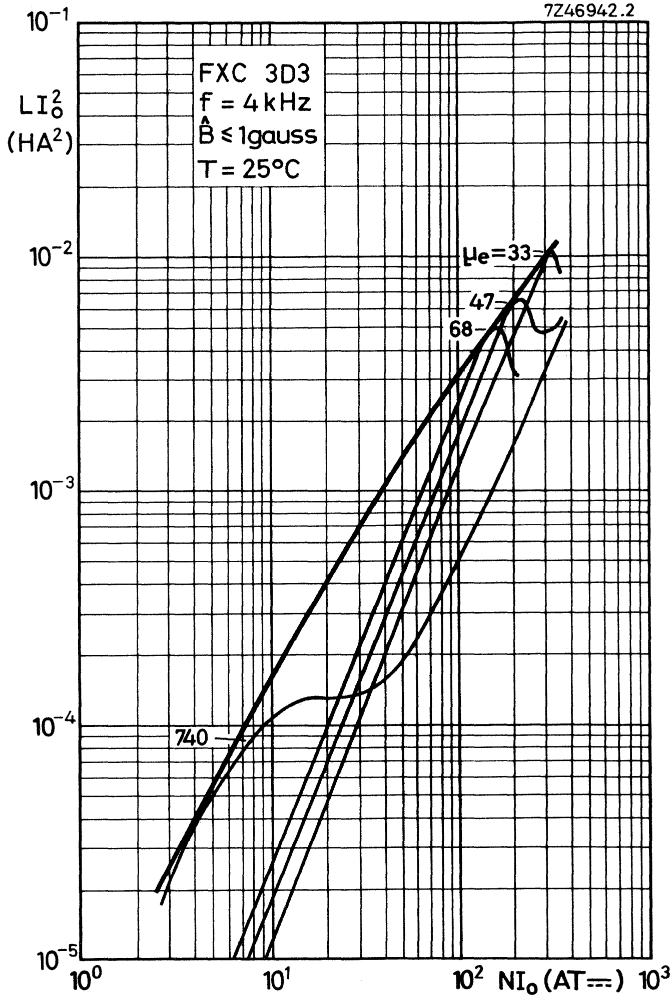




HANNA CURVES

Indicating the optium inductance for a certain μ_e-value and direct current.
Typical values.




7Z46942.2
LI_o^2
(HA^2)
FXC 3D3
f = 4 kHz
$\hat{B}$ ≤ 1gauss
T = 25°C
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
μ_e = 33
47
68
740
10^0
10^1
10^2
NI_o (AT ⎓)
10^3

POTCORES

INTRODUCTION

Three types of core can be supplied:

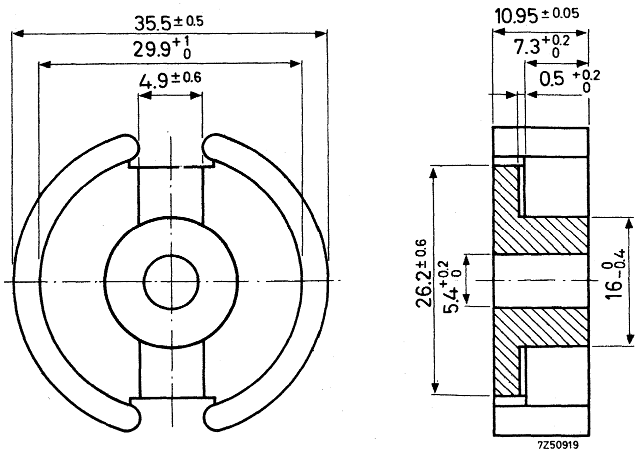
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E_6 range of values or an inductance factor (A_L) in the R_5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).

Potcores and associated parts are ordered by their 12-digit catalog number.
Quantity: a primary pack contains 8 potcore halves or 4 pieces of pre-adjusted potcore, so please order in multiples of these quantities.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B7	4322 020 22500
3H1	4322 020 22510
3D3	4322 020 22520

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (°C)	grade		
		3B7	3H1	3D3
T.F. x 10^6	+5 to +23		+0.5 to +1.5	
	+23 to +55		+0.5 to +1.5	
	+23 to +70	-0.6 to +0.6	1)	0 to +2
D.F. x 10^6 (10-100 min)	23 + 1	≤ 4.3	≤ 4.3	≤ 12

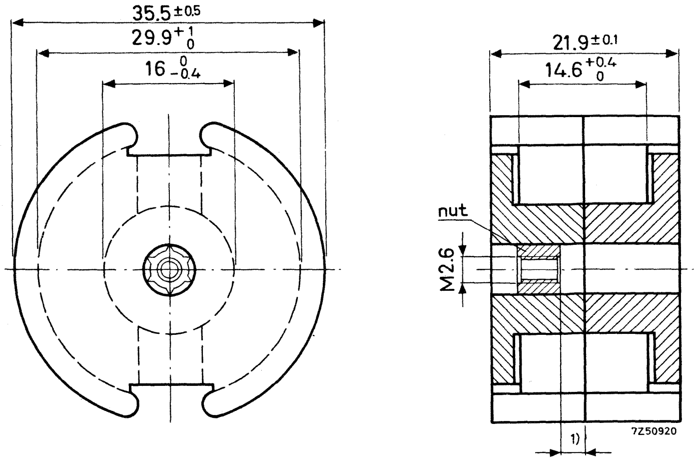
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 350 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II	$\hat{B}$ (Gs)	freq. (kHz)	grade		
			3B7	3H1	3D3
μ_e	≤ 1	4	≥ 1520	≥ 1520	
	≤ 1	100			≥ 560
α	≤ 1	4	≤ 11.7	≤ 11.7	
	≤ 1	100			≤ 19.3
$\frac{\tan \delta}{\mu_i}$ x 10^6	≤ 1	4	≤ 1.2	≤ 1.2	
	≤ 1	100	≤ 6	≤ 6	≤ 8
	≤ 1	500			≤ 18
	≤ 1	1000			≤ 45
$q_{2-24-100}$	15 - 30	4	≤ 1.8	≤ 1.0	
	3 - 12	100			≤ 3.0

1) For orientation: +0.5 to +1.5.

PRE-ADJUSTED POTCORES

Dimensions in mm



With nut, catalog number = 4322 022 3....
Without nut, catalog number = 4322 022 1....

Weight		= 54 g
Effective length	l_e	= 5.32 cm
	$\Sigma \frac{l_e}{A_e}$	= 2.64 cm^{-1}
Effective volume	V_e	= 10.7 cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 33, grade 3D3, potcore with nut, catalog number = 4322 022 32430
   A_L = 1600, grade 3B7, potcore without nut, catalog number = 4322 022 13120
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

---

1) See Adjustment curves.

Potcores with standard μ_e values [1])

μ_e	α	tolerance on inductance (%)	catal. No.: 4322 022 3.... with nut 4322 022 1.... without nut		
			3B7	3H1	3D3
33	79.7	± 1	–	–	2430
47	66.8	± 1	–	–	2440
68	55.6	± 1	2050	2250	2450
100	45.8	± 1.5	2060	2260	–
150	37.4	± 2	2070	2270	–
220	30.9	± 3	2080	2280	–
330	25.2	± 3	2090	2290	–
750	16.7	± 25	–	–	2400*
2030	10.2	± 25	2000*	2200*	–

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

Potcores with standard A_L factors [1])

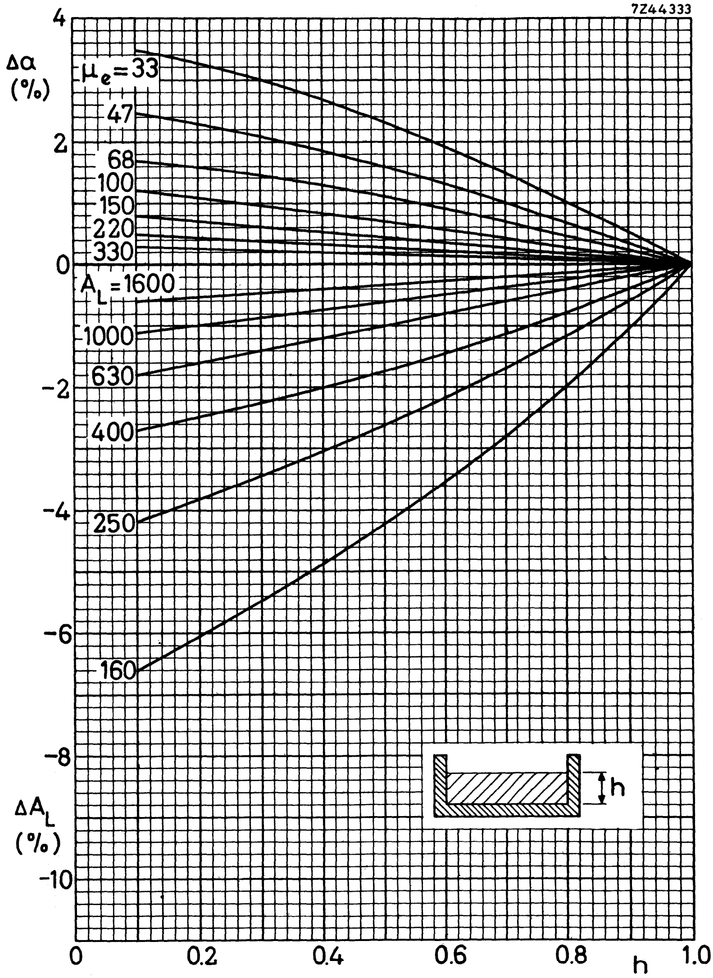
A_L	corresponding μ_e-value	tolerance on inductance (%)	catal. No.: 4322 022 3.... with nut 4322 022 1.... without nut		
			3B7	3H1	3D3
40	8.39	± 1	3020	3220	–
100	21	± 1	3040	3240	–
160	33.6	± 1	–	–	3450
250	52.5	± 1	3060	3260	3460
400	84	± 1.5	3080	3280	3480
630	132	± 2	3100	3300	–
1000	210	± 3	3110	3310	–
1600	336	± 3	3120	3320	–

Inductance $L = N^2 A_L$ (in 10^{-9} H)

1) See Notes on the previous page.

* Only available without nut.

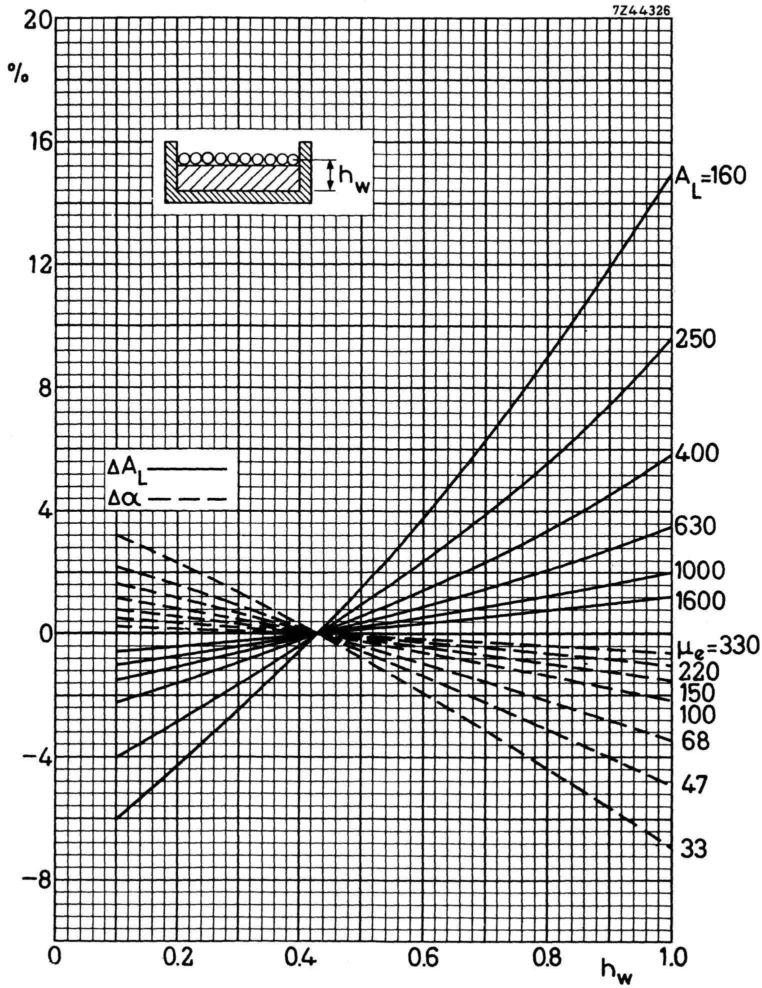
DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3.

Example: On a single-section coil former only 0.4 part of the available height is used. A potcore with μ_e = 68 in that case obtains an α factor of 55.6 + 1.20 %.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_w on a single-section coil former.

Valid for ferroxcube 3B7, 3H1 and 3D3.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 68 obtains for that winding an α factor of 55.6 - 1.6 %.

COIL FORMERS

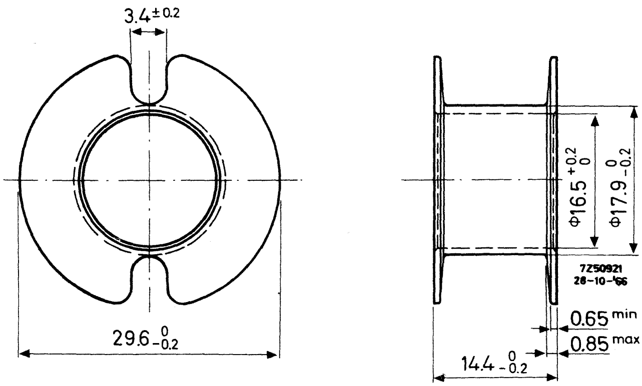
GENERAL

Three types of coil former can be supplied:

- with one section
- with two sections
- with three sections

The dimensions conform with the following specifications: I.E.C.133 (international), C.C.T.U. 06-02 (France) and D.I.N. 41 294 (Germany).
The dimensions in the drawings are in mm.

SINGLE-SECTION COIL FORMER



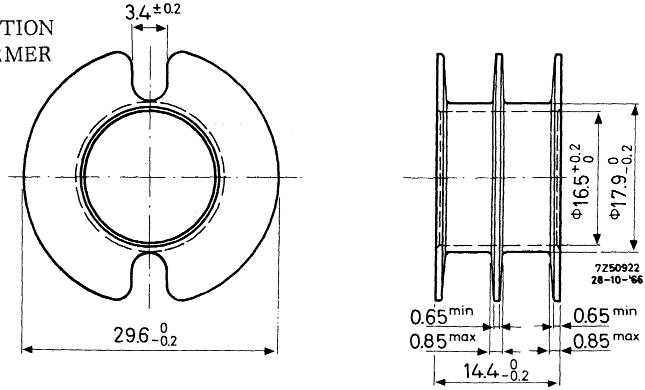
Catalog number	4322 021 30390
Material	glassfibre-reinforced polyacetal
Window area	75 mm^2
Mean length of turn	7.4 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 3.59 \times 10^3 \ \Omega/H$$

Weight 1.2 g

TWO-SECTION
COIL FORMER



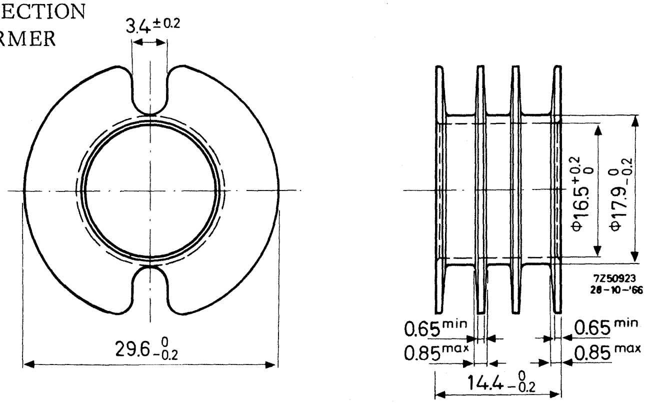
Catalog number	4322 021 30400
Material	glassfibre-reinforced polyacetal
Window area	2 x 35 mm^2
Mean length of turn	7.4 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 3.81 \times 10^3 \ \Omega/H$$

Weight 1.55 g

THREE-SECTION
COIL FORMER



Catalog number	4322 021 30410
Material	glassfibre-reinforced polyacetal
Window area	3 x 22 mm^2
Mean length of turn	7.4 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 4.06 \times 10^3 \ \Omega/H$$

Weight 1.8 g

INDUCTANCE ADJUSTORS

CONTINUOUS ADJUSTORS

The tolerances on inductance of the pre-adjusted potcores (with adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.

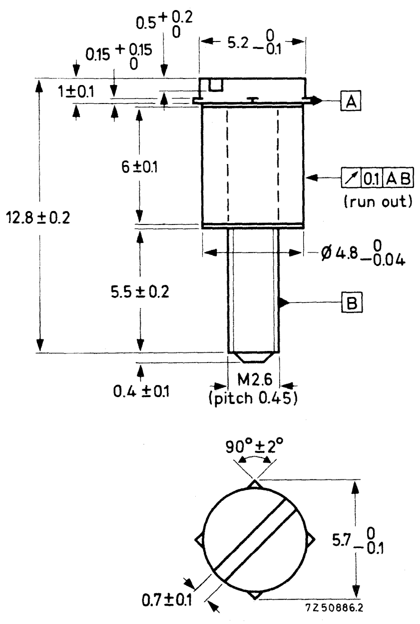


Fig. A

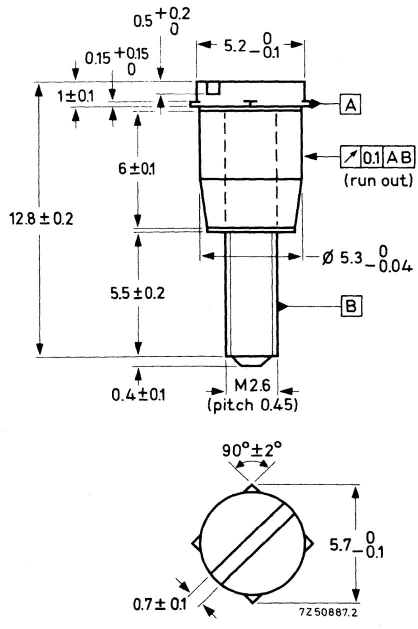


Fig. B

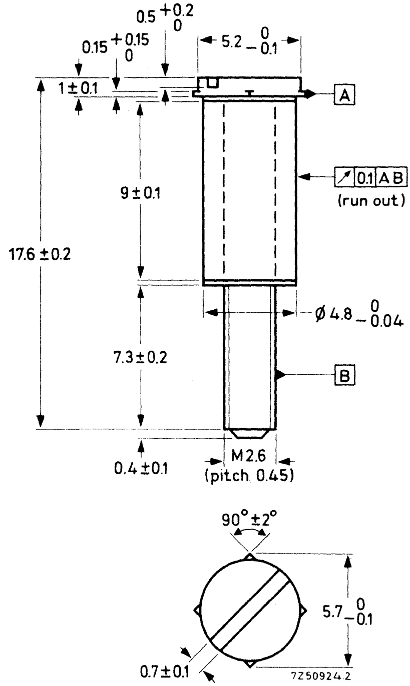


Fig.C

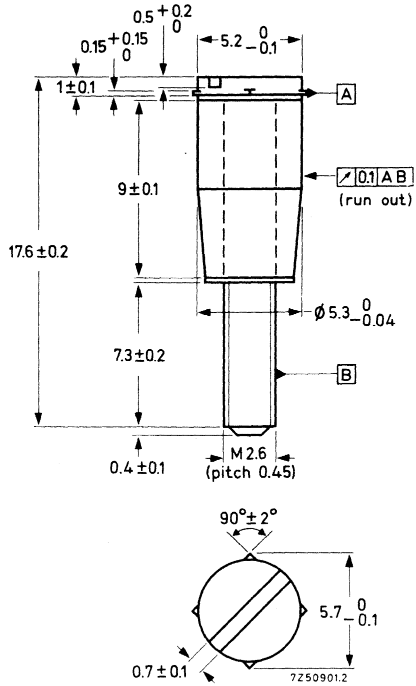


Fig.D

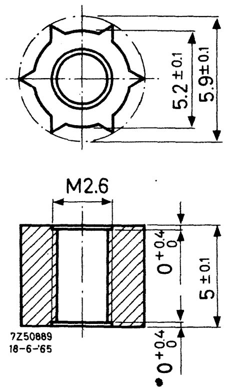
Types of adjustor and recommended applications for potcores with grade 3B7, 3H1 and 3D3:

Fig.	colour	catalog number 4322 021	potcore	
			μ_e	A_L
A	yellow	30790	33	160
B	white	30980	47	250
B	white	30980	68	
A	brown	30810	100	400
A	brown	30810		630
C	grey	31110	150	
B	grey	31090	220	1000
D	black	31120	330	1600

The adjustors are packed in bags of 100, so please order in multiples of 100.

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

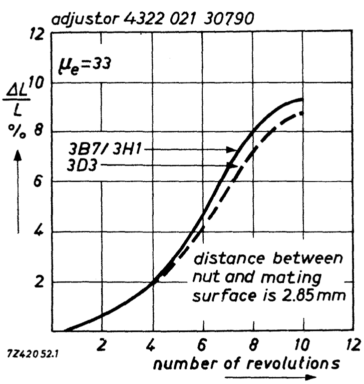


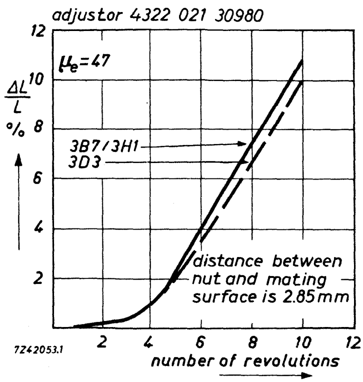
Catalog number	4322 021 30160
Material	polycarbonate
Max. impregnation temperature for 24 hours	120 °C
Recommended distance from mating surface to nut (See Adjustment curves)	2.85 ± 0.15 mm or 4.95 ± 0.15 mm

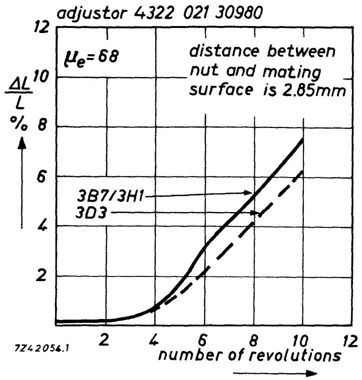
The nuts are packed in bags of 100, so please order in multiples of 100.

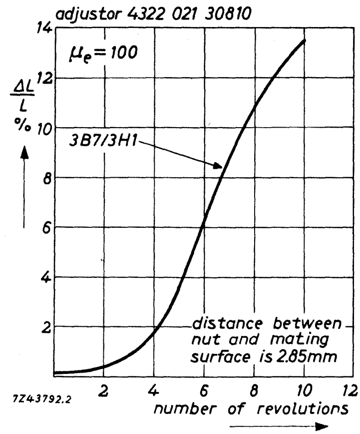
For more information see Potcores General, Mounting data.

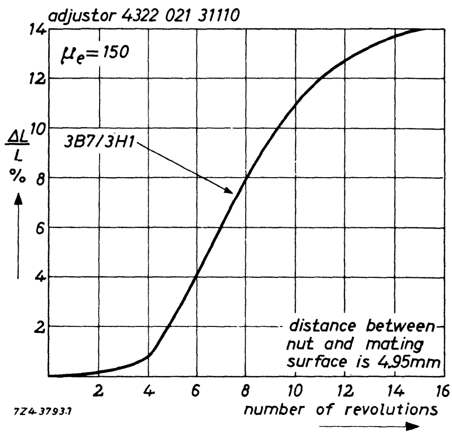
ADJUSTMENT CURVES

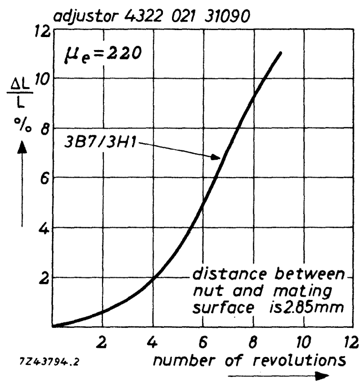


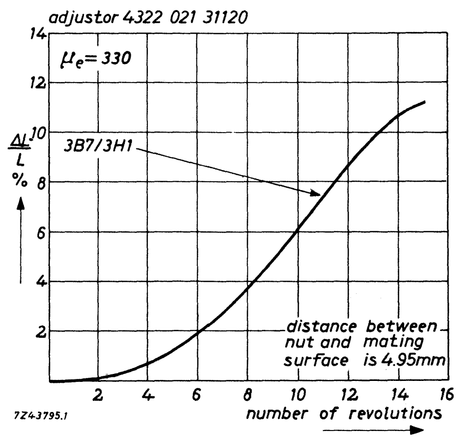



adjustor 4322 021 30980
$\mu_e = 68$
distance between nut and mating surface is 2.85mm
3B7/3H1
3D3
$\frac{\Delta L}{L}$ %
number of revolutions
7Z42054.1


adjustor 4322 021 30810
$\mu_e = 100$
3B7/3H1
distance between nut and mating surface is 2.85mm
$\frac{\Delta L}{L}$ %
number of revolutions
7Z43792.2


adjustor 4322 021 31110
$\mu_e = 150$
3B7/3H1
distance between nut and mating surface is 4.95mm
$\frac{\Delta L}{L}$ %
number of revolutions
7Z43793.1

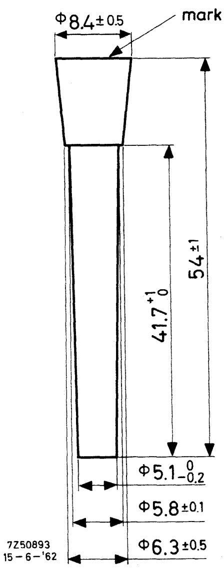

adjustor 4322 021 31090
$\mu_e = 220$
3B7/3H1
distance between nut and mating surface is 2.85mm
$\frac{\Delta L}{L}$ %
number of revolutions
7Z43794.2

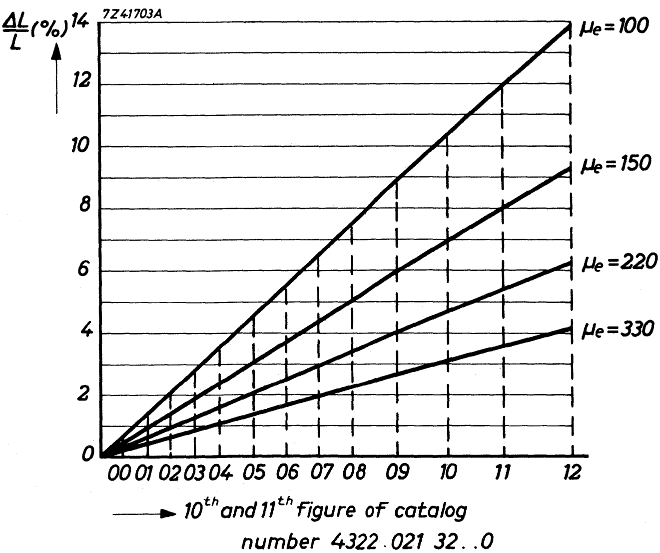

adjustor 4322 021 31120
$\mu_e = 330$
3B7/3H1
distance between nut and mating surface is 4.95mm
$\frac{\Delta L}{L}$ %
number of revolutions
7Z43795.1

STEP-BY-STEP ADJUSTORS

These adjustors are used when a continuous adjustment of the inductance is not necessary. For instance, they are applied in loading coils to bring the inductance within a certain tolerance field. They are not suitable for adjusting the inductance to an exact value, as is usually necessary in filters. The increment of the losses caused by these adjustors is negligible.
A range of 13 flexible conical adjustors is available under the catalog numbers 4322 021 32000 up to 021 32120. Each adjustor causes an increase in the inductance; the higher the catalog number, the greater the effect. The influence of each adjustor on the inductance at different μ_e values of the potcore can be found from the graph.
The 10th and 11th figure of the catalog number are indicated on the head of the adjustor. It should be borne in mind that, when using these adjustors, the inductance of the coil should initially be lower than the wanted value.
When the correct adjustor has been found, it is inserted in the centre hole of the pot. An adhesive (for instance Pliobond of Good Year) is used as sliding and fixing material. After fixing the protruding ends are cut off.

The maximum impregnation temperature is 150 °C.
The maximum working temperature is 90 °C.
Material: rubber with powder iron.

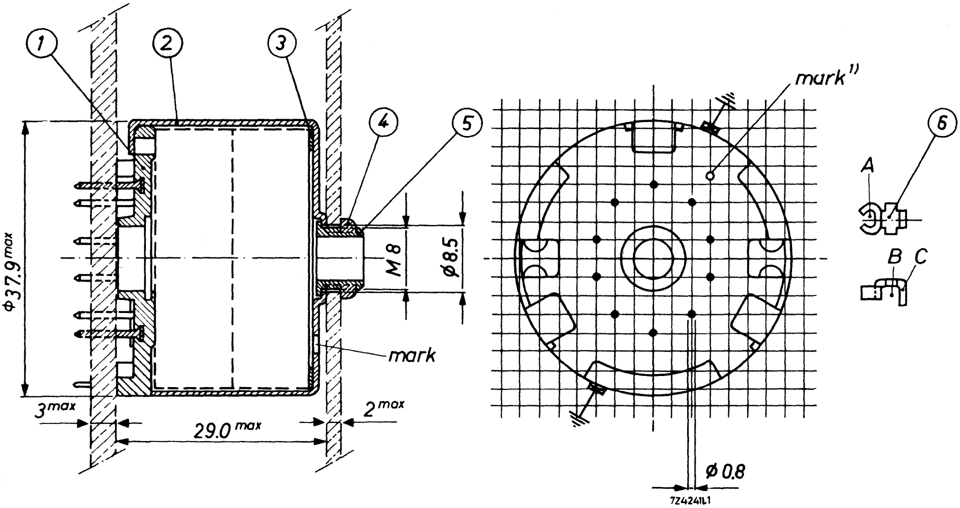




Dimensions in mm

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30490	(4) nut	4322 021 30710
(2) brass container	4322 021 30570	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30680	(6) soldering spring	4322 021 30700 (10x)

The core is suitable for mounting on printed-wiring boards and on conventional panels.

The parts 1, 2, 3 (and 6) are sufficient to construct an assembly for use in combination with printed wiring.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The ten soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3 $\pm$ 0.1 mm diameter.

---

[1]) There is another mark in a similar position on the top of the container.

If one-hole mounting is preferred, the parts 4 and 5 should be added. The coil assembly may then be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

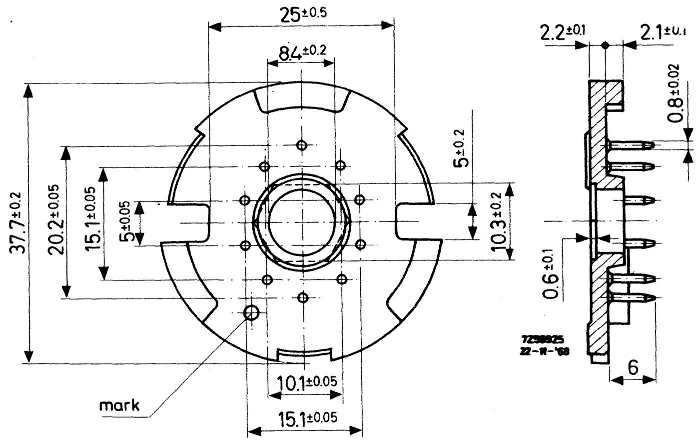
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 350 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

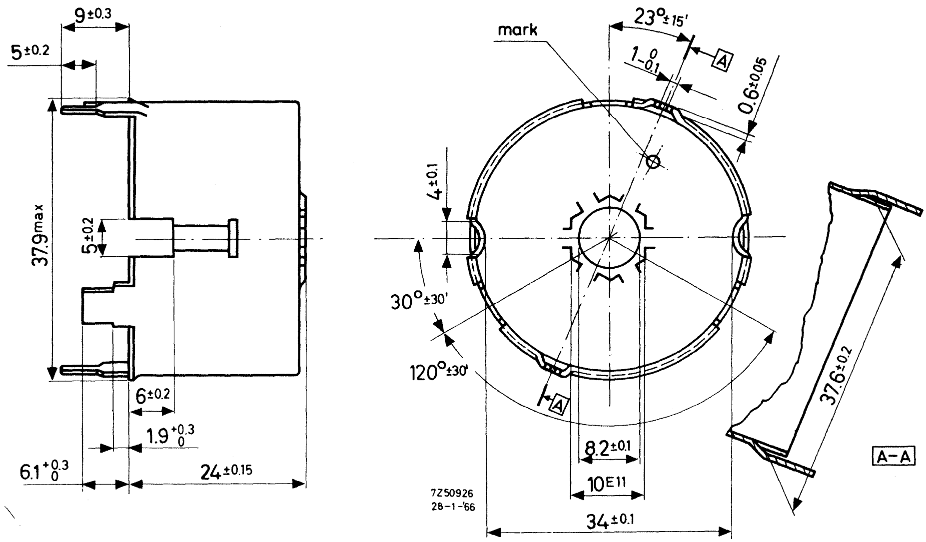
(1) Tag plate 4322 021 30490

Plate : reinforced polyester
Pins : phosphorbronze, dipsoldered



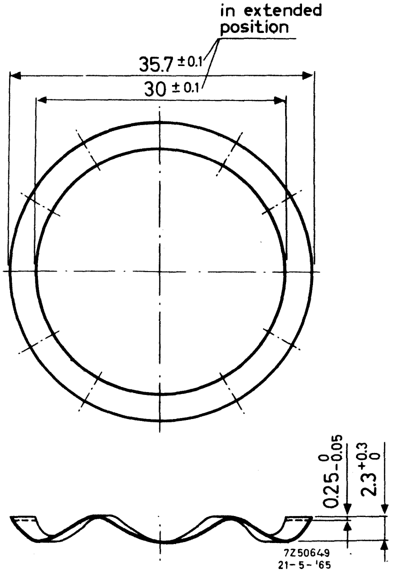
(2) Container 4322 021 30570

Material : brass, nickel plated



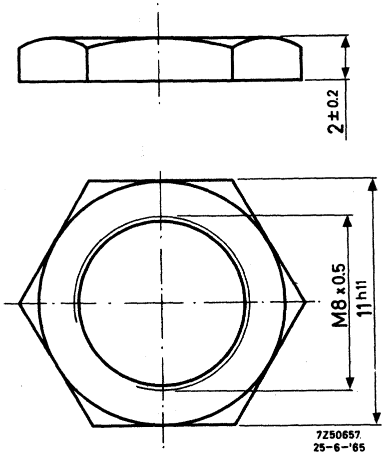
(3) Spring 4322 021 30680

Material : steel



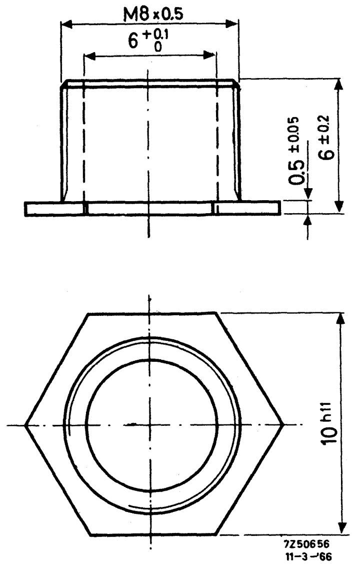
(4) Nut 4322 021 30710

Material : brass, nickel plated



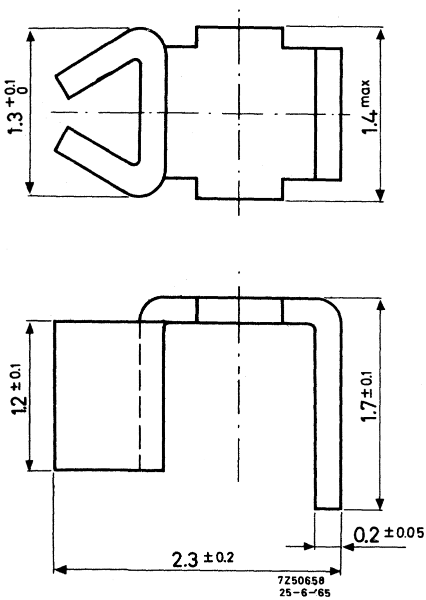
(5) Fixing bush 4322 021 30720

Material : brass, nickel plated



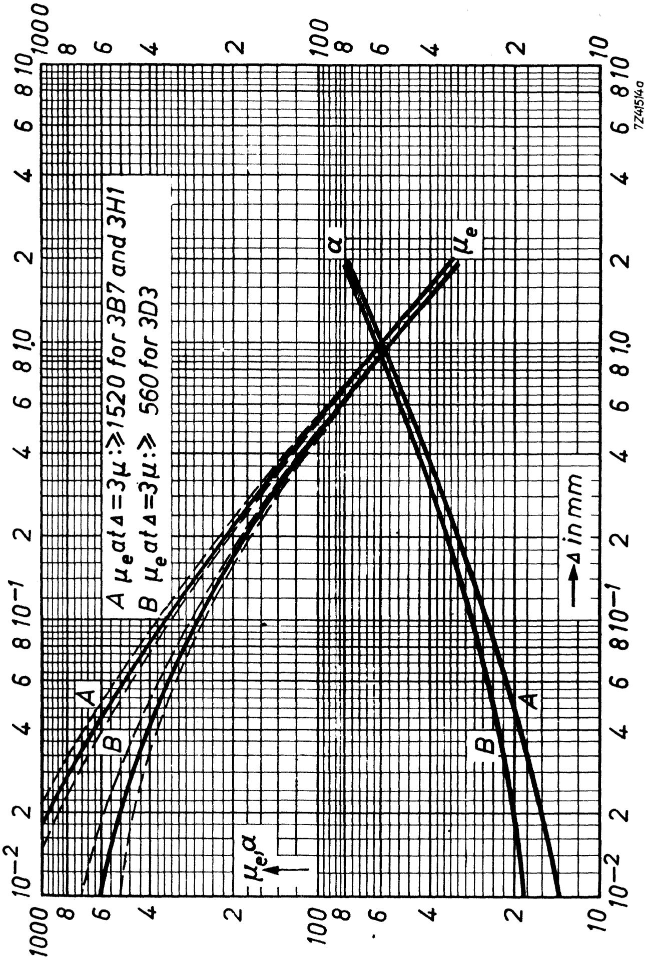
(6) Soldering spring 4322 021 30700

Material : brass, dipsoldered



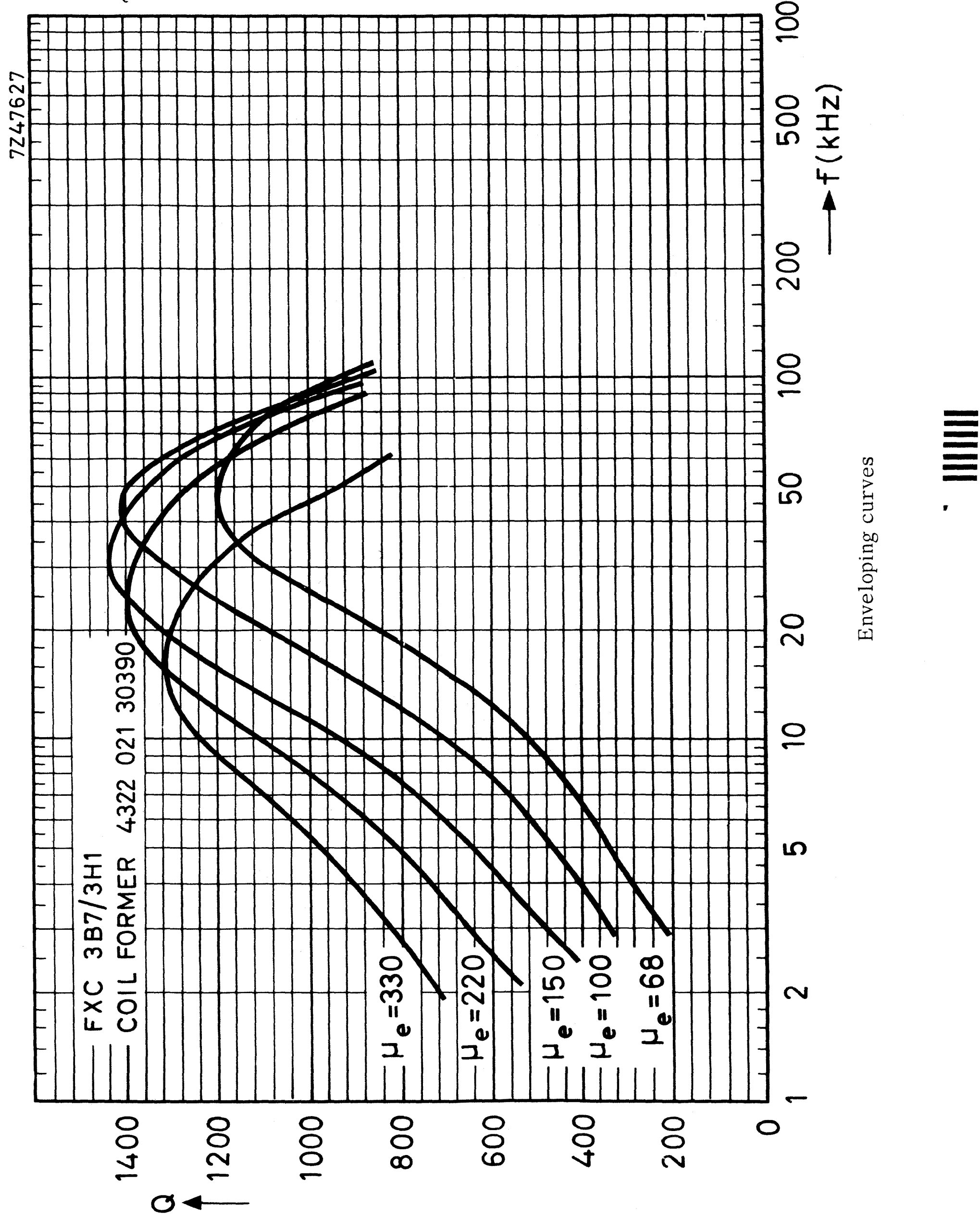
CHARACTERISTIC CURVES

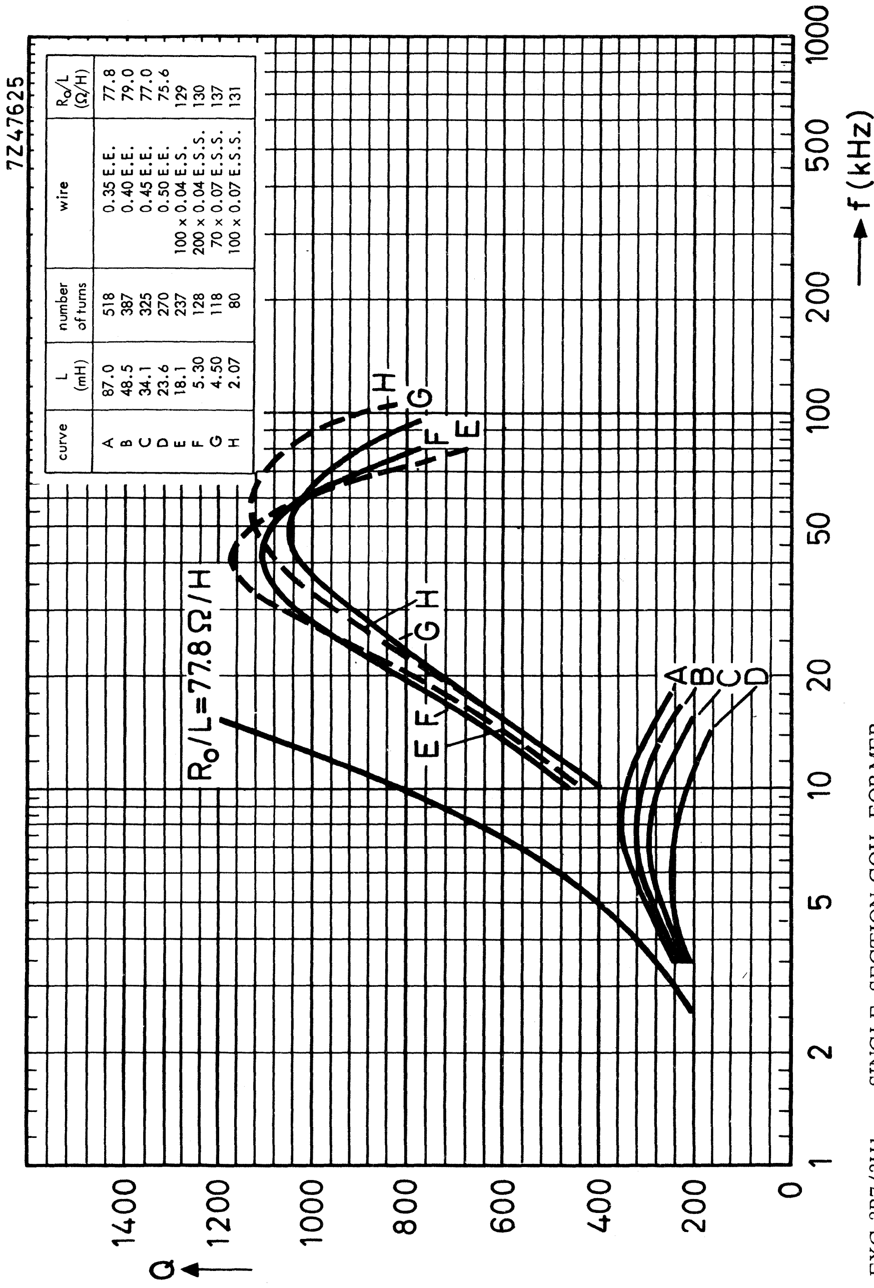
μ_e-α CURVES



Relative effective permeability and turn factor for 1 mH as a function of the air gap length

TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1

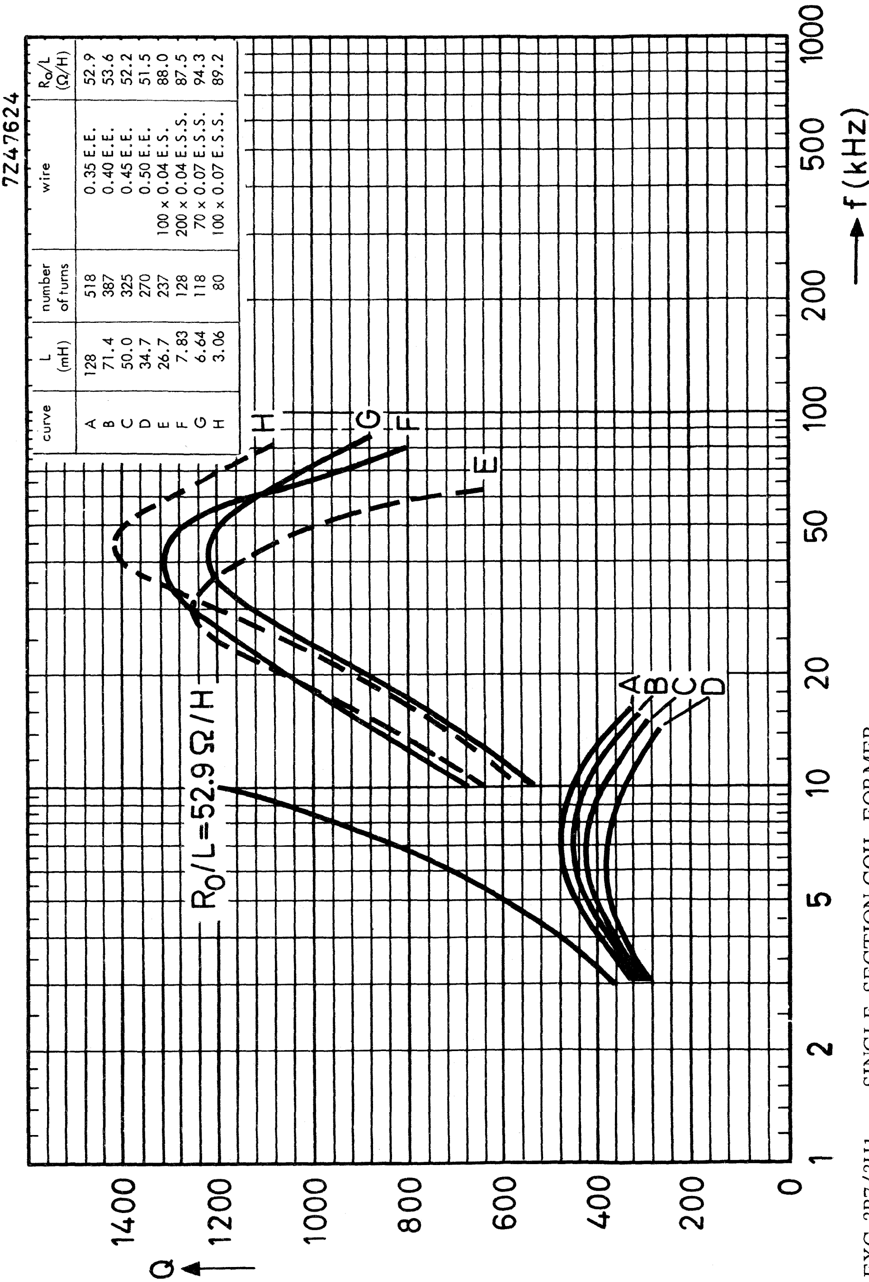




curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	87.0	518	0.35 E.E.	77.8
B	48.5	387	0.40 E.E.	79.0
C	34.1	325	0.45 E.E.	77.0
D	23.6	270	0.50 E.E.	75.6
E	18.1	237	100 × 0.04 E.S.	129
F	5.30	128	200 × 0.04 E.S.S.	130
G	4.50	118	70 × 0.07 E.S.S.	137
H	2.07	80	100 × 0.07 E.S.S.	131

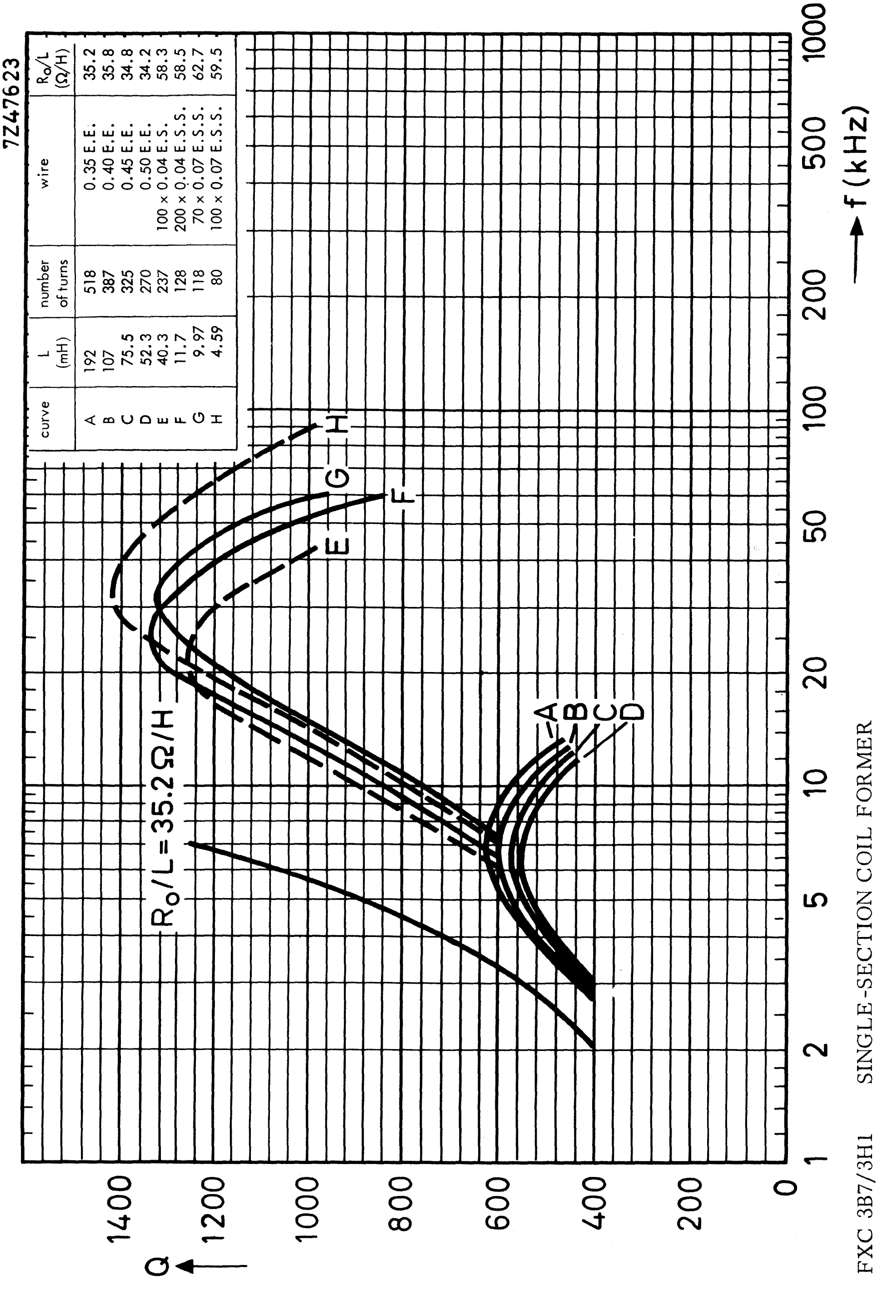
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 68$



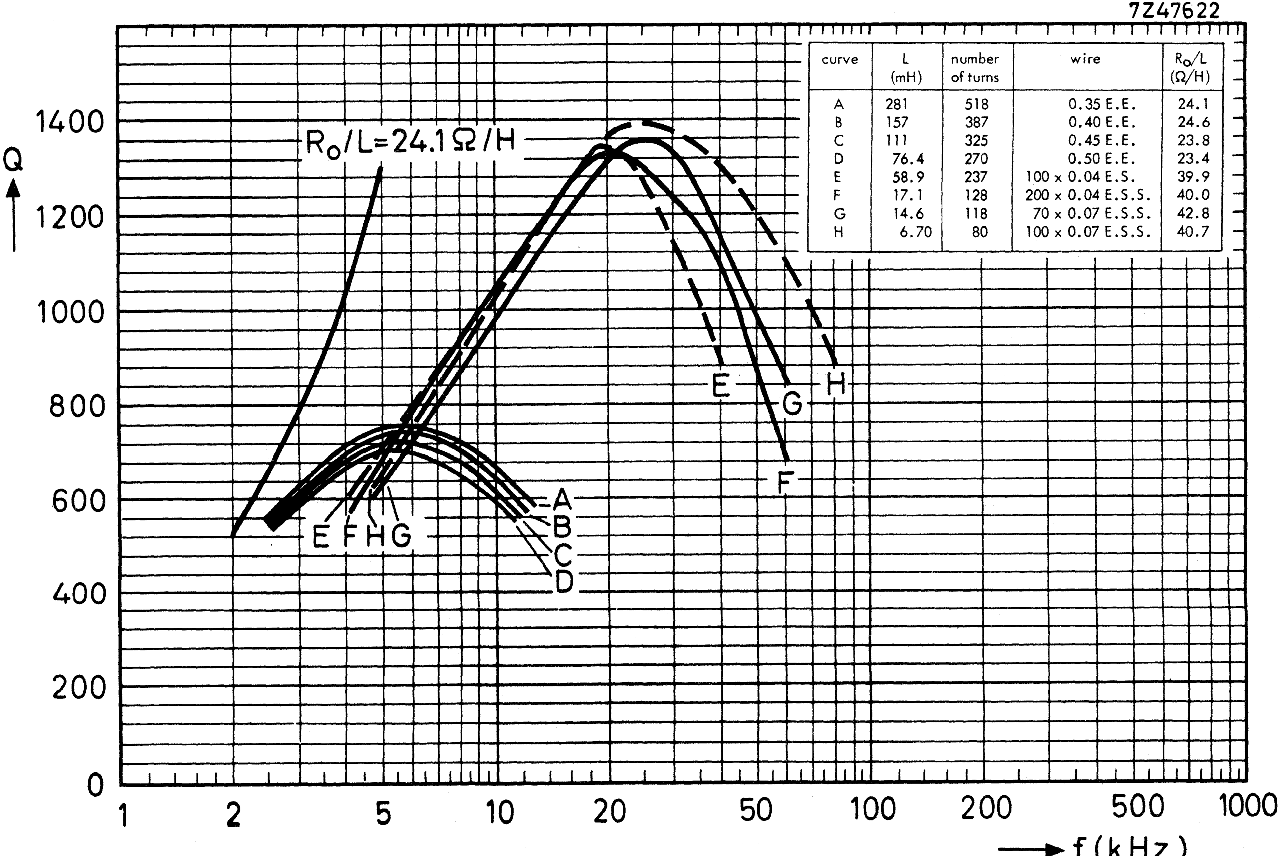
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	128	518	0.35 E.E.	52.9
B	71.4	387	0.40 E.E.	53.6
C	50.0	325	0.45 E.E.	52.2
D	34.7	270	0.50 E.E.	51.5
E	26.7	237	100 × 0.04 E.S.	88.0
F	7.83	128	200 × 0.04 E.S.S.	87.5
G	6.64	118	70 × 0.07 E.S.S.	94.3
H	3.06	80	100 × 0.07 E.S.S.	89.2

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 100$



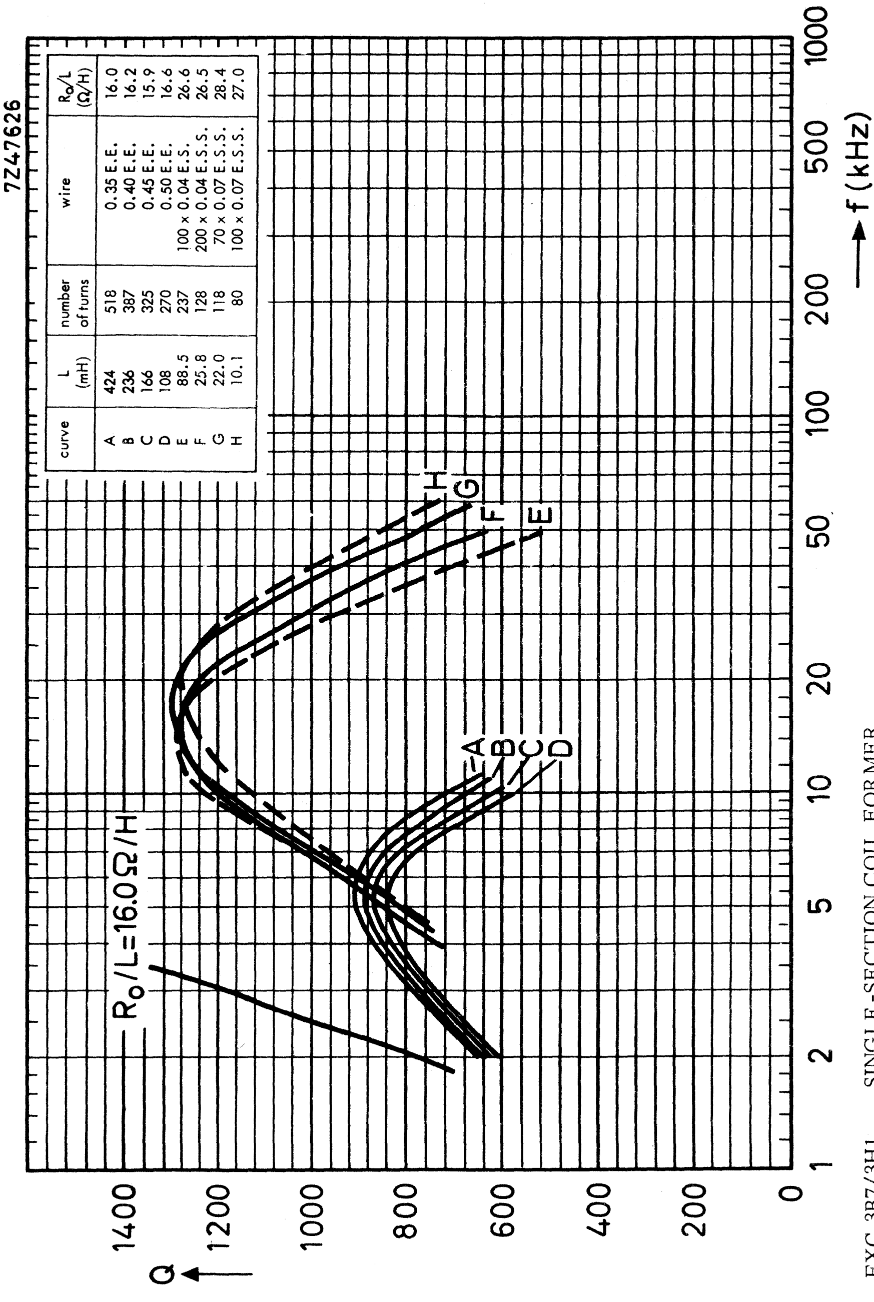
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	192	518	0.35 E.E.	35.2
B	107	387	0.40 E.E.	35.8
C	75.5	325	0.45 E.E.	34.8
D	52.3	270	0.50 E.E.	34.2
E	40.3	237	100 × 0.04 E.S.	58.3
F	11.7	128	200 × 0.04 E.S.S.	58.5
G	9.97	118	70 × 0.07 E.S.S.	62.7
H	4.59	80	100 × 0.07 E.S.S.	59.5

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
$\mu_e = 150$



curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	281	518	0.35 E.E.	24.1
B	157	387	0.40 E.E.	24.6
C	111	325	0.45 E.E.	23.8
D	76.4	270	0.50 E.E.	23.4
E	58.9	237	100 x 0.04 E.S.	39.9
F	17.1	128	200 x 0.04 E.S.S.	40.0
G	14.6	118	70 x 0.07 E.S.S.	42.8
H	6.70	80	100 x 0.07 E.S.S.	40.7

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER
μ_e = 220

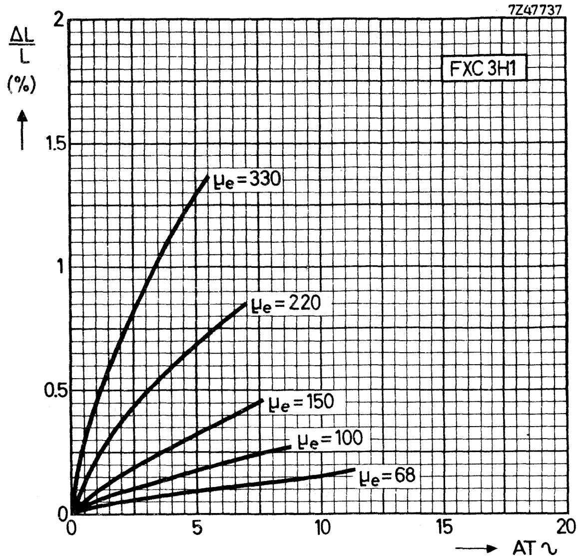


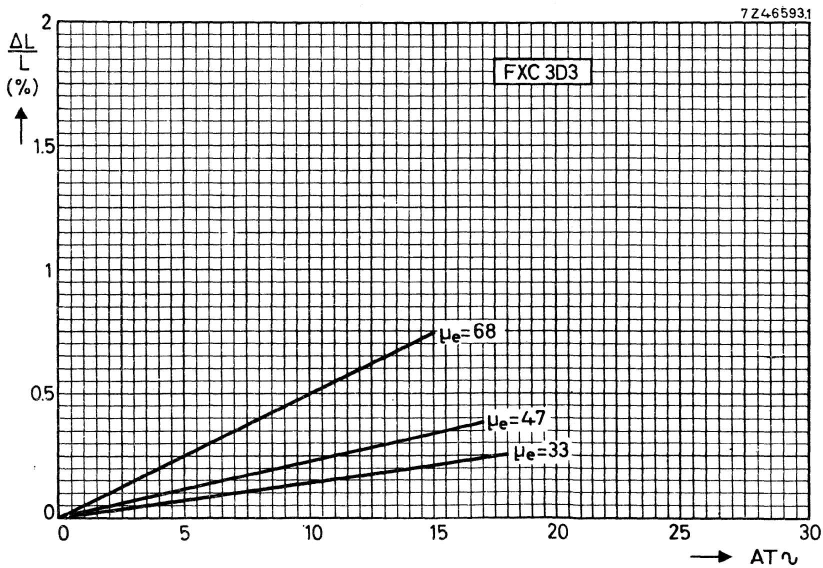
curve	L (mH)	number of turns	wire	R_o/L (Ω/H)
A	424	518	0.35 E.E.	16.0
B	236	387	0.40 E.E.	16.2
C	166	325	0.45 E.E.	15.9
D	108	270	0.50 E.E.	16.6
E	88.5	237	100 x 0.04 E.S.	26.6
F	25.8	128	200 x 0.04 E.S.S.	26.5
G	22.0	118	70 x 0.07 E.S.S.	28.4
H	10.1	80	100 x 0.07 E.S.S.	27.0

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER

$\mu_e = 330$

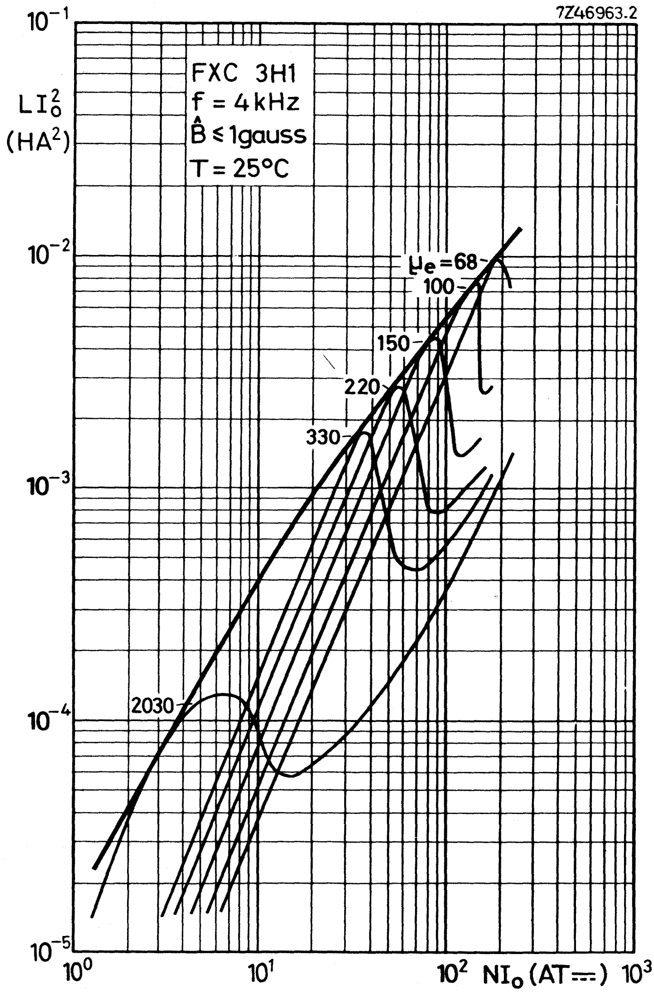
INDUCTANCE VARIATION AS A FUNCTION OF AT ~



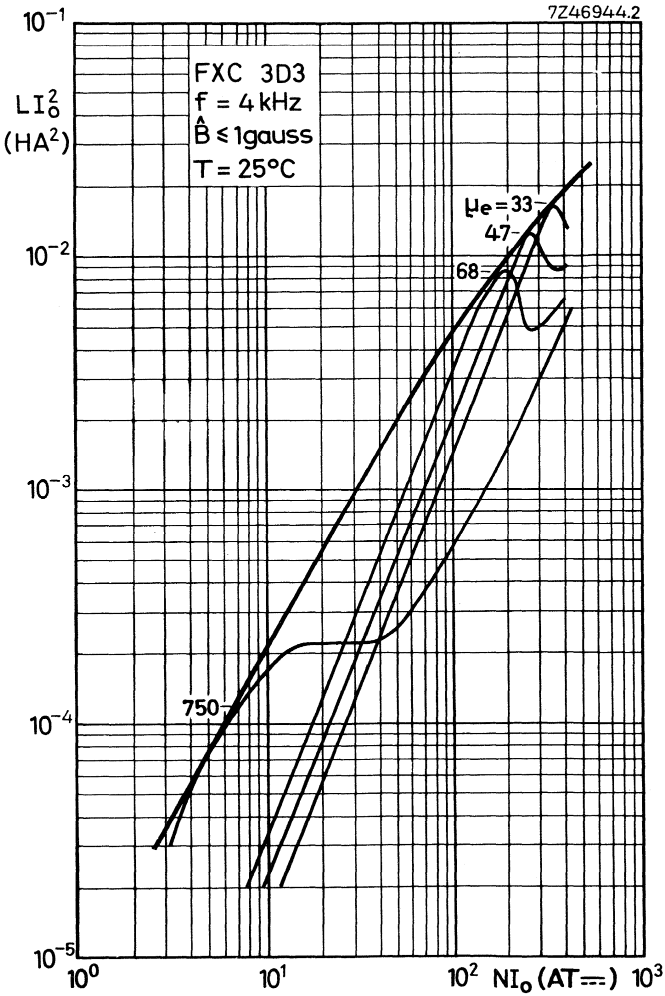


HANNA CURVES

Indicating the optimum inductance for a certain μ_e-value and direct current. Typical values.



Typical values



POTCORES

INTRODUCTION

Three types of core can be supplied:

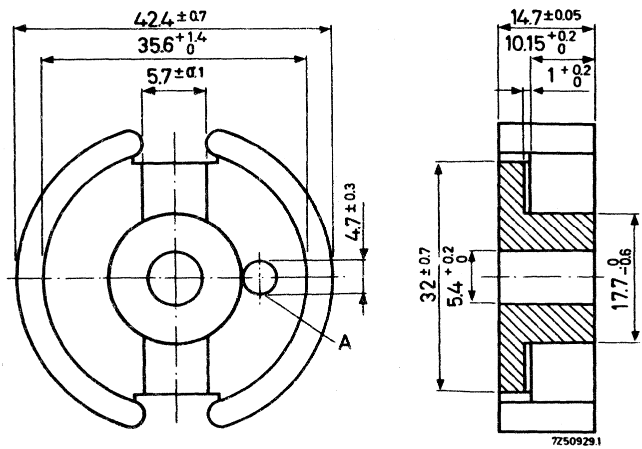
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores (potcores with an air gap) which are provided with a nut for an adjustor. These have a relative effective permeability (μ_e) in accordance with the E6 range of values or an inductance factor (A_L) in the R5 range.
- Pre-adjusted potcores without nut.

The dimensions of the potcores are in accordance with the following specifications: I.E.C. 133 (international), C.C.T.U. 06-04 and 06-08 (France), D.I.N. 41 293 (Germany) and B.S. 4061 (Great Britain).

Potcores and associated parts are ordered by their 12-digit catalog number.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number (without hole A)	catalog number (with hole A)
3B7	4322 020 22750	4322 020 22780
3H1	4322 020 22760	4322 020 22790

The versions without hole A are used for filter coils, the versions with hole A for L-asymmetry adjustment of loading coils.

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (^oC)	grade 3B7	grade 3H1	
T.F. x 10^6	+5 to +23		+0.5 to +1.5	
	+23 to +55		+0.5 to +1.5	
	+23 to +70	-0.6 to +0.6	1)	
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	

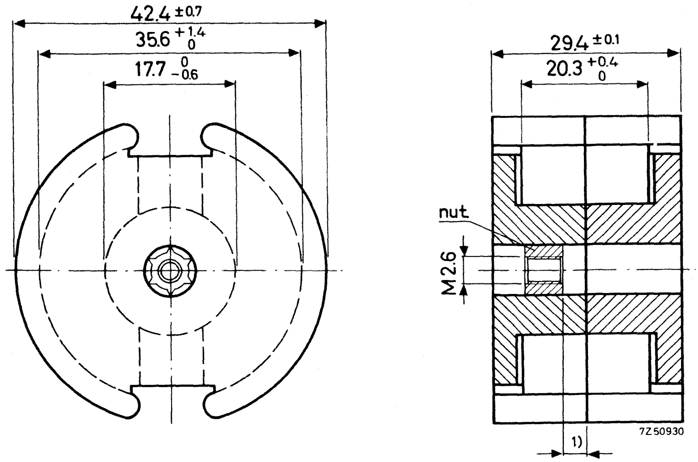
For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 550 Newton, the values in Table II are guaranteed at 25 ± 10 ^oC.

Table II	$\hat{B}$ (Gs)	freq. (kHz)	grade	3B7	3H1
μ_e	≤ 1	4		≥ 1580	≥ 1580
α	≤ 1	4		≤ 11.4	≤ 11.4
$\frac{\tan\delta}{\mu_i} \times 10^6$	≤ 1	4		≤ 1.2	≤ 1.2
	≤ 1	100		≤ 8	≤ 8
$q_{2-24-100}$	15-30	4		≤ 1.8	≤ 1.0

1) For orientation: +0.5 to +1.5.

PRE-ADJUSTED POTCORES (without hole A)

Dimensions in mm



With nut, catalog number = 4322 022 3....
Without nut, catalog number = 4322 022 1....

Weight = 104 g

Effective length l_e = 6.86 cm

$\Sigma \frac{l_e}{A_e} = 2.59\ cm^{-1}$

Effective volume V_e = 18.2 cm^3

Notes to the tables on the next page

1. Examples of catalog number:
   μ_e = 100, grade 3B7, potcore with nut, catalog number = 4322 022 34060
   A_L = 250, grade 3H1, potcore without nut, catalog number = 4322 022 15260
2. The inductance will only be within the given tolerance if the winding space of the coil is completely filled.
3. The versions marked with a * are only available without nut because adjustment would not be possible as the air gap of these potcores is practically zero.

[1]) See Adjustment curves.

Potcores with standard μ_e values [1])

μ_e	α	tolerance on inductance (%)	catal. No. 4322 022 3.... with nut / 4322 022 1.... without nut 3B7	3H1	
33	78.4	± 1	-	-	
47	65.7	± 1	-	-	
68	55.0	± 1	-	4250	
100	45.0	± 1.5	4060	4260	
150	36.8	± 2	4070	4270	
220	30.4	± 3	4080	4280	
330	24.8	± 3	4090	4290	
2120	9.85	± 25	4000*	4200*	

Number of turns $N = \alpha \sqrt{L}$ (L in 10^{-3} H)

Potcores with standard A_L factors [1])

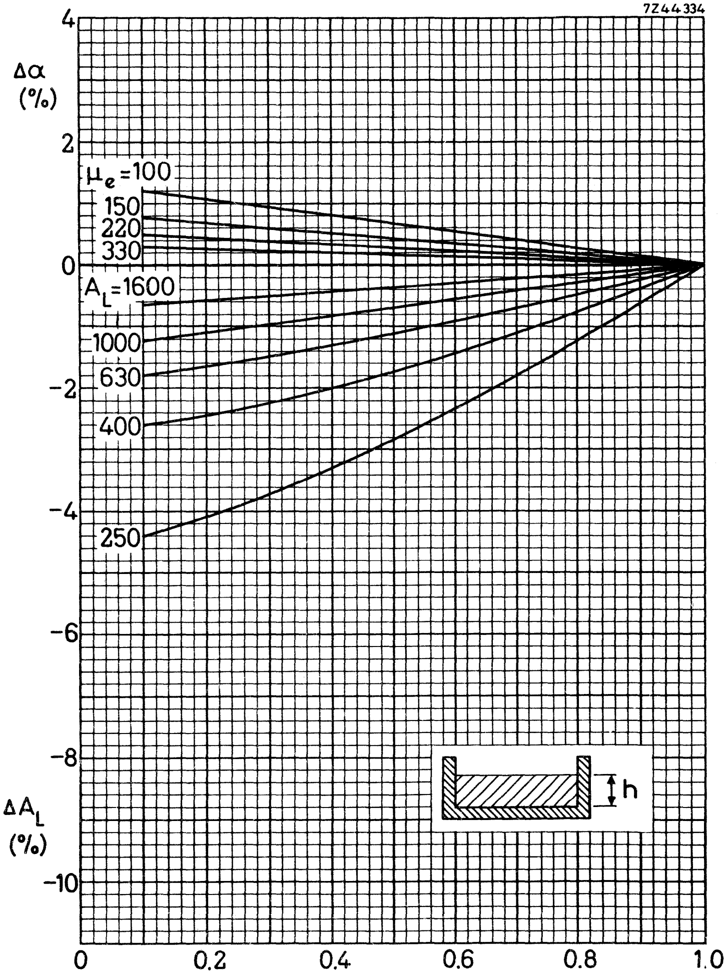
A_L	corresponding μ_e-value	tolerance on inductance (%)	catal. No. 4322 022 3.... with nut / 4322 022 1.... without nut	3B7	3H1
250	51	± 1		5060	5260
400	81	± 1		5080	5280
630	130	± 2		5100	5300
1000	205	± 3		5110	5310
1600	325	± 3		5120	5320

Inductance $L = N^2 A_L$ (in 10^{-9} H)

1) See Notes on the previous page.

*) Only available without nut.

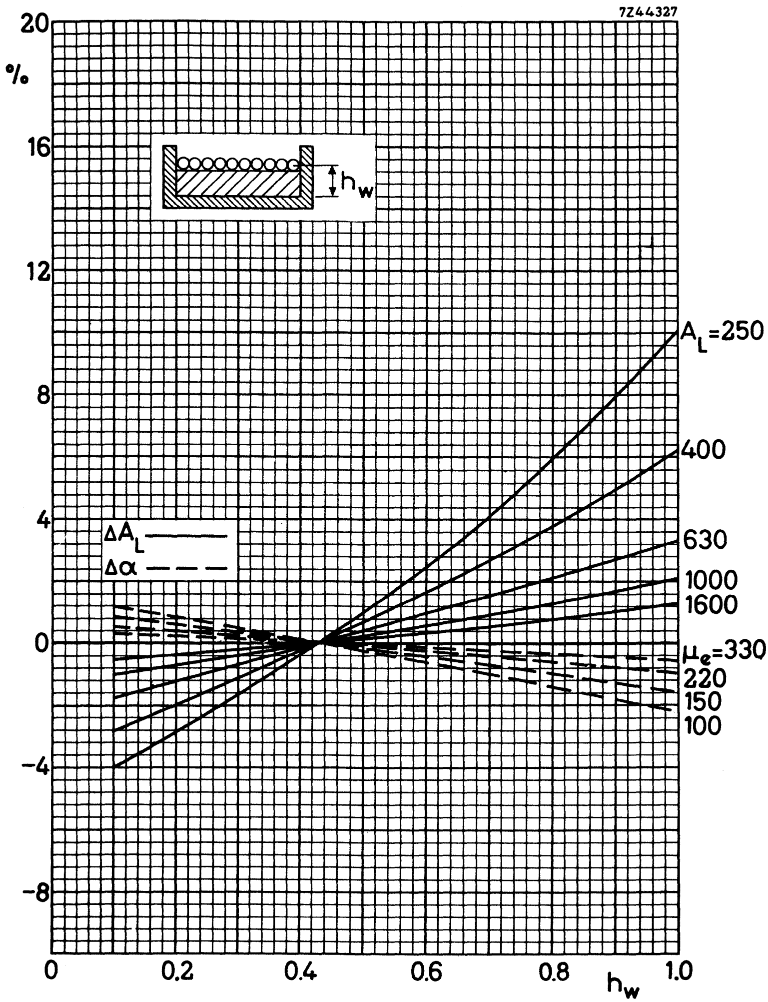
DATA FOR WHEN THE COIL FORMER IS PARTLY FILLED



Increase of the α and decrease of the A_L factor for different μ_e values and A_L factors as a function of the relative winding height on a single-section coil former.

Valid for ferroxcube 3B5, 3B7 and 3H1.

Example: On a single-section coil former only 0.4 part of the available height is used. A potcore with μ_e = 100 in that case obtains an α factor of 45.0 + 0.75 %.



Variation of the α and A_L factors for a coupling winding of one layer as a function of its winding height h_W on a single-section coil former.

Valid for ferroxcube 3B5, 3B7 and 3H1.

Example: On a single-section coil former a coupling winding is laid on 0.7 of the available height. A potcore with μ_e = 100 obtains for that winding an α factor of 45.0 - 1.0 %.

COIL FORMERS

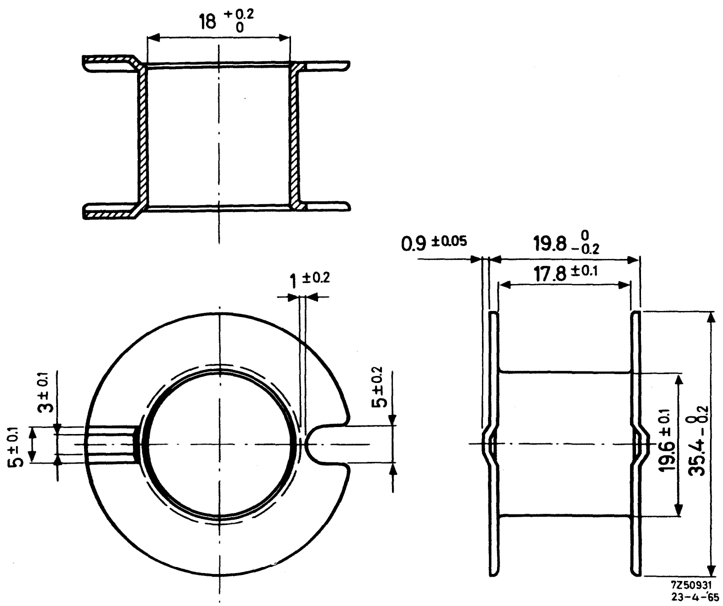
GENERAL

Two types of coil former can be supplied:

- with one section
- with two sections

The dimensions in the drawings are in mm

SINGLE-SECTION COIL FORMER



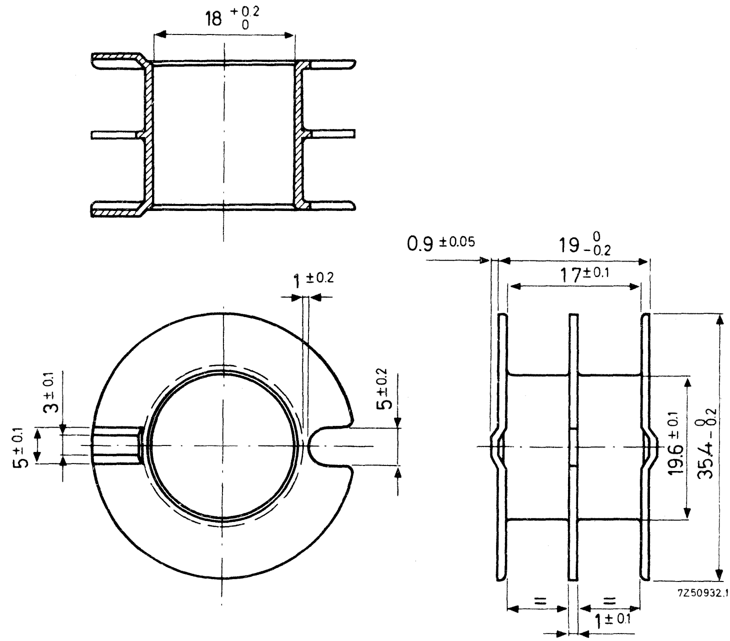
Catalog number	4322 021 30420
Material	polycarbonate K486
Window area	140 mm^2
Mean length of turn	8.6 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 2.16 \times 10^3 \quad \Omega/H$$

Weight 2.4 g

TWO-SECTION COIL FORMER



Catalog number	4322 021 30430
Material	polycarbonate K486
Window area	2 x 63 mm^2
Mean length of turn	8.6 cm
Max. temperature	130 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 2.40 \times 10^3 \quad \Omega/H$$

Weight 3.0 g

INDUCTANCE ADJUSTORS

CONTINUOUS ADJUSTORS

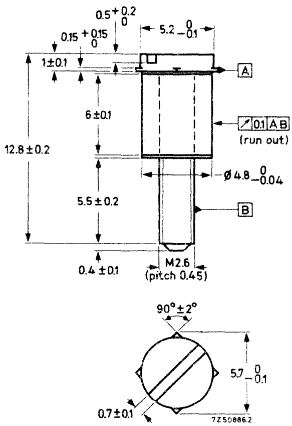


Fig. A

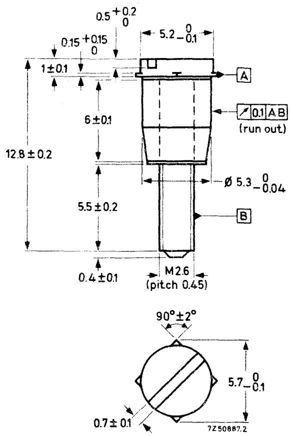


Fig. B

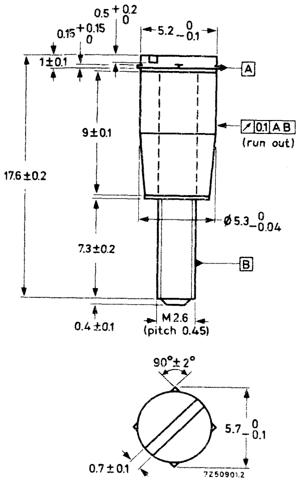


Fig. C

The tolerances on inductance of the pre-adjusted potcores (with adjustor) are given on the pages "Potcores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy <0.03% by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see following pages.
The adjustor is screwed through the potcore into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.

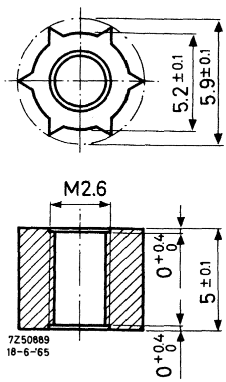
Types of adjustor and recommended applications

Fig.	colour	catalog number 4322 021	potcore	
			μ_e	A_L
B	white	30980	68	250
A	brown	30810	100	400
A	brown	30810		630
B	grey	31090	150	1000
B	grey	31090	220	
C	black	31120	330	1600

The adjustors are packed in bags of 100, so please order in multiples of 100.

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

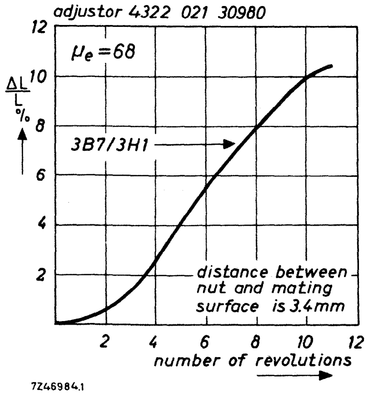


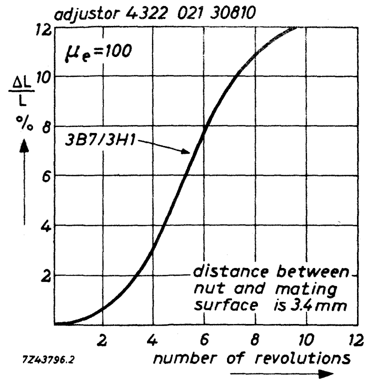
Catalog number	4322 021 30160
Material	polycarbonate
Max. impregnation temperature for 24 hours	120 °C
Recommended distance from mating surface to nut (see Adjustment curves)	3.4 ± 0.15 mm or 5.0 ± 0.15 mm

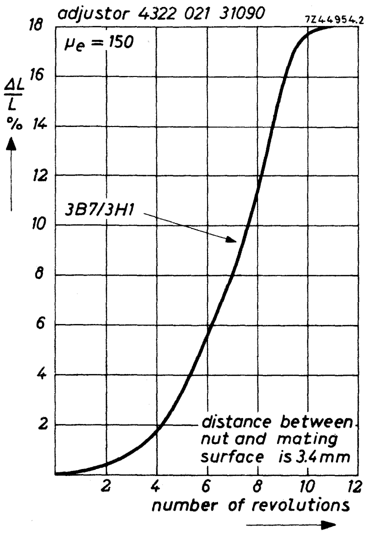
The nuts are packed in bags of 100, so please order in multiples of 100.

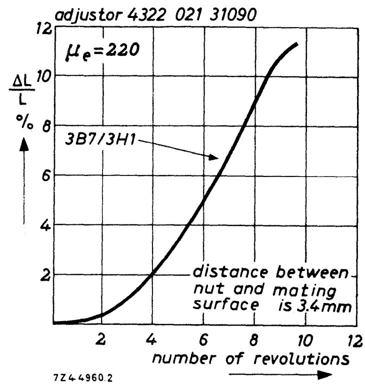
For more information see Potcores General, Mounting Data.

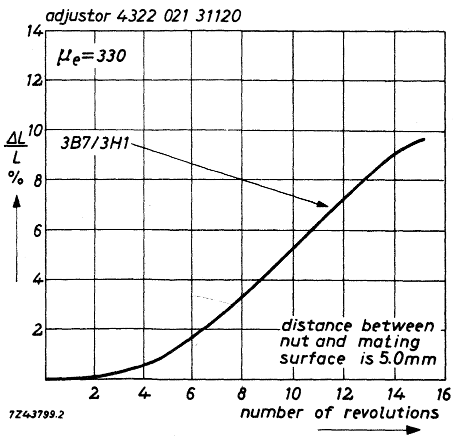
ADJUSTMENT CURVES







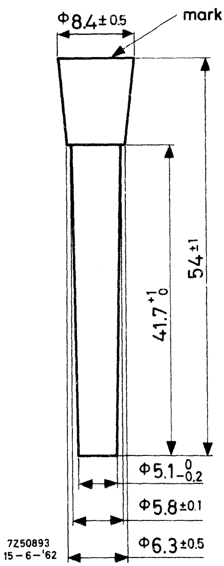


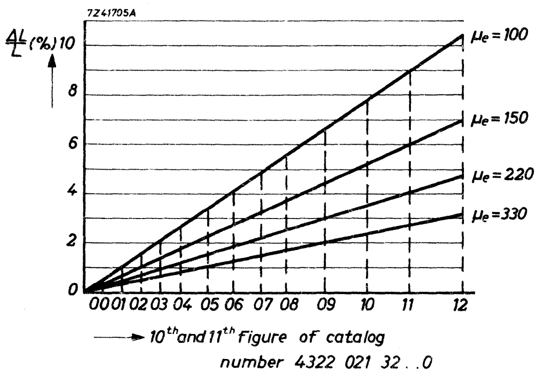


STEP-BY-STEP ADJUSTORS

These adjustors are used when a continuous adjustment of the inductance is not necessary. For instance, they are applied in loading coils to bring the inductance within a certain tolerance field. They are not suitable for adjusting the inductance to an exact value, as is usually necessary in filters. The increment of the losses caused by these adjustors is negligible.
A range of 13 flexible conical adjustors is available under the catalog numbers 4322 021 32000 up to 021 32120. Each adjustor causes an increase in the inductance; the higher the catalog number, the greater the effect. The influence of each adjustor on the inductance at different μ_e values of the potcore can be found from the graph.
The 10th and 11th figure of the catalog number are indicated on the head of the adjustor. It should be borne in mind that, when using these adjustors, the inductance of the coil should initially be lower than the wanted value.
When the correct adjustor has been found, it is inserted in the centre hole of the pot. An adhesive (for instance Pliobond of Good Year) is used as sliding and fixing material. After fixing the protruding ends are cut off.

The maximum impregnation temperature is 150 °C.
The maximum working temperature is 90 °C.
Material: rubber with powder iron.

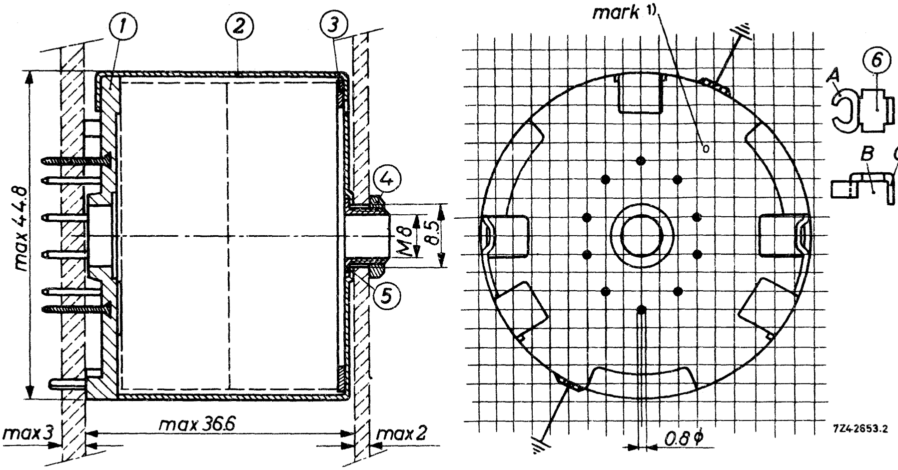




Dimensions in mm

MOUNTING PARTS

MOUNTING



(1) tag plate	4322 021 30500	(4) nut	4322 021 30710
(2) brass container	4322 021 30580	(5) fixing bush	4322 021 30720
(3) spring	4322 021 30690	(6) soldering spring	4322 021 30700 (10x)

The core is suitable for mounting on printed-wiring boards and on conventional panels.

The parts 1, 2, 3 (and 6) are sufficient to construct an assembly for use in combination with printed wiring.

If stranded wire is applied the use of a soldering spring (6) is recommended. Part A of this spring is put over the pin; then the wire is put in B and lip C is bent over.

For solid wire the soldering spring is not strictly necessary.

The ten soldering pins are arranged to fit printed-wiring boards with a 0.1 inch grid as well as those with a 2.50 mm grid.
The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3±0.1 mm diameter.

---

[1]) There is another mark in a similar position on the top of the container.

If one-hole mounting is preferred, the parts 4 and 5 should be added. The coil assembly may then be mounted on panels having a thickness of up to 2 mm. The panel should be provided with a hole of 8.5 mm diameter.

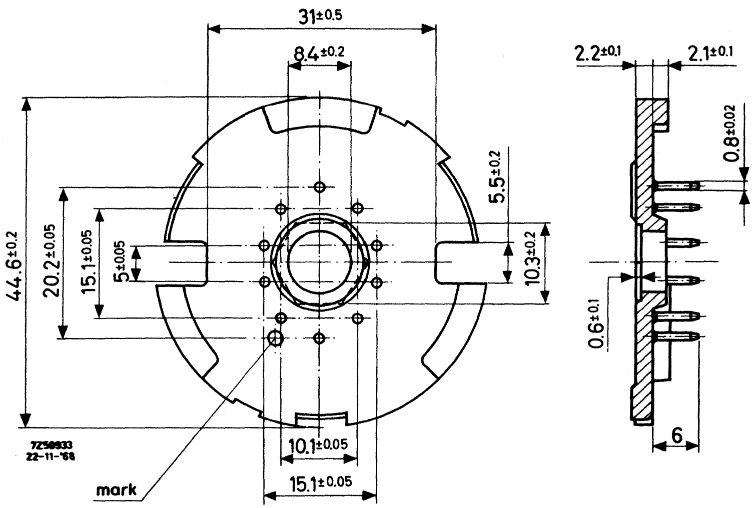
It is recommended to place the spring (3) in the position indicated in order to obtain the best stability against shock and vibration.

Before bending the lips of the container, pressure should be exercised evenly on the rim of the tag plate until the latter meets the container. The force which is required is approximately 550 Newton. After bending the lips the spring will have the correct tension.

PART DRAWINGS (dimensions in mm)

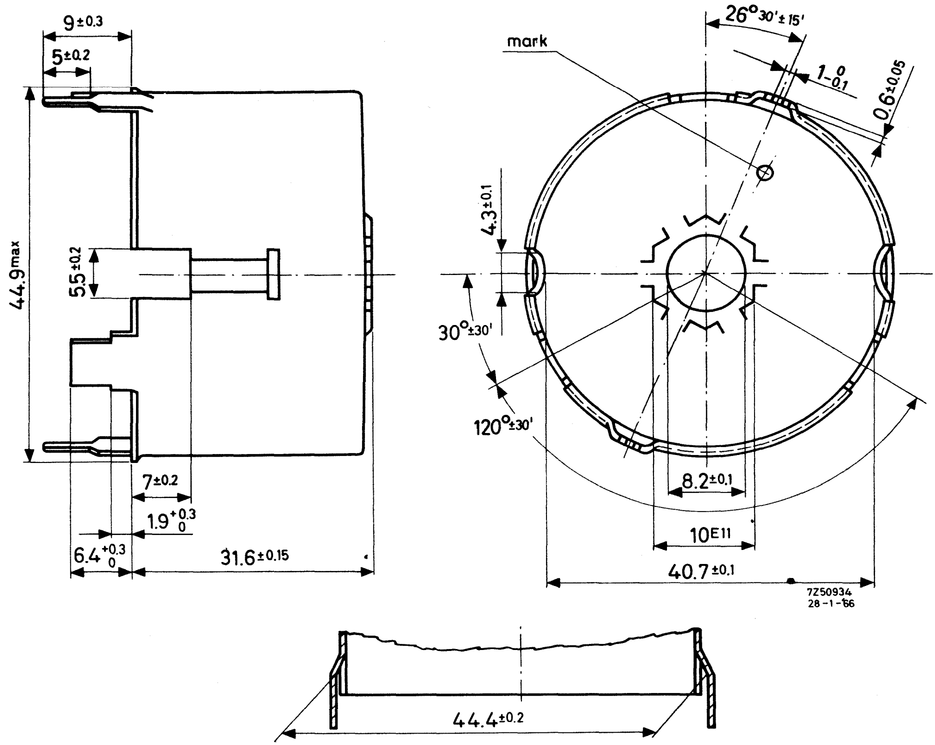
(1) Tag plate 4322 021 30500

Plate: reinforced polyester
Pins : phosphorbronze, dip soldered



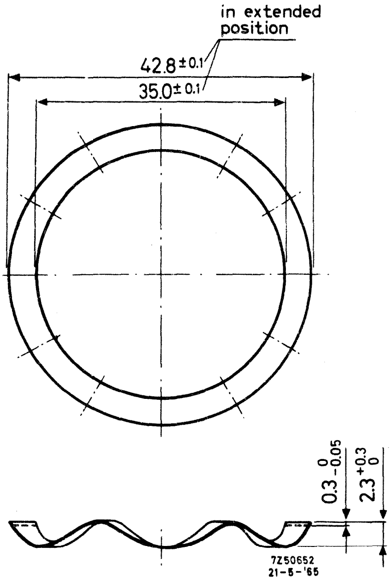
(2) Container 4322 021 30580

Material: brass, nickel plated



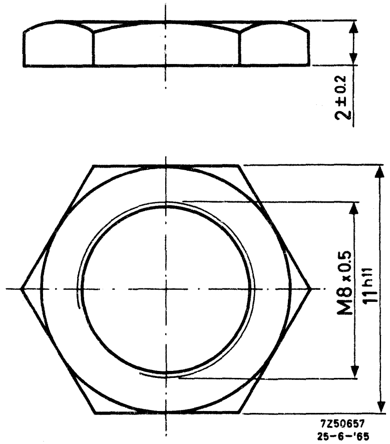
(3) Spring 4322 021 30690

Material: chrome-nickelsteel



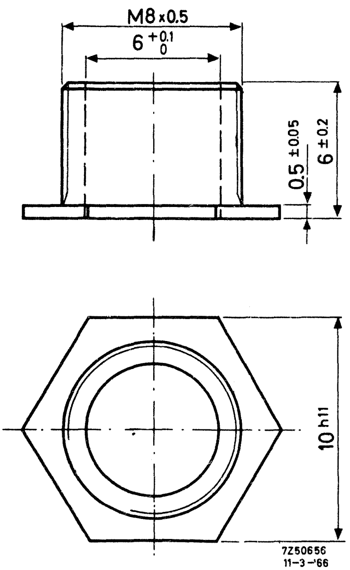
(4) Nut 4322 021 30710

Material: brass, nickel plated



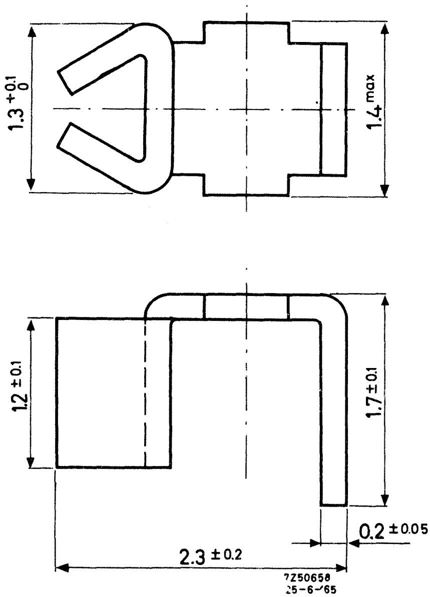
(5) Fixing bush 4322 021 30720

Material: brass, nickel plated



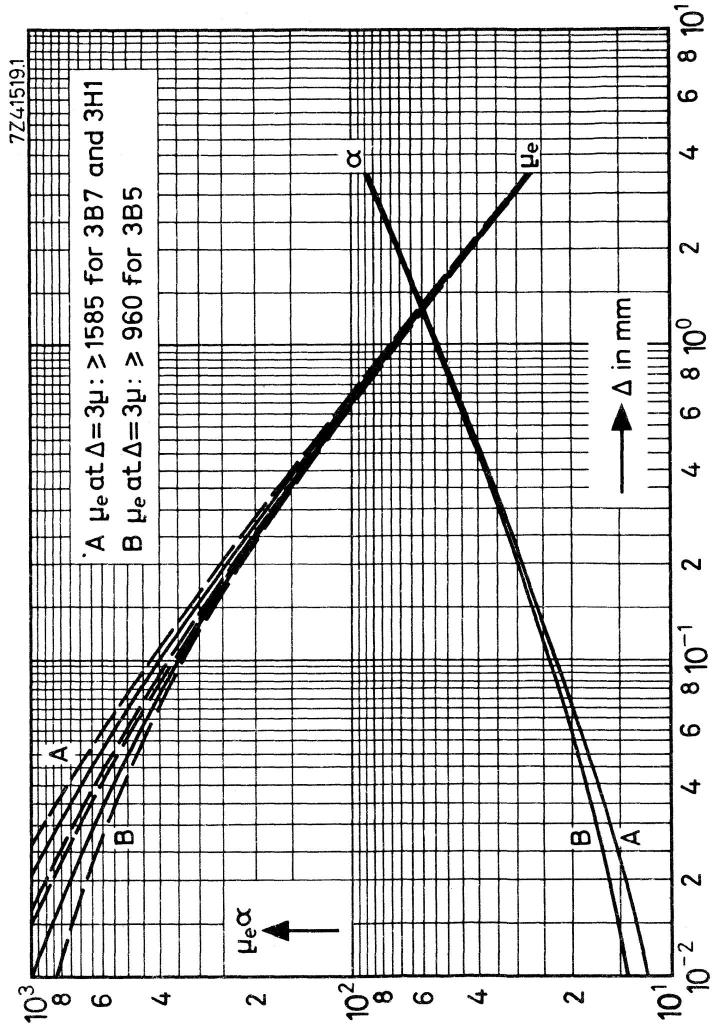
(6) Soldering spring 4322 021 30700

Material: brass, dipsoldered



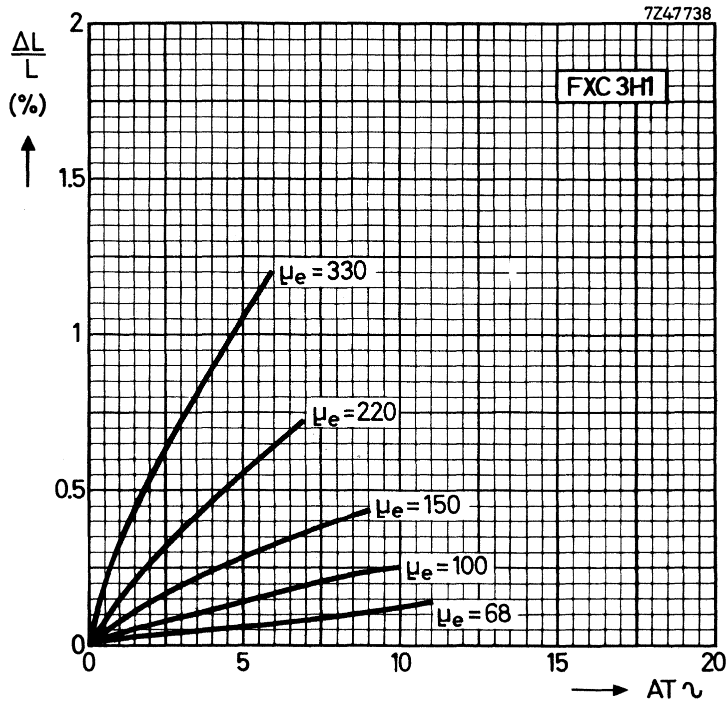
CHARACTERISTIC CURVES

μ_e-α CURVES



Relative effective permeability and turn factor for 1 mH as a function of the air gap length

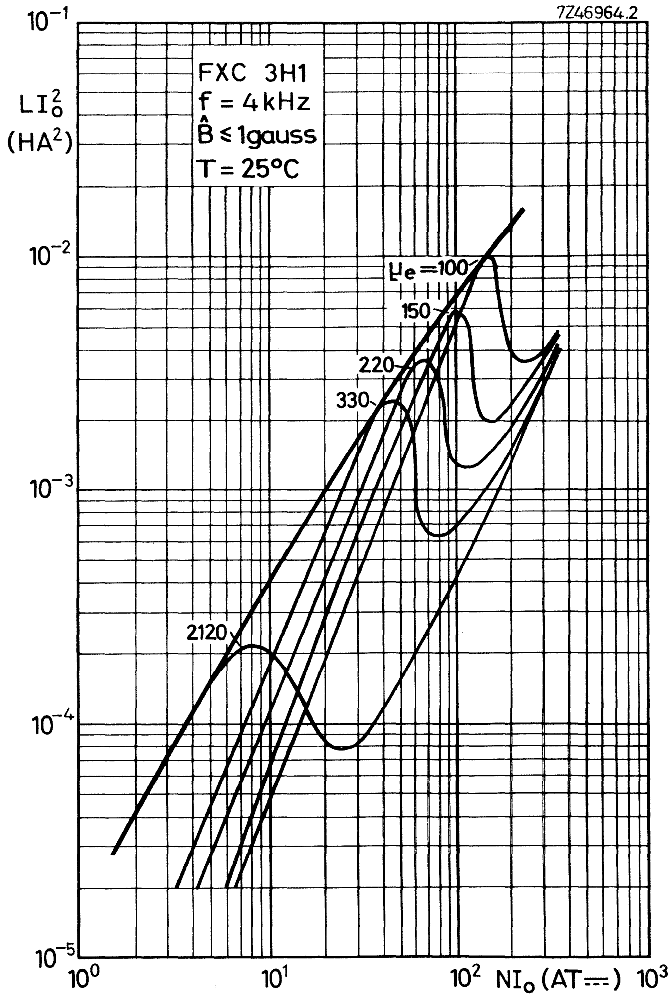
INDUCTANCE VARIATION AS A FUNCTION OF AT ~



HANNA CURVE

Indicating the optimum inductance for a certain μ_e-value and direct current.

Typical values



POTCORES

INTRODUCTION

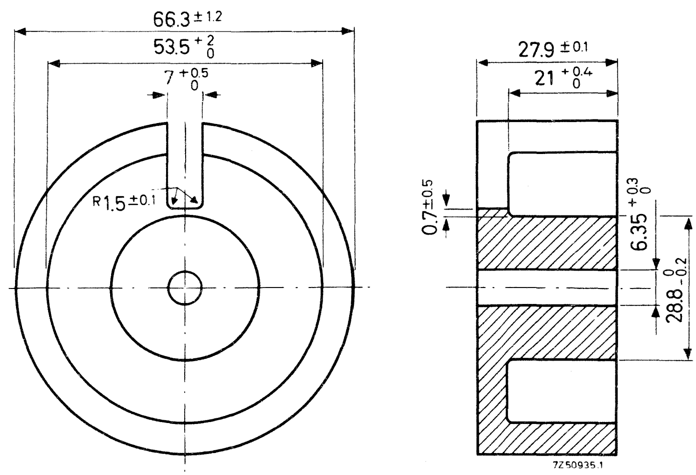
Two types of core can be supplied:

- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted potcores, available to special order. The μ_e values can be chosen from the E_6 standard series of values, the A_L values from the R_5 series.

Potcores and associated parts are ordered by their 12-digit catalog number.

SEPARATE POTCORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalog number
3B5	4322 020 23010
3E1	4322 020 23000
3H1	4322 020 23020

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I	temp. (°C)	grade		
		3B5	3E1	3H1
T.F. x 10^6	+5 to +23			+0.5 to +1.5
	+23 to +55			+0.5 to +1.5
	+23 to +70	0 to +2	-	+0.5 to +1.5[1)]
D.F. x 10^6 (10-100 min)	+23 ± 1	≤ 7.5	-	≤ 4.3

For the combination of two potcore halves randomly chosen from a batch and pressed together with a force of 1700 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II	$\hat{B}$ (Gs)	freq. (kHz)	grade		
			3B5	3E1	3H1
μ_e	≤ 1	4	≥ 1000	≥ 1970	≥ 1695
α	≤ 1	4	≤ 11.7	≤ 8.25	≤ 8.96
$\frac{\tan\delta}{\mu_i} \times 10^6$	≤ 1	4	≤ 2.5	-	≤ 1.4
	≤ 1	10	≤ 5	-	≤ 3.5
	≤ 1	100	≤ 25	-	≤ 13
$q_{2-24-100}$	15-30		≤ 2.5	-	≤ 1.0

Weight (two halves) = 550 g

Core factor and effective dimensions:

Effective length l_e = 12.3 cm

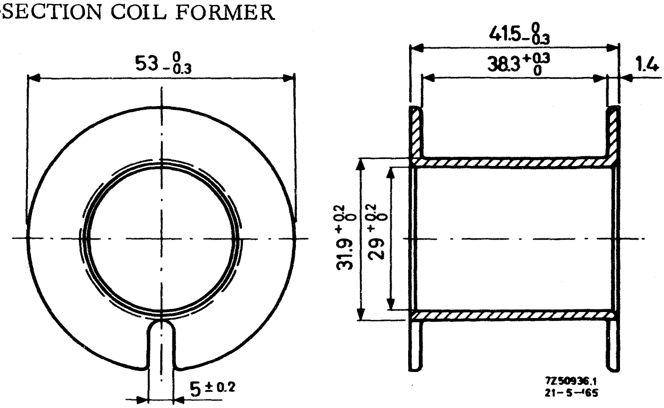
$\Sigma \frac{l_e}{A_e}$ = 1.72 cm^{-1}

Effective volume V_e = 88.3 cm^3

1) For orientation only.

COIL FORMERS

SINGLE-SECTION COIL FORMER



Catalog number	4322 021 31320		D.C. losses	
Material	polycarbonate K486		$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 0.80 \times 10^3 \ \Omega/H$	
Window area	400 mm^2			
Mean length of turn	13 cm			
Max. temperature	130 °C		Weight	11.8 g

SQUARE CORES

SQUARE CORES

INTRODUCTION

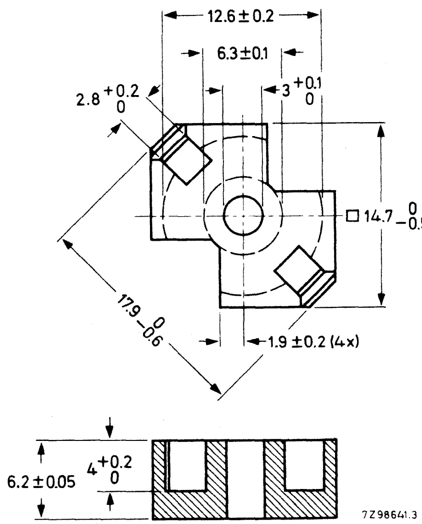
Three types of core can be supplied:
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted cores (2 halves with an airgap) which are provided with a nut for an adjustor. These cores have an inductance factor A_L in accordance with the R5 (R10) range.
- Pre-adjusted cores without nut.

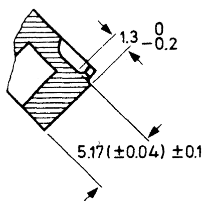
Square cores and associated parts are ordered by their 12-digit catalogue number.

Quantity: a primary pack contains 20 core halves or 10 pre-adjusted cores, so please order in multiples of these quantities.

SEPARATE CORE HALVES

Dimensions in mm





Versions

ferroxcube grade	catalogue number	
3H1	4322 020 25130	
3B7	4322 020 25120	
3D3	4322 020 25140	For grade 3E4
4C6	4322 020 25150	see Pre-adjust-
improved 3E1	4322 020 25180	ed Cores.

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I (Values with a * are for guidance only.)

	temp. (°C)	grade					
		3H1	3B7	3D3	4C6	3E4	impr. 3E1
T.F. x 10^6	+5 to +23	+0.5 to +1.5	−0.6 to +1.0*	−	−2 to +4	−	
	+23 to +55	+0.5 to +1.5	−0.6 to +0.6	−	0 to +6	−	
	+23 to +70	+0.5 to +1.5	−0.6 to +0.6	0 to 2	−	−	
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 12	≤ 10	≤ 1.9*	

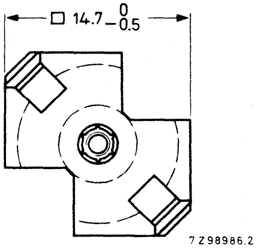
For the combination of two halves randomly chosen from a batch and pressed together with a force of 50 Newton, the values in Table II are guaranteed at 25±10 °C.

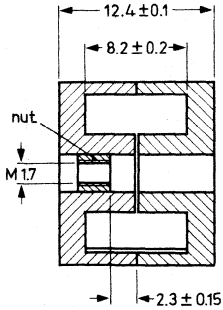
Table II (Values with a * are for guidance only.)

	$\hat{B}$ (Gs)	freq. (MHz)	grade					
			3H1	3B7	3D3	4C6	3E4	impr. 3E1
μ_e	1	0.004	−	−	−	−	−	≥ 2030
	7-10	0.004	−	−	−	−	−	−
	1	0.1	≥ 1270	≥ 1270	≥ 520	≥ 93	−	−
α	1	0.004	−	−	−	−	−	≤ 17.5*
	7-10	0.004	−	−	−	−	−	−
	1	0.1	≤ 22.2*	≤ 22.2*	≤ 34.6*	≤ 81.6*	−	−
A_L	1	0.004	−	−	−	−	−	≥ 3260
	7-10	0.004	−	−	−	−	−	−
	1	0.1	≥ 2030*	≥ 2030*	≥ 830*	≥ 150*	−	−
$\frac{\tan\delta}{\mu_i} \times 10^6$	1	0.004	−	−	−	−	≤ 2.5	≤ 2.5
	1	0.03	≤ 2.5	≤ 2.5	−	−	−	−
	1	0.1	≤ 5	≤ 5	≤ 8	−	≤ 15	≤ 20
	1	0.5	−	−	≤ 14	−	−	≤ 200
	1	1.0	−	−	≤ 30	−	−	−
	1	2.0	−	−	−	≤ 40	−	−
	1	10.0	−	−	−	≤ 100	−	−
$q_{2-24-100}$	15-30	0.004	≤ 1.4	≤ 1.8/≤ 1.4*	−	−	≤ 1.8	≤ 3
	3-12	0.1			≤ 3	≤ 10		

PRE-ADJUSTED CORES

Dimensions in mm





Weight	5.4 g
Mean length of lines of force	l_e = 2.5 cm
Mean area of lines of force	A_e = 0.319 cm^2
	$\sum \frac{l_e}{A_e}$ = 7.84 cm^{-1}
Effective volume	V_e = 0.799 cm^3

Notes to the table on the next page

1. Example of catalogue number:
   A_L = 250, grade 3H1, core with nut, catalogue number 4322 022 75260.
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut.
   The air gap of these types is practically zero and consequently inductance adjustment is not possible.

Cores with standard A_L values [1])

A_L	corre-sponding μ_e value	tol. on induct-ance (%)	catal. No. 4322 022 7.... with nut / 4322 022 5.... without nut					
			3B7	3H1	3D3	4C6	3E4	impr.3E1
25	15.6	± 1				5810	–	–
40	24.9	± 1	5020	5220	5420	5820	–	–
63	39.4	± 1	5030	5230	5430	5830	–	–
100	62.4	± 2	5040	5240	5440	–	–	–
160	100	± 2	5050	5250	5450	–	–	–
200	122	± 2	5170	5370	–	–	–	–
250	156	± 2	5060	5260	–	–	–	–
315	197	± 2	5070	5270	–	–	–	–
400	249	± 2	5080	5280	–	–	–	–
630	394	± 3	5100	5300	–	–	–	–
1000	624	± 10	5110	5310	–	–	–	–
1250	780	± 10	5190	5390	–	–	–	–
2700	1690	± 25	5000	5200	–	–	–	–
4750	3000	± 25	–	–	–	–	–	5800*
6000	3750	± 25	–	–	–	–	5900*	–

Inductance $L = N^2 A_L$ (in 10^{-9}H)

[1]) See Notes on the previous page.

* Only available without nut

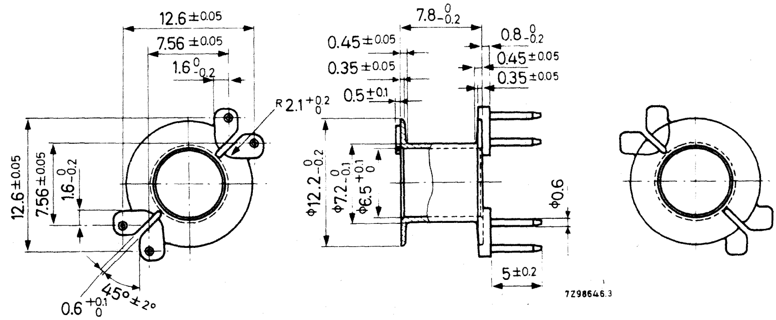
COIL FORMERS

GENERAL

Four types of coil former can be supplied:
- with 1 section and 4 pins
- with 2 sections and 4 pins
- with 1 section and 6 pins
- with 2 sections and 6 pins

The arrangement of the soldering pins is suitable for both 0.1" and 2.50 mm grid, see "Mounting".

SINGLE-SECTION, 4-PIN COIL FORMER



Catalogue number 4322 021 31720

Material: reinforced polyester with phosphorbronze dipsoldered pins

Window area 17.3 mm^2

Mean length of turn 3.0 cm

Max. temperature 180 °C

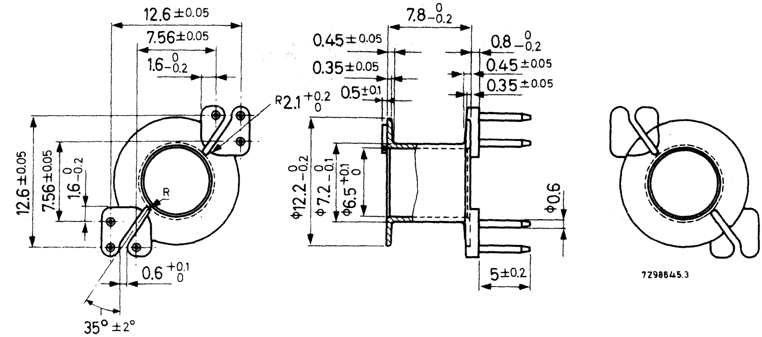
Solderability according to I.E.C.68-2-20, part 2, test T

D.C. losses:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 18.9 \times 10^3 \ \Omega/H$$

Weight 0.20 g

SINGLE-SECTION, 6-PIN COIL FORMER



Catalogue number 4322 021 31710

Material: reinforced polyester with phosphorbronze dipsoldered pins

Window area	17.3 mm^2
Mean length of turn	3.0 cm
Max. temperature	180 °C

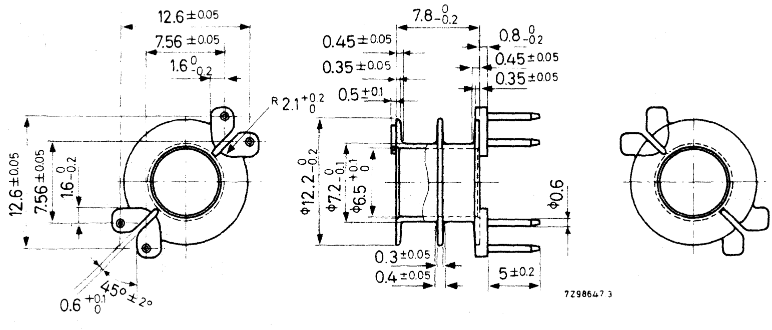
Solderability according to I.E.C.68-2-20, part 2, test T

D.C. losses:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 18.9 \times 10^3 \ \Omega/H$$

Weight 0.20 g

TWO-SECTION, 4-PIN COIL FORMER



Catalogue number 4322 021 31740

Material: reinforced polyester with phosphorbronze dipsoldered pins

Window area	2 x 8.2 mm^2
Mean length of turn	3.0 cm
Max. temperature	180 °C

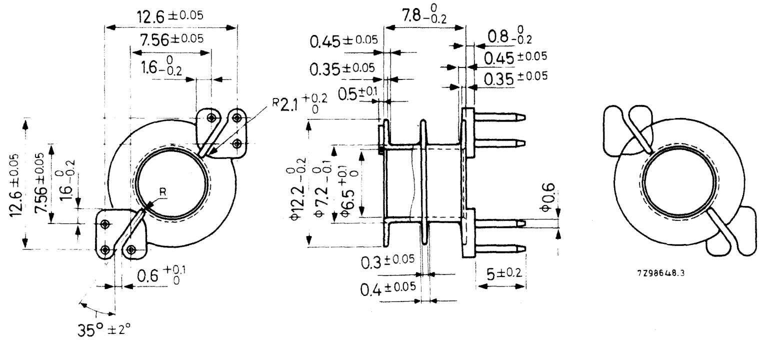
Solderability according to I.E.C.68-2-20, part 2, test T

D.C. losses:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 19.9 \times 10^3 \ \Omega/H$$

Weight 0.20 g

TWO-SECTION, 6-PIN COIL FORMER



Catalogue number 4322 021 31730

Material: reinforced polyester with phosphorbronze dipsoldered pins

Window area 2 x 8.2 mm^2

Mean length of turn 3.0 cm

Max. temperature 180 °C

Solderability according to I.E.C.68-2-20, part 2, test T

D.C. losses:

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 19.9 \times 10^3 \ \Omega/H$$

Weight 0.20 g

INDUCTANCE ADJUSTORS

ADJUSTORS

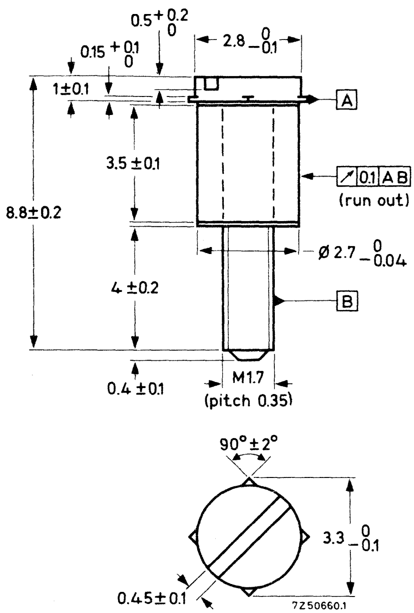


Fig. A

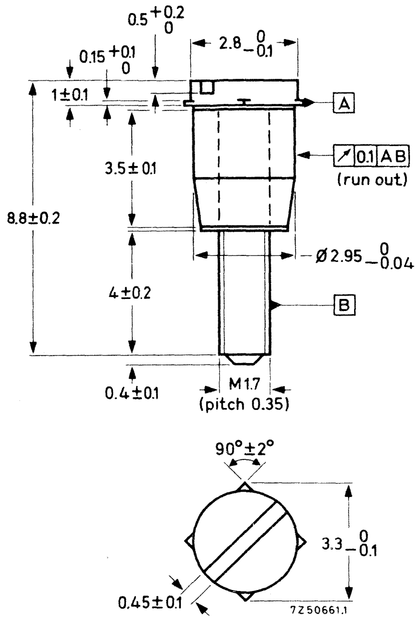


Fig. B

The tolerances on inductance of the pre-adjusted cores (without adjustor) are given below "Pre-adjusted Cores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil (see following pages).
The adjustor is screwed through the centre hole of the core into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower A_L value.
The influence of the adjustor on the variability of the inductance is negligible. The maximum permissible temperature is 110 °C.
The table shows the type of adjustor recommended for different square cores.

Table I, available types:

Fig.	colour	catalogue number
A	brown	4322 021 30730
A	green	4322 021 30760
A	red	4322 021 30770
B	yellow	4322 021 30960
B	white	4322 021 30970
B	grey	4322 021 31080

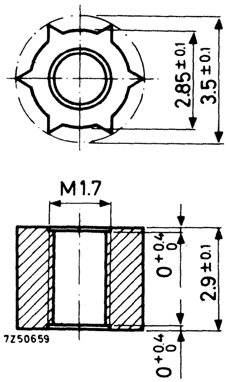
Table II, recommended application

A_L	3B7/3H1/3D3 catalogue number
160	4322 021 30970
200	4322 021 30970
250	4322 021 30730 or 4322 021 30970
315	4322 021 30730
400	4322 021 30730
630	4322 021 31080

The adjustors are packed in bags of 100, so please order in multiples of 100.

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut them selves.



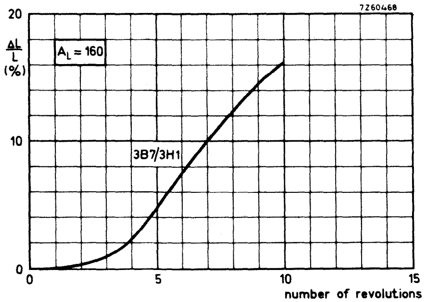
Catalogue number	4322 021 30140
Material	polycarbonate
Max. impregnation temperature during 24 hours	120 °C
Recommended distance from mating surface to nut	2.3 ± 0.15 mm

The nuts are packed in bags of 100, so please order in multiples of 100.

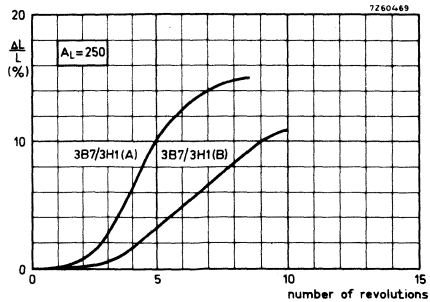
ADJUSTMENT CURVES

Distance between nut and mating surface = 2.3 mm for all A_L values

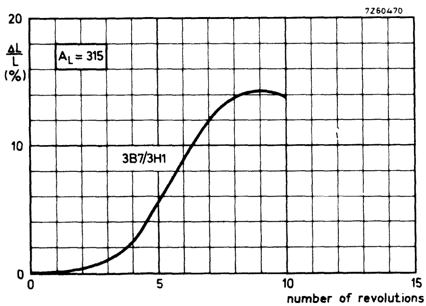
Adjustor 4322 021 30970



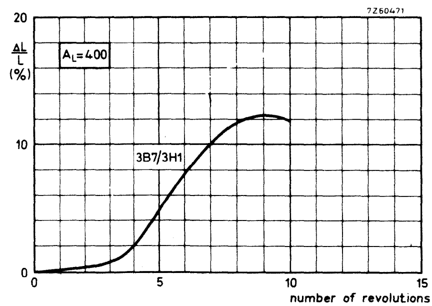
Curve A: adjustor 4322 021 30730
Curve B: adjustor 4322 021 30970



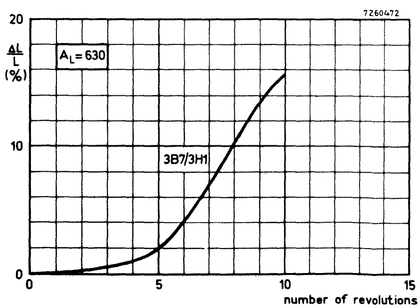
Adjustor 4322 021 30730



Adjustor 4322 021 30730

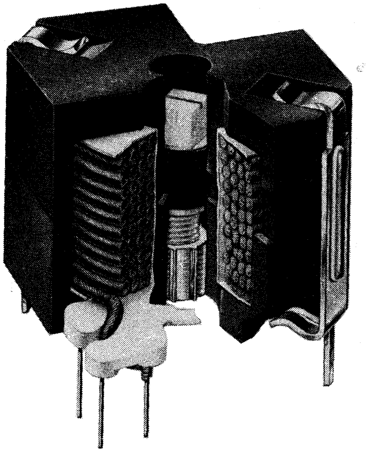


Adjustor 4322 021 31080



ASSEMBLING AND MOUNTING

ASSEMBLING



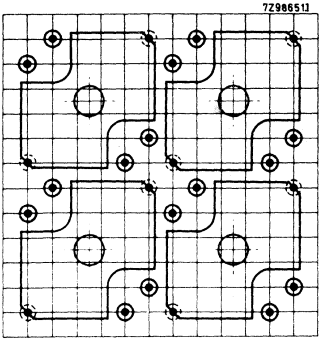
RZ 25252

The drawing shows the simplicity of the assembly; the core halves are held together by two clips. The tags of the clips are used for mechanical fastening and/or for earthing.
For a stable inductance it is recommended to cement the lower flange of the coil former in the lower core half.

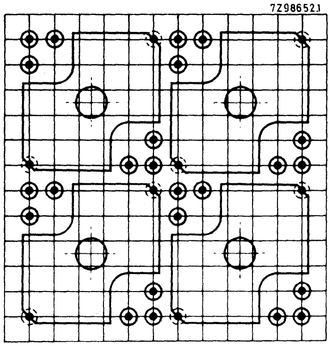
The use of a tool for attaching the clips is recommended. Drawings of a simple tool for this purpose are available under number 4322 058 00150.

MOUNTING

The soldering pins of coil formers and clips are so arranged that they will fit printed-wiring boards with a 0.1 in grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 2.4 mm. The recommended hole diameter in the board is 1.0 to 1.3 mm.

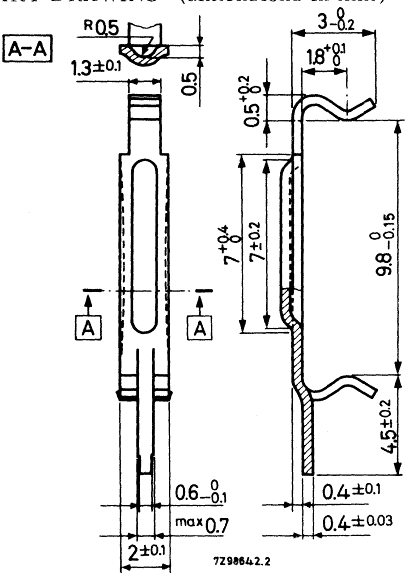


⊙ 1)



⊙ 1)

PART DRAWING (dimensions in mm)



Clip 4322 021 31780
Material: steel; nickel and gold plated

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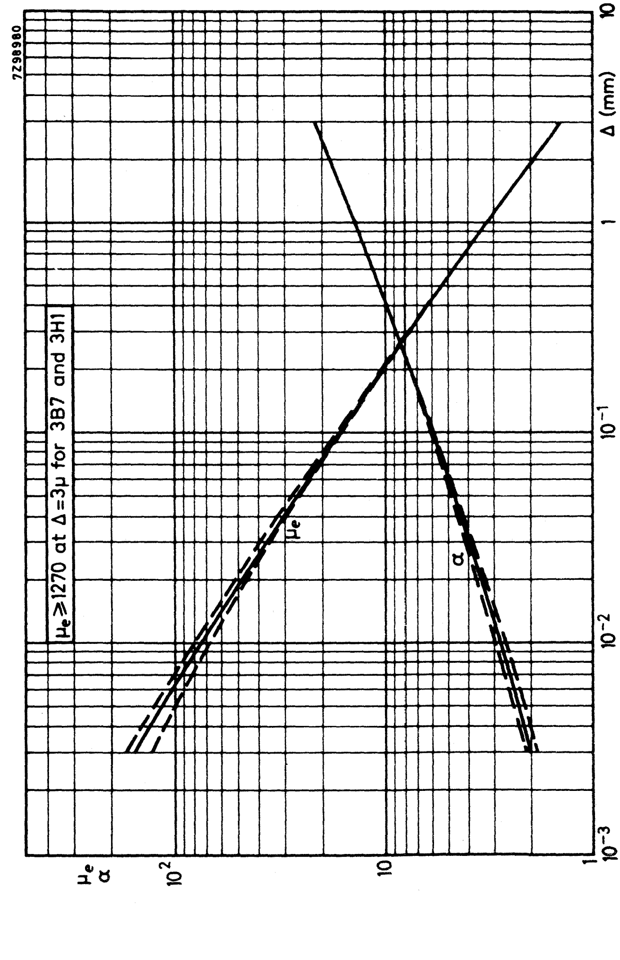
1) Holes for tag on clip 3422 021 31780 (earth points).

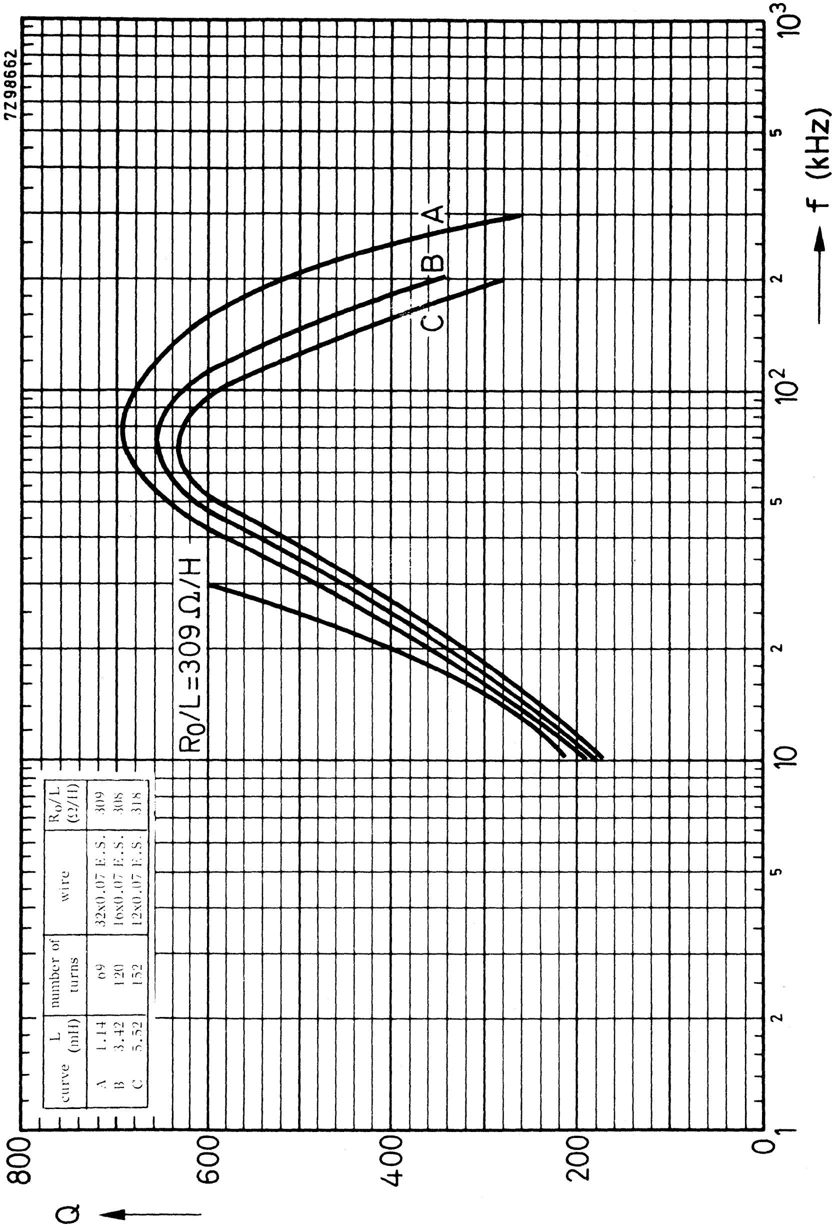
CHARACTERISTIC CURVES

μ_e - α CURVES



Relative effective permeability and turn factor for 1 mH as a function of the air gap length

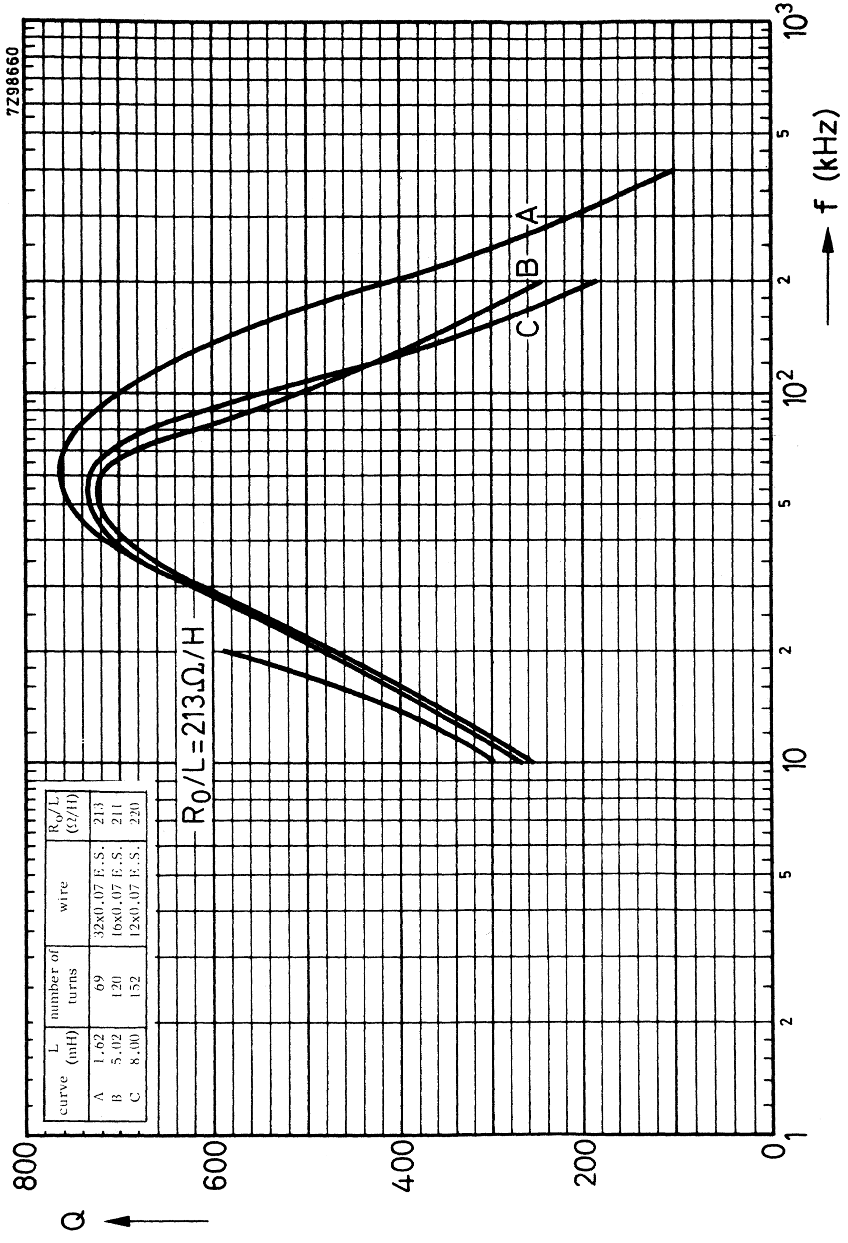
TYPICAL Q-CURVES FOR FXC 3B7 AND 3H1



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	1.14	69	32x0.07 E.S.	309
B	3.42	120	16x0.07 E.S.	308
C	5.52	152	12x0.07 E.S.	318

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER (Provisional curves)

$\mu_e = 150$

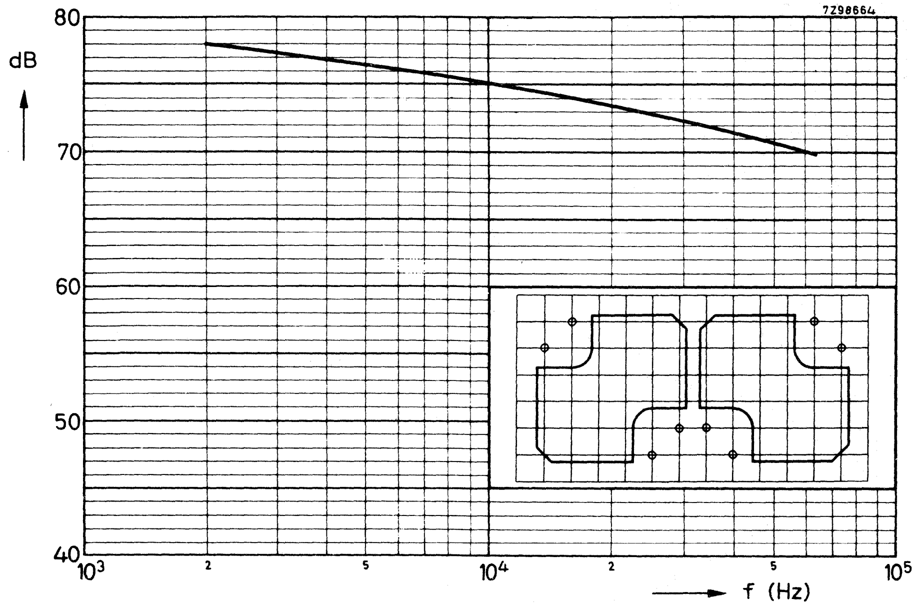


curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	1.62	69	32x0.07 E.S.	213
B	5.02	120	16x0.07 E.S.	211
C	8.00	152	12x0.07 E.S.	220

FXC 3B7/3H1 SINGLE-SECTION COIL FORMER (Provisional curves)

$\mu_e = 220$

CROSSTALK ATTENUATION



SQUARE CORES

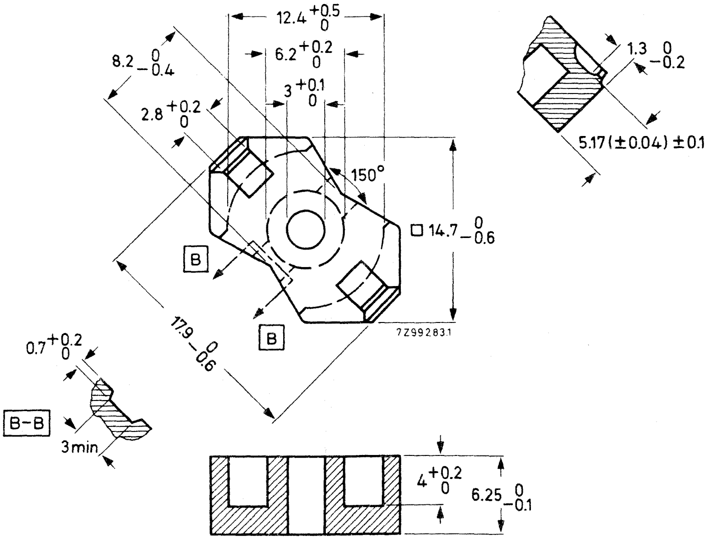
INTRODUCTION

Three types of core can be supplied:
- Separate core halves, air gap to be ground by the user himself.
- Pre-adjusted cores (2 halves with an airgap) which are provided with a nut for an adjustor. These cores have an inductance factor A_L in accordance with the R5 (R10) range.
- Pre-adjusted cores without nut.

Square cores and associated parts are ordered by their 12-digit catalogue number.
Quantity: a primary pack contains 20 core halves or 10 pre-adjusted cores, so please order in multiples of these quantities.

SEPARATE CORE HALVES

Dimensions in mm



Versions

ferroxcube grade	catalogue number
3H1	4322 020 25020
3B7	4322 020 25040
3D3	4322 020 25060
4C6	4322 020 25080
improved 3E1	4322 020 25170
3E4	(pre-adjusted only)

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I

	temp. (^{o}C)	grade					
		3H1	3B7	3D3	4C6	impr.3E1	**3E4**
T.F. x 10^6	+5 to +23	+0.5 to +1.5	**-0.6 to +0.6***	–	-2 to +4	–	–
	+23 to +55	+0.5 to +1.5	**-0.6 to +0.6**	–	0 to +6	–	–
	+23 to +70	+0.5 to +1.5	-0.6 to +0.6	0 to 2	–	–	–
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	≤ 12	≤ 10	–	–

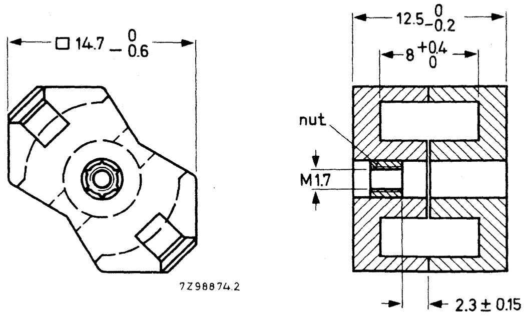
For the combination of two halves randomly chosen from a batch and pressed together with a force of 50 Newton, the values in Table II are guaranteed at 25±10 ^{o}C.

Table II (Values with a* are for guidance only.)

	$\hat{B}$ (Gs)	freq. (MHz)	grade					
			3H1	3B7	3D3	4C6	impr.3E1	**3E4**
μ_e	1	0.004	–	–	–	–	≥ 2060*	–
	7-10	0.004	–	–	–	–	–	
	1	0.1	≥ 1280	≥ 1280	≥ 520	≥ 93	–	–
α	1	0.004	–	–	–	–	≥ 18.2*	–
	7-10	0.004	–	–	–	–	–	
	1	0.1	≤ 23.1*	≤ 23.1*	≤ 36.3*	≤ 85.8*	–	–
A_L	1	0.004	–	–	–	–	≥ 3000	–
	7-10	0.004	–	–	–	–	–	
	1	0.1	≥ 1870*	≥ 1870*	≥ 760*	≥ 136*	–	–
$\frac{\tan\delta}{\mu_i}$ x 10^6	1	0.004					≤ 2.5	
	1	0.03	≤ 2.5	≤ 2.5				
	1	0.1	≤ 5	≤ 5	≤ 8		≤ 20	≤ 15
	1	0.5			≤ 14		≤ 200	
	1	1.0			≤ 30			
	1	2.0				≤ 40		
	1	10.0				≤ 100		
q2-24-100	15-30	0.004	≤ 1.4	≤ 1.8/≤ 1.4*			≤ 3.0	≤1.8
	3-12	0.1			≤ 3.0	≤ 15		

PRE-ADJUSTED CORES

Dimensions in mm



Weight	5.2 g
Mean length of lines of force	l_e = 2.7 cm
Mean area of lines of force	A_e = 0.31 cm^2
	$\sum \frac{l_e}{A_e}$ = 8.6 cm^{-1}
Effective volume	V_e = 0.84 cm^3

Notes to the tables on the next page

1. Example of catalogue number:
   A_L = 250, grade 3H1, core with nut, catalogue number 4322 022 67260.
2. The inductance will only be within the given tolerance if the winding space of the coil former is completely filled.
3. The versions marked with a * are only available without nut.
   The air gap of these types is practically zero and consequently **inductance adjustment is not possible.**

Cores with A_L values [1])

A_L	corre-sponding μ_e value	tol. on induct-ance (%)	catal. No. 4322 0226....with nut 4322 0224....without nut					
			3B7	3H1	3D3	4C6	3E4	impr.3E1
25	17.1	±1				7810		
40	27.4	±1			7420	7820		
63	43.1	±1			7430	7830		
100	62.0	±2			7440			
160	110	±2	7050	7250	7450			
200	137	±2	7060	7350				
250	171	±2	7070	7260				
315	216	±2	7080	7270				
400	274	±2	7100	7280				
630	431	±3	7110	7300				
1000	620	±10	7190	7310				
1250	856	±10	7000	7390				
2500	1710		–	7200				
4400	3010	±25	–	–	–	–	–	7800*
5500	3770	±25	–	–	–	–	79[illegible]*	–

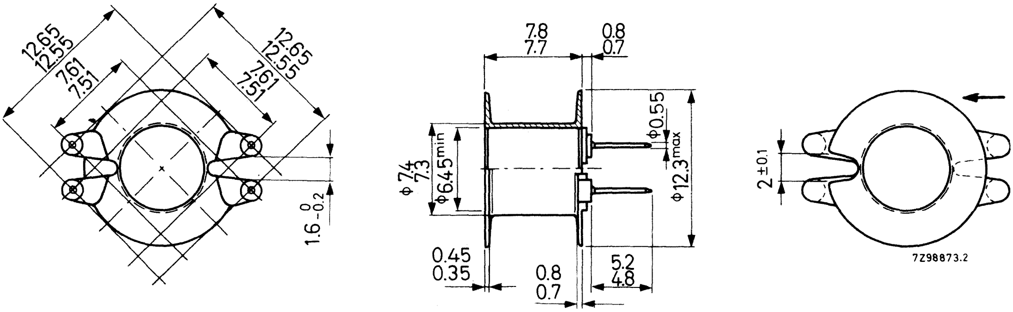
Inductance $L = N^2 A_L$ (in 10^{-9}H)

1) See Notes on the previous page.

* Only available without nut

COIL FORMERS

SINGLE-SECTION, FOUR-PIN COIL FORMER



Catalogue number	4312 021 29240
Material	diallylphthalate blue
Window area	16.2 mm^2
Mean length of turn	3 cm
Max. temperature	180 °C

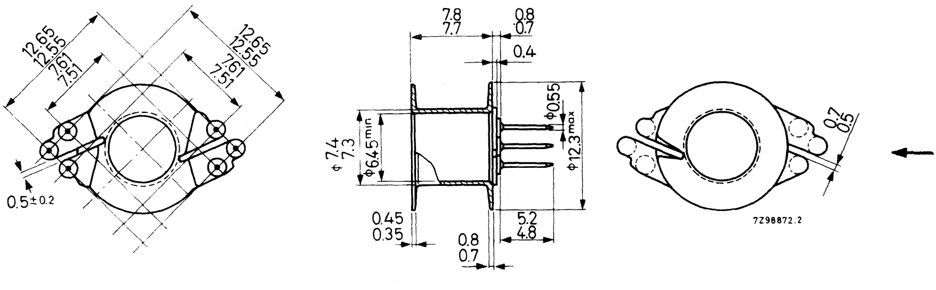
D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 22.6 \times 10^3 \ \Omega/H$$

Solderability according to I.E.C.68-2-20, part 2, test T

Weight 0.4 g

SINGLE-SECTION, SIX-PIN COIL FORMER



Catalogue number	4312 021 29250
Material	diallylphthalate blue
Window area	16.2 mm^2
Mean length of turn	3.0 cm
Max. temperature	180 °C

D.C. losses

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 22.6 \times 10^3 \ \Omega/H$$

Solderability according to I.E.C.68-2-20, part 2, test T

Weight 0.4 g

INDUCTANCE ADJUSTORS

ADJUSTORS

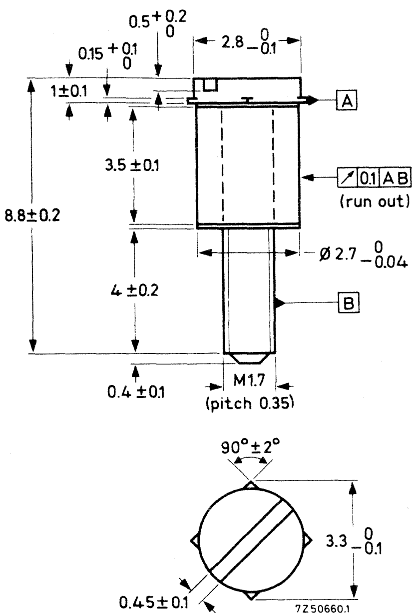


Fig. A

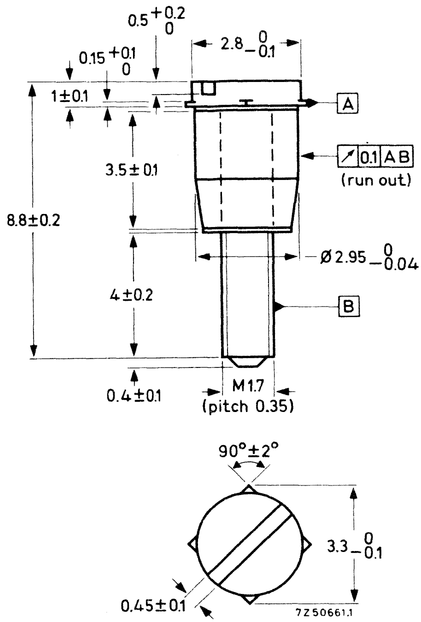


Fig. B

The tolerances on inductance of the pre-adjusted cores (without adjustor) are given below "Pre-adjusted Cores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03 % by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil (see following pages).

The adjustor is screwed through the centre hole of the core into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower A_L value.

The influence of the adjustor on the variability of the inductance is negligible. The maximum permissible temperature is 110 °C.

Table II shows the type of adjustor recommended for different cores.

Table I, available types

Fig.	colour	catal. No.
A	brown	4322 021 30730
B	yellow	4322 021 30960
B	white	4322 021 30970
B	grey	4322 021 31080

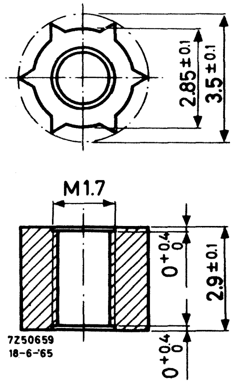
Table II, recommended application

A_L	catal. No.
160	4322 021 30960
250	4322 021 30970
315	4322 021 30730
400	4322 021 30730
630	4322 021 31080

The adjustors are packed in bags of 100, so please order in multiples of 100.

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

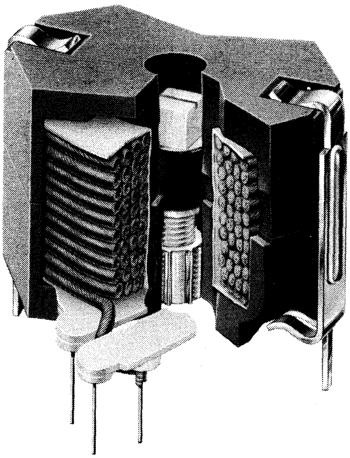


Catalogue number	4322 021 30140
Material	polycarbonate
Max. impregnation temperature during 24 hours	120 °C
Recommended distance from mating surface to nut	2.3 ± 0.15 mm

The nuts are packed in bags of 100, so please order in multiples of 100.

ASSEMBLING AND MOUNTING

ASSEMBLING



A 52776

Cementing

During the cementing procedure care must be taken that the centre holes are kept in one line.

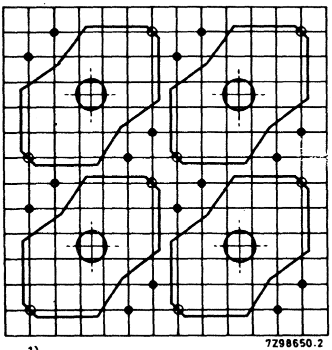
Assembly with clips

The core halves can be clamped together in an easy way by using two clips. The tags of the clips are used for mechanical fastening and/or for earthing.
For a stable inductance it is recommended to cement the lower flange of the coil former in the lower core half.

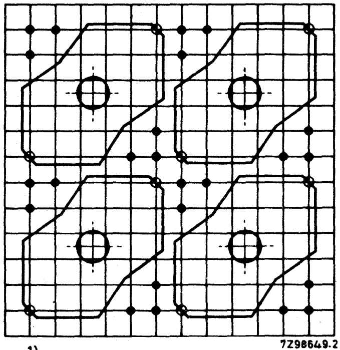
The use of a tool for attaching the clips is recommended. Drawings of a simple tool for this purpose are available under number 4322 058 00150

MOUNTING

The soldering pins of coil formers and clips are so arranged that they will fit printed-wiring boards with a 0.1 in grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 2.4 mm. The recommended hole diameter in the board is 1.0 to 1.3 mm.

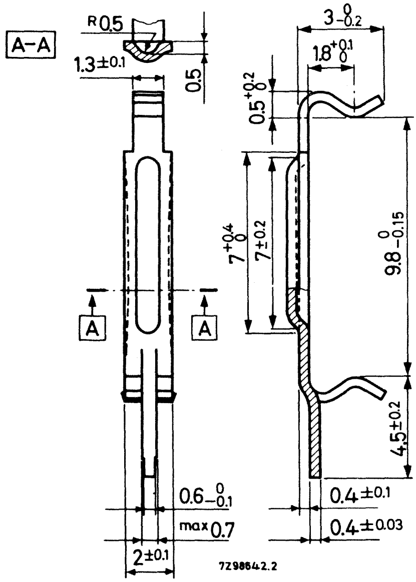


o [1)]



o [1)]

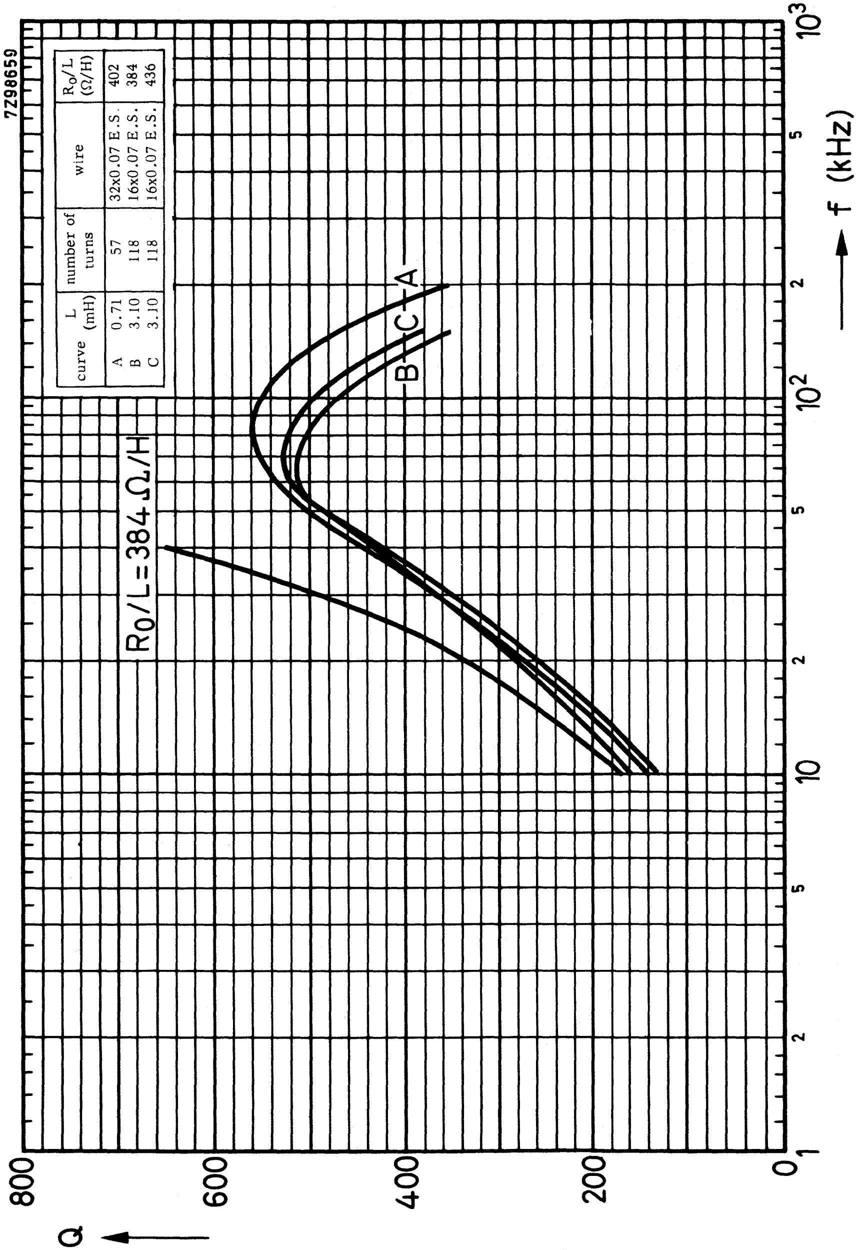
PART DRAWING (dimensions in mm)



Clip 4322 021 31780
Material: steel, nickel and gold plated

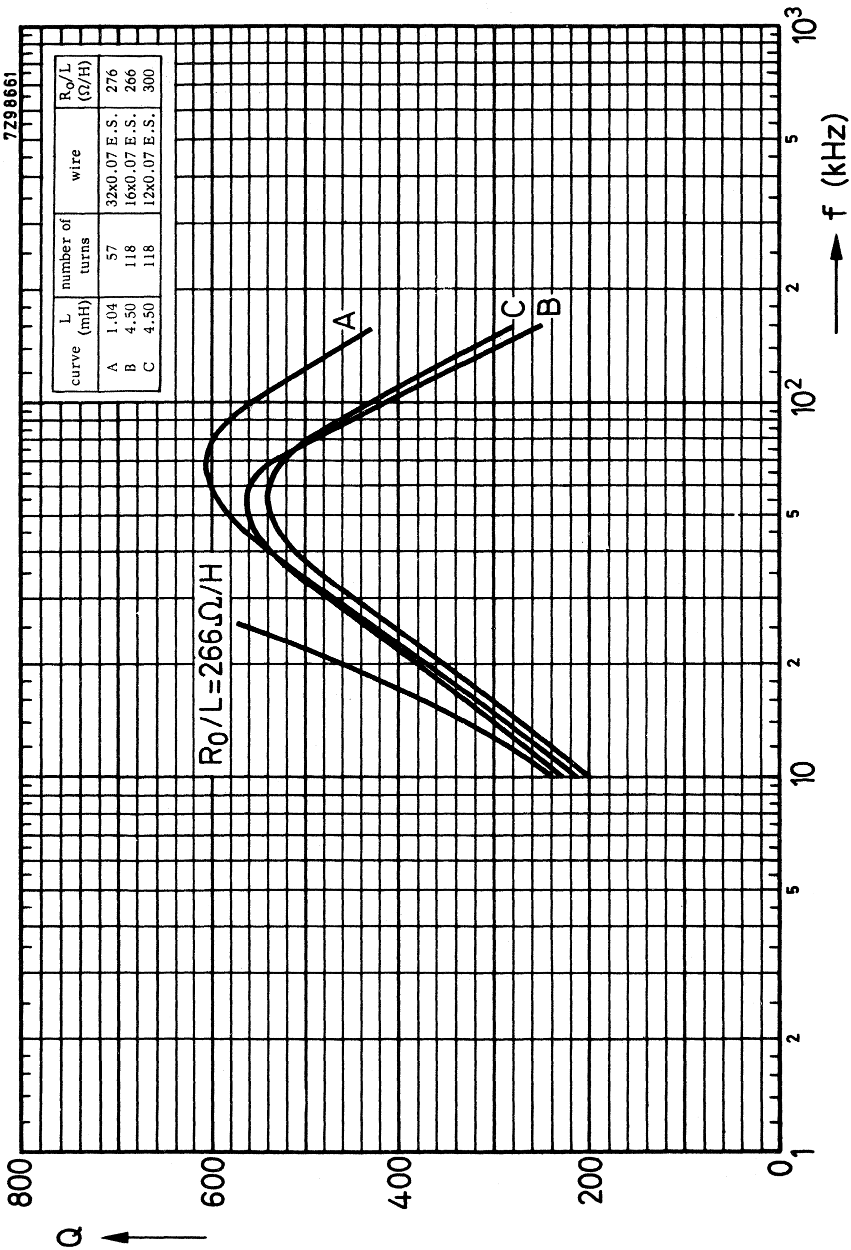
[1]) Holes for tag on clip 3422 021 31780 (earth points).

CHARACTERISTIC CURVES



curve	L (mH)	number of turns	wire	R_0/L (Ω/H)
A	0.71	57	32x0.07 E.S.	402
B	3.10	118	16x0.07 E.S.	384
C	3.10	118	16x0.07 E.S.	436

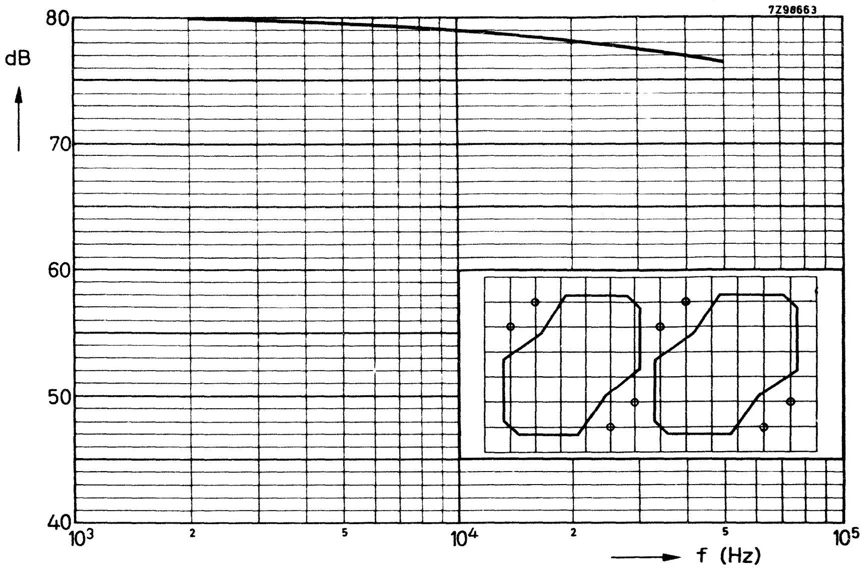
FXC 3B7/3H1 SINGLE-SECTION COIL FORMER (Provisional curves)
$\mu_e = 150$



FXC 3B7/3H1 SINGLE-SECTION COIL FORMER (Provisional curves)

$\mu_e = 220$

CROSSTALK ATTENUATION



Ferroxcube transformer cores

GENERAL

INTRODUCTION

Although potcores can often be used with much success for transformers, there are a number of specific shapes available, such as E-, X-, H-cores and toroids, which have especially been designed for this purpose. For a short description of these shapes the relevant sections should be consulted.

At higher frequencies they are superior to dust or laminated cores because of the low eddy current losses of ferroxcube.

The high permeability of ferroxcube makes it suitable for low frequencies as well, especially H-cores and toroids in the 3E2 and 3E3 grades, which have a μ_i value of > 5000 and $> 10\,000$ respectively.

At frequencies of several kHz ferroxcube transformer cores are also very suitable for power applications. Preferred shapes for these applications are E-, U- and X-cores.

SURVEY OF SYMBOLS

l_e — effective length of the magnetic path in cm

A_e — cross section of a homogeneous part of the core in cm^2

μ_i — relative initial permeability, defined by

$$\mu_i = \lim_{H \to 0} \frac{B}{H}$$

μ_e — relative effective permeability, defined by

$$\mu_e = \frac{\Sigma \frac{l_e}{A_e}}{\Sigma \frac{l_e}{\mu_i A_e}}$$

μ_{dif} — relative differential permeability, defined by

$$\mu_{dif} = \frac{dB}{dH}$$

V_e — effective volume of a core in cm^3 = volume of an ideal toroid in the same material grade and with the same magnetic properties as the core. V_e is calculated by:

$$V_e = \frac{\left(\Sigma \frac{l_e}{A_e} \right)^3}{\left(\Sigma \frac{l_e}{A_e^2} \right)^2} \quad cm^3$$

Δ — length of the air gap in mm

α — turns factor = number of turns for 1 mH

A_L — inductance factor in nanohenry per $turn^2$ $(1\ nH = 10^{-9} H)$

$\hat{H}$ — peak field strength in oersted

$\hat{B}$ — peak induction in gauss

AT — amperes x turns

N — number of turns

I_e — d.c. current in amperes

Curie point — critical temperature in °C above which the ferromagnetic body is paramagnetic

$D.F. = \frac{\mu_1 - \mu_2}{\mu_1^2 \log \frac{t2}{t_1}}$ disaccomodation factor, which gives the permeability variation of the core, measured between 10 and 100 minutes after demagnetisation.

$q_{2-24-100}$ constant for hysteresis losses standardized for an effective volume of 24 cm^3, μ_e = 100 and measured between two currents, corresponding with two B_{max} values.

At 800 Hz for a given volume V_e and for an equivalent permeability μ_e, we obtain:

$$q_{2-V-\mu} = q_{2-24-100} \times \left(\frac{\mu_e}{100}\right)^{3/2} \times \sqrt{\frac{24}{V_e}} \quad \Omega/H^{3/2}\ mA$$

$$\frac{R_h}{L} = q_{2-V-\mu} \times \sqrt{L} \times i \times \frac{f}{800} \quad \Omega/H$$

(L in henry, f in Hz and i in mA)

ρ specific resistance in Ωcm measured with d.c. current

$\frac{\tan \delta}{\mu_i}$ constant for eddy current and residual losses together at a certain frequency, determined at $\hat{B} \leq 1$ gauss through the coil. The resulting R/L value for eddy current and residual losses is:

$$\frac{R}{L} = \frac{\tan \delta}{\mu_i} \times \mu_e \times 2\pi f \ \Omega/H \ (f \text{ in Hz})$$

DETERMINING THE A_L-AND μ_e-VALUE

The A_L- or α-factor of transformer cores is determined with the following number of turns:

core type	number of turns	wire diam. (mm)	catalog number of measuring coil
E20	60	0.30	3U71065/14
E30	50	0.30	3U71065/15
E42	35	0.50	3U71065/16
E55	25	1.2	3U71065/3
E65	35	1.0	3U71065/10
X22	175	0.40 ortho-	7622 301 04011
X30	175	0.70 cyclic	7622 301 04111
X35	251	0.70 wound	7622 301 04211
H7	25 (one layer)	0.15	-
H10	20 (one layer)	0.20	-
H16	30 (one layer)	0.25	-
H20	30 (one layer)	0.30	-

From the measured value of L, A_L and α can be calculated using the following formulas:

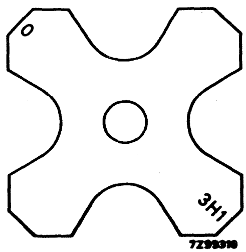
$$L = N^2 A_L \quad \text{and} \quad \alpha = \frac{10^3}{\sqrt{A_L}} \qquad \text{(L in nH)}$$

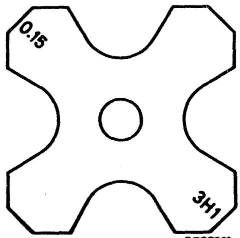
and the value of μ_e from

$$L = \frac{0.4\ \pi\ N^2 . \mu_e . 10^{-5}}{\Sigma \frac{l_e}{A_e}} \qquad \text{(L in mH)}$$

$\Sigma \frac{l_e}{A_e}$ can be found in the pages relevant to the transformer cores.

MARKING

type	type designation	example	position of marking
E cores without airgap length > 26 mm	E and dimensions material date manufacturer	E 42/21/15 3E1 B7A	on half of the backface [E42/21/15 3E1 B7A |]
length < 26 mm	material	3E1	on half of the backface [3E1 |]
	E and dimensions date manufacturer	E 20/10/5 B7A	on the primary pack
E cores with airgap length > 26 mm	E and dimensions material airgap	E 42/21/15 3E1 0.9	on half of the backface [E42/21/15 3E1 0.9 |]
	date manufacturer	B7A	on the primary pack
length < 26 mm	material, airgap	3E1 0.05	on the backface [3E1 | 0.05]
	E and dimensions date manufacturer	E 20/10/5 B7A	on the primary pack
cross cores without airgap	material zero (0)	3H1 0	on the back of two opposite legs 
	catalogue number date manufacturer	4322 020 23752 B7A	on the primary pack

type	type designation	example	position of marking
cross cores with airgap	material airgap	3H1 0.15	on the back of two opposite legs 
	catalogue number date manufacturer	4322 020 23982 B7A	on the primary pack

MOUNTING DATA

Special tools have been designed for bending the lips of the containers of X and H-cores.
We do not supply these tools, but we are prepared to provide drawings of them on request.

Catalogue numbers of the tools are:

for X22	4322 058 00080
X30	4322 058 00090
X35	4322 058 00100
H7	4322 058 00110
H10	4322 058 00120
H16	4322 058 00140
H20	4322 058 00130

See also the remarks with regard to the mounting parts in the pages relevant to the transformer cores.

E- AND I-CORES

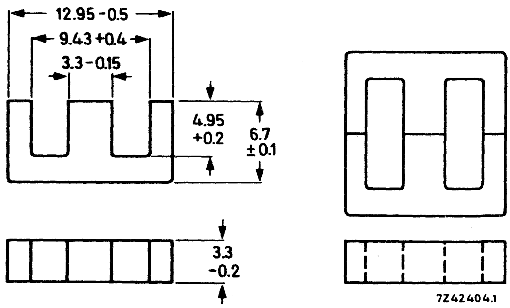
INTRODUCTION

The ferroxcube E and I-cores are typical transformer cores. They can be used from voice frequencies up to some MHz.
Ferroxcube E and I-cores can also be used successfully for power applications. In comparison with conventional laminated iron cores a much higher frequency can be chosen, as a result of the very low eddy current losses of the ferroxcube. In many cases the dimensions can be smaller as compared with the same conventional cores.

The hysteresis losses, and consequently the third harmonic distortion of ferroxcube cores are lower than that of other materials.
For the low induction applications an additional advantage of ferroxcube E and I-cores is, that the intitial permeability remains constant over a very large frequency range.

The mating surfaces are ground with a roughness of $< 0.8\ \mu m$.

E – CORE



Ferroxcube grade	3H1
Approximate weight	0.83 g
Catalogue number	4322 020 34510

A transformer core can be built up by combining an even number of E-cores. A shape that is often chosen is the shell type transformer 13/13/3 composed of two cores type E13/7/3.

shell type transformer	13/13/3

Dimensional quantities

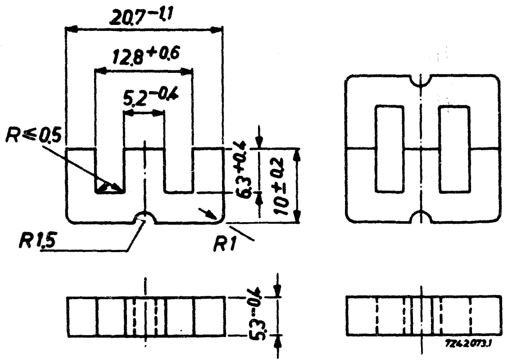
mean length of lines of force	l_e	=	3.14	cm
mean area of lines of force	A_e	=	0.101	cm^2
	$\Sigma \frac{l_e}{A_e}$	=	30.9	cm^{-1}
effective volume	V_e	=	0.318	cm^3

Electrical properties at 25 ±10 °C

at $\Delta = 0$:	μ_e	$\geq$ 1390
	A_L	$\geq$ 566
	α	$\leq$ 42.1
at 4 kHz and $\hat{B}$ between 15 and 30 gauss	$q_{2\text{-}24\text{-}100}$	$\leq 1.8\ \Omega/H^{3/2}$ mA

Mechanical force at which the electrical properties are determined is 30 Newton
Number of turns for L mH $N = \alpha\sqrt{L}$.

E-CORES



The dimensions are according to German specification D.I.N. 41295.

Ferroxcube grade	3E1	improved 3E1
Approximate weight	4 g	4g
Cat. number of E-core	4322 020 34530	4322 020 34830

A transformer core can be built up by combining an even number of E-cores. A shape that is often chosen is the shell type transformer 20/20/5 composed of two cores type E 20/10/5.

shell type transformer 20/20/5

Dimensional quantities:

mean length of lines of force	l_e =	4.28	cm
mean area of lines of force	A_e =	0.312	cm^2
	$\Sigma \frac{l_e}{A_e}$ =	13.7	cm^{-1}
effective volume	V_e =	1.34	cm^3

Electrical properties at 25 ± 10 °C		3E1	improved 3E1
at Δ = 0:	μ_e	= 1650-2760	2100-3500 *)
	A_L	= 1515-2520	1925-3200
	α	≤ 25.7	
at 4 kHz and $\hat{B}$ between 15 and 30 gauss	q2-24-100	≤ 7	≤ 3 Ω/($H^{3/2}$.mA)
at 4 kHz and $\hat{B} \leq 1$ gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 2.5
at 100 kHz and $\hat{B} \leq 1$ gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 20
at 500 kHz and $\hat{B} \leq 1$ gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 200

Mechanical force at which the electrical properties are determined is 55 Newton

Number of turns for L mH $N = \alpha\sqrt{L}$.

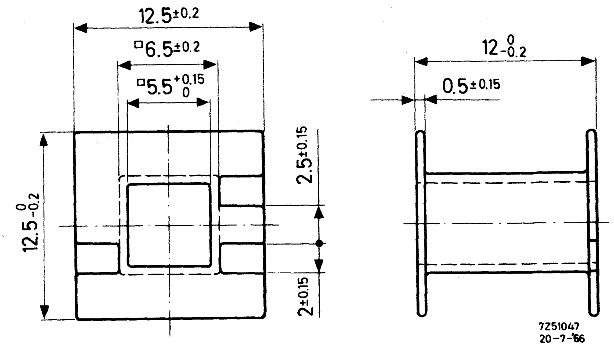
The following E-core can be delivered with an airgap (ground in each E-core):

catalogue number	material	airgap length in mm
4322 020 34550	3E1	0.15 ± 0.015

*) In the temperature range +23 to +70 °C $\mu_e \geq 2100$.

COIL FORMERS

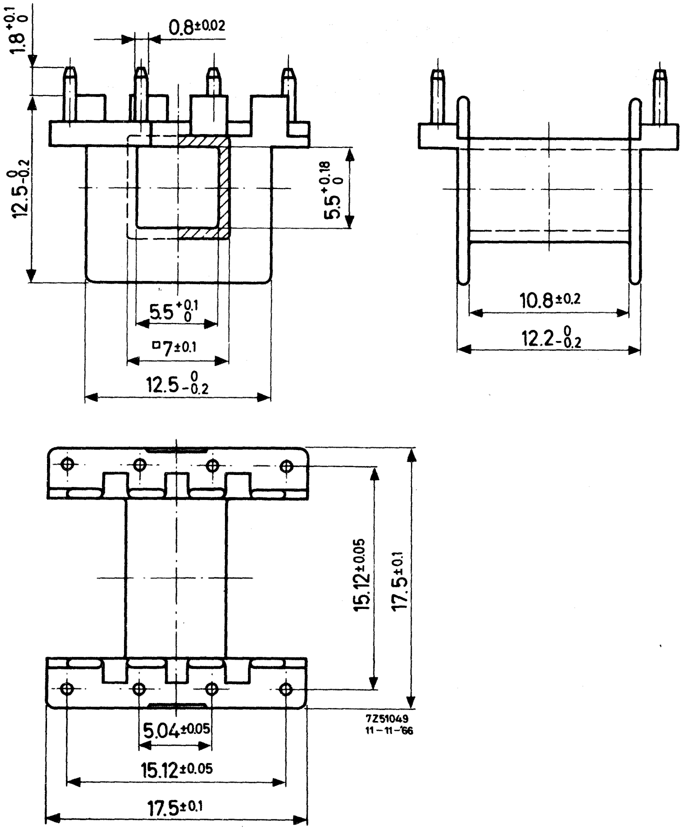
for shell type transformer 20/20/5 (M 20)



catalog number	4312 021 28431
material	polycarbonate
minimum window area in mm^2	27
mean length of turn in cm	3.8
approximate weight in g	0.5
maximum temperature in °C	130

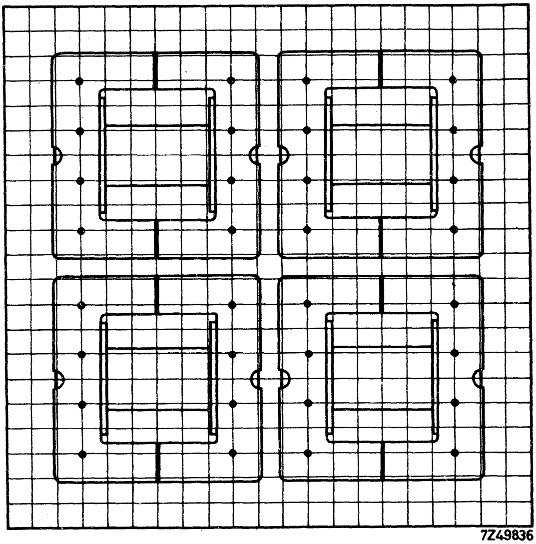
The dimensions are practically according to German specification D.I.N. 41305.

With soldering pins.



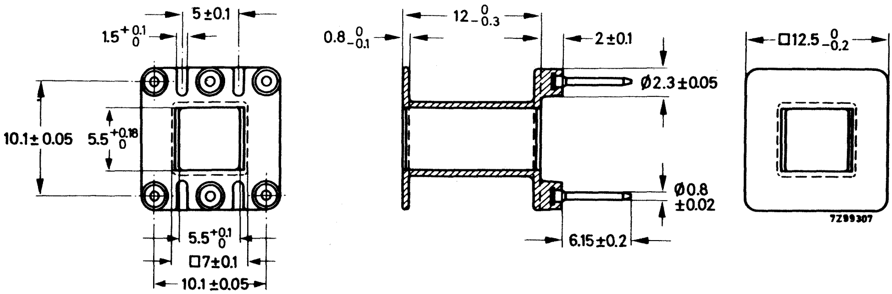
catalog number	4322 021 20240
material	reinforced polyester with brass dipsoldered pins
minimum window area in mm^2	27
mean length of turn in cm	3.8
approximate weight in g	
maximum temperature for dipsoldering during 5 - 6 s in °C	280
maximum working temperature in °C	130

The coil former fits a shell type transformer 20/20/5 (M 20). The soldering pins are so arranged as to fit a grid of 2.52mm. They will fit printed wiring boards with 0.1" grid as well as those with a 2.50mm grid. The pin length is sufficient for a board thickness of up to 3mm. The board should be provided with holes of 1.3±0.1mm diameter.



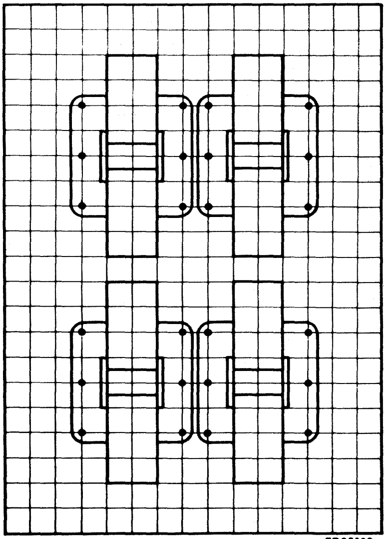
COIL FORMERS
for shell type transformer 20/20/5 (M20)

With soldering pins.

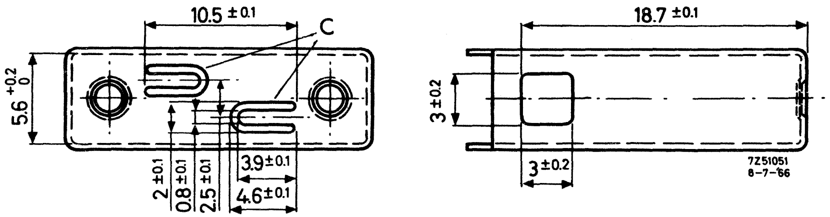


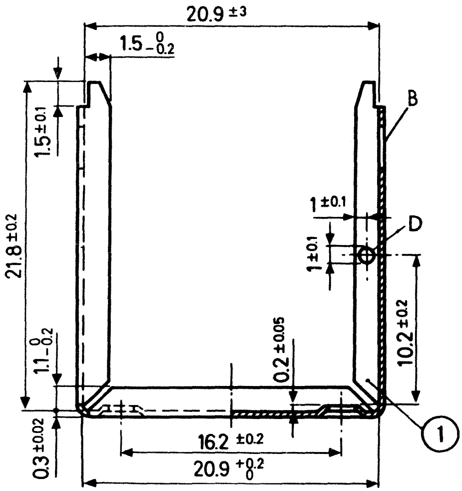
catalogue number	4322 021 20140
material	reinforced polyester with brass dipsoldered pins
minimum window area in mm^2	27
mean length of turn in cm	3.8
approximate weight in g	
maximum temperature for dipsoldering during 5-6 s in ^{o}C	280
maximum working temperature in ^{o}C	130

The coil former fits a shell type transformer 20/20/5 (M20). The soldering pins are so arranged as to fit a grid of 2.52 mm. They will fit printed-wiring boards with 0.1 in grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3 ± 0.1 mm diameter.

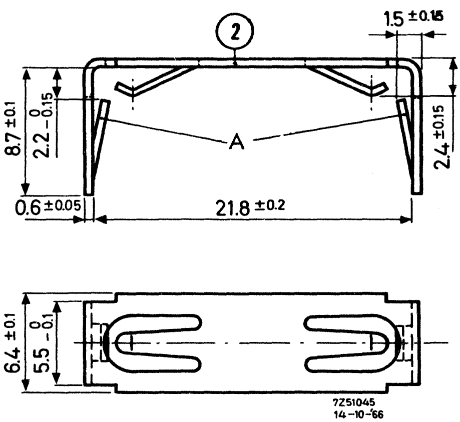


MOUNTING PARTS





(1). Clasp 4322 021 20160
Material: brass, tin-plated



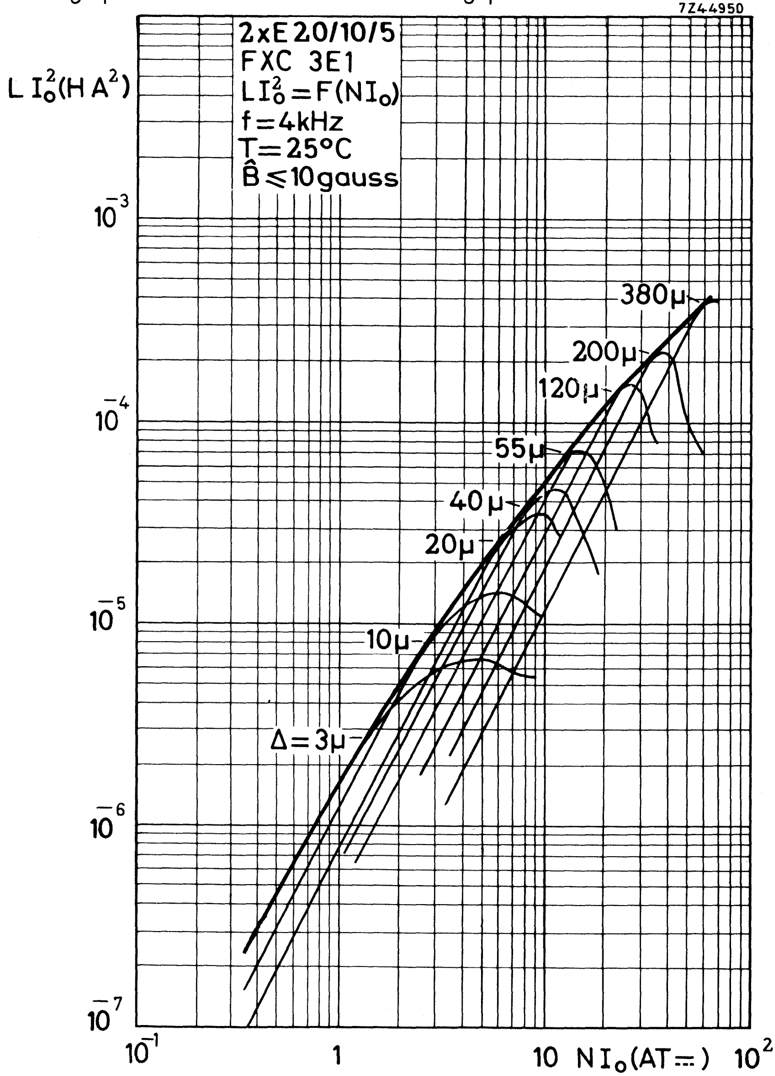
(2). Spring 4322 021 20220
Material: phosphorbronze, tin-plated

The construction is mounted by pushing the spring over the clasp in such a way that the lips A of the spring catch in the square holes B of the clasp. The mechanical pressure, required to keep the two E-cores together is exercised by means of two lips on top of the spring. No special tool is required for mounting the construction.

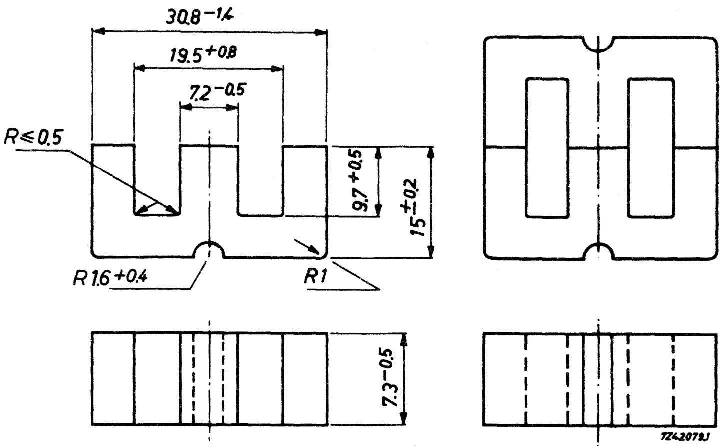
The construction can be used in horizontal and vertical position.
If the construction is used in vertical position, the lips C of the clasp must be bent. The dimensions and mutual distance of these lips are chosen in such a way that they fit printed-wiring boards with a grid of 0.1" as well as those with a grid of 2.50 mm.
If used in a horizontal position the clasp can be earthed by means of a copper wire soldered in hole D.

CHARACTERISTIC CURVES

HANNA CURVES (typical values)
Indicating optimum inductance for a certain airgap and direct current.



E-CORES



The dimensions are according to German specification D.I.N. 41295.

Ferroxcube grade	3E1	improved 3E1
Approximate weight	11 g	11g
Cat. number of E-core	4322 020 34630	4322 020 34840

A transformer core can be built up by combining an even number of E-cores. A shape that is often chosen is the shell type transformer 30/30/7 composed of two cores type E 30/15/7.

shell type transformer 30/30/7

Dimensional quantities:

mean length of lines of force	l_e =	6.69	cm
mean area of lines of force	A_e =	0.597	cm^2
	$\Sigma \frac{l_e}{A_e}$ =	11.2	cm^{-1}
effective volume	V_e =	4.00	cm^3

Electrical properties at 25 ± 10 °C		3E1	improved 3E1
at Δ = 0:	μ_e	= 1795-2990	2375-3955 *)
	A_L	= 2010-3350	2665-4440
	α	≤ 22.3	
at 4 kHz and $\hat{B}$ between 15 and 30 gauss	$q_{2-24-100}$	≤ 7	≤ 3 Ω/($H^{3/2}$.mA)
at 4 kHz and $\hat{B}$ ≤ 1 gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 2.5
at 100 kHz and $\hat{B}$ ≤ 1 gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 20
at 500 kHz and $\hat{B}$ ≤ 1 gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 200

Mechanical force at which the electrical properties are determined is 110 Newton.

Number of turns for L mH $N = \alpha\sqrt{L}$.

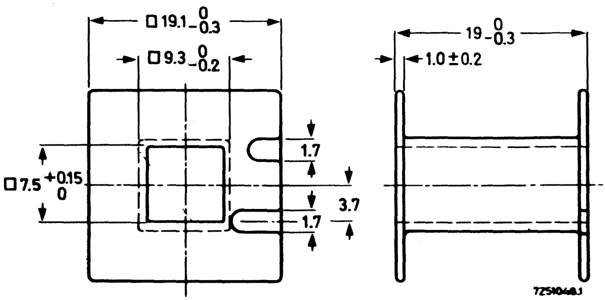
The following E-cores with an airgap (ground in each E-core) can be delivered:

catalogue number	material	airgap length in mm
4322 020 34650	3E1	0.15 ± 0.015
4322 020 34660	3E1	0.30 ± 0.015

*) In the temperature range +23 to +70 °C $\mu_e \geq 2375$

COIL FORMERS

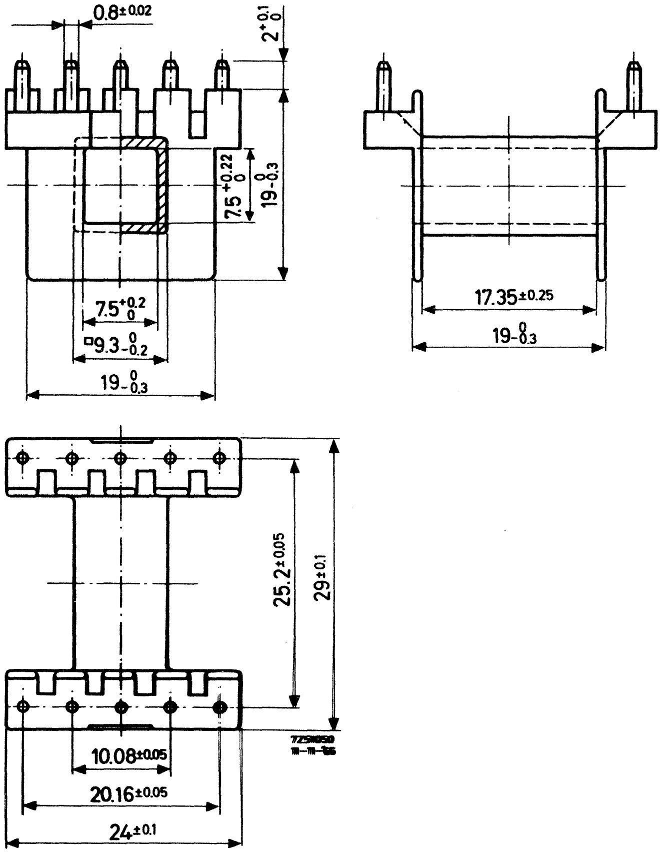
for shell type transformer 30/30/7 (M 30)



catalog number	4312 021 28550
material	polycarbonate
minimum window area in mm^2	80
mean length of turn in cm	5.6
approximate weight in g	1.3
maximum temperature in °C	130

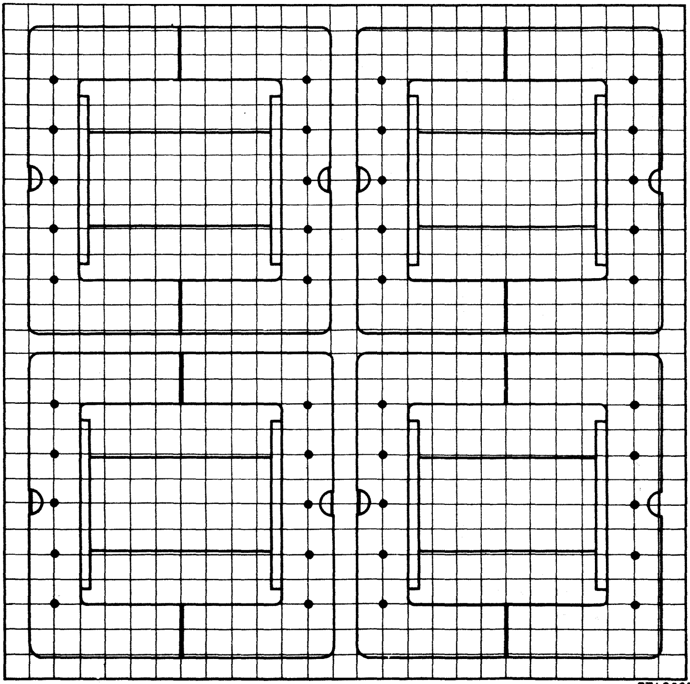
The dimensions are practically according to German specification D.I.N. 41305.

With soldering pins.



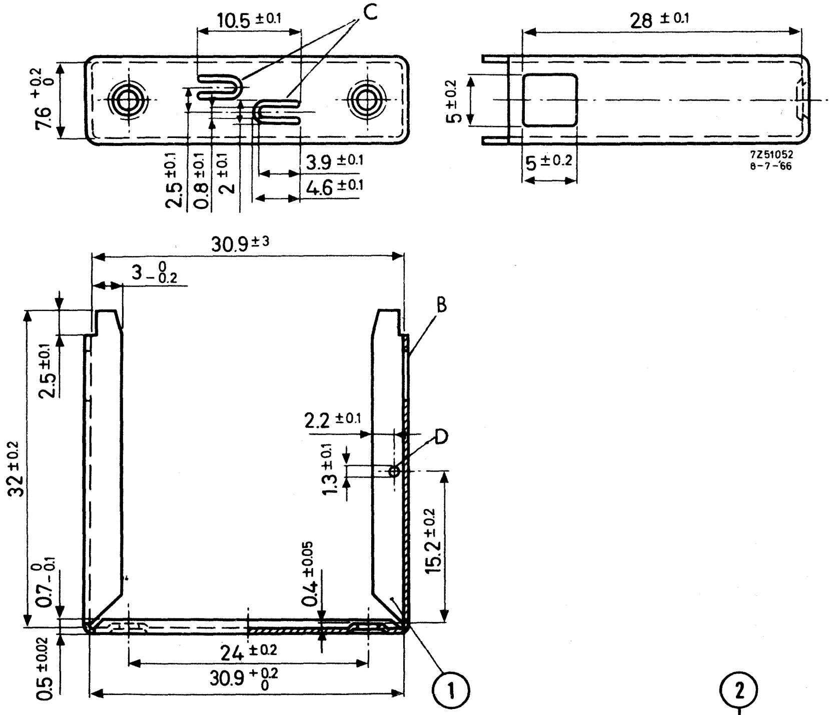
catalog number	4322 021 20250
material	reinforced polyester with brass dipsoldered pins
minimum window area in mm^2	80
mean length of turn in cm	5.6
approximate weight in g	
maximum temperature for dipsoldering during 5 - 6 s in °C	280
maximum working temperature in °C	130

The coil former fits a shell type transformer 30/30/7 (M30). The soldering pins are so arranged as to fit a grid of 2.52mm. They will fit printed-wiring boards with 0.1" grid as well as those with a 2.50mm grid. The pin length is sufficient for a board thickness of up to 3mm. The board should be provided with holes of 1.3±0.1mm diameter.

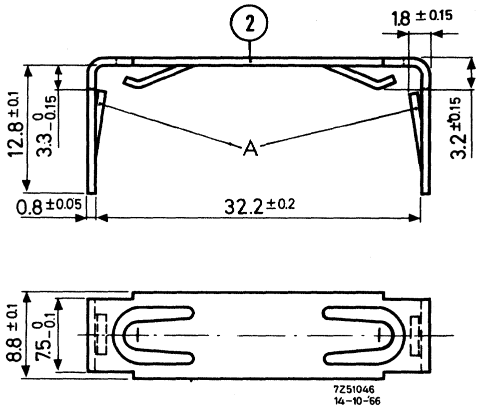


7Z49835

MOUNTING PARTS



(1). Clasp 4322 021 20170
Material: brass, tin-plated



(2). Spring 4322 021 20230
Material: phosphorbronze, tin-plated

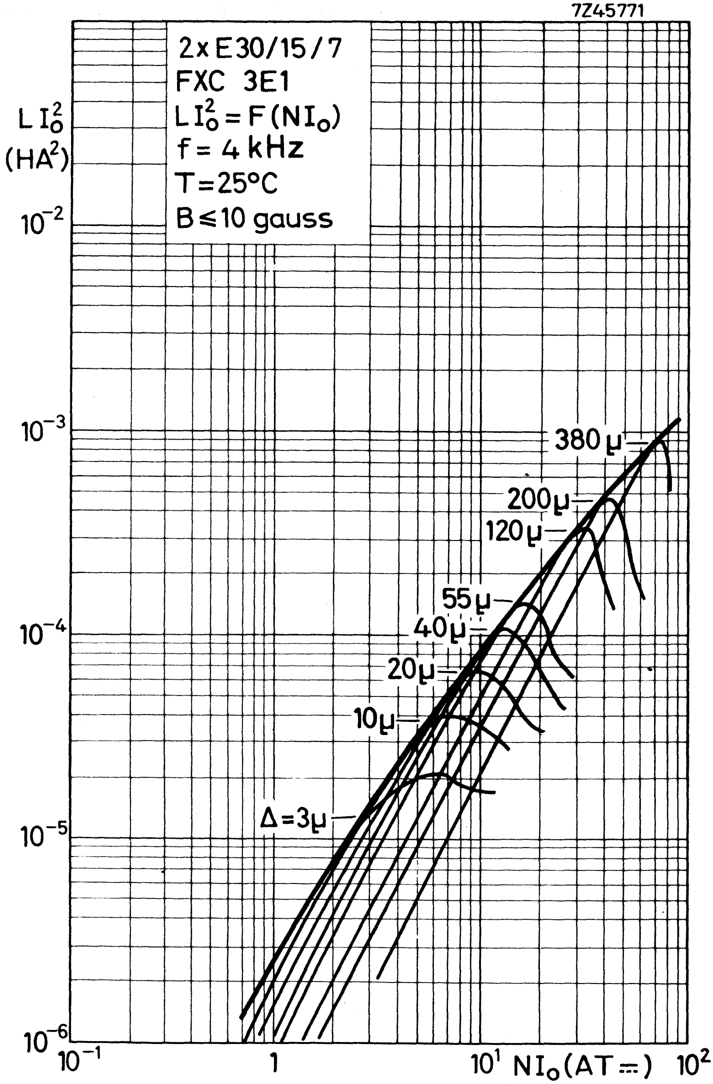
The construction is mounted by pushing the spring over the clasp in such a way that the lips A of the spring catch in the square holes B of the clasp. The mechanical pressure, required to keep the two E-cores together is exercised by means of two lips on top of the spring. No special tool is required for mounting the construction.

The construction can be used in horizontal and vertical position.
If the construction is used in vertical position, the lips C of the clrsp must be bent. The dimensions and mutual distance of these lips are chosen in such a way that they fit printed-wiring boards with a grid of 0.1" as well as those with a grid of 2.50 mm.
If used in a horizontal position the clasp can be earthed by means of a copper wire soldered in hole D.

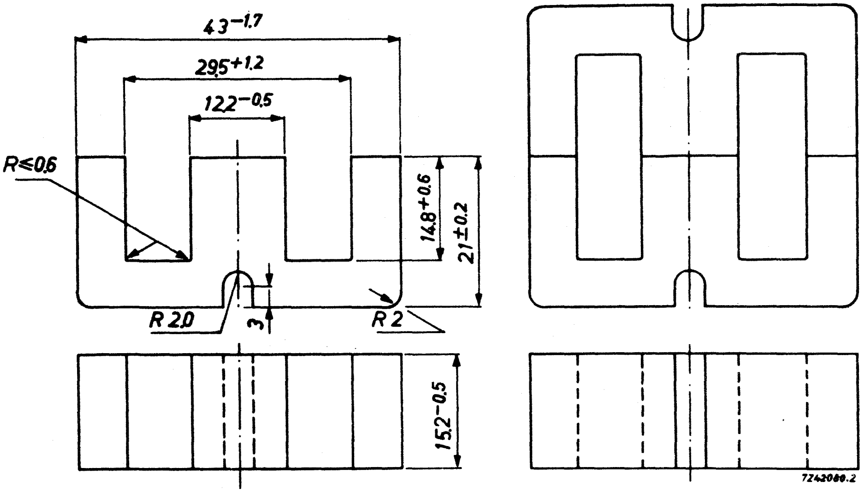
CHARACTERISTIC CURVES

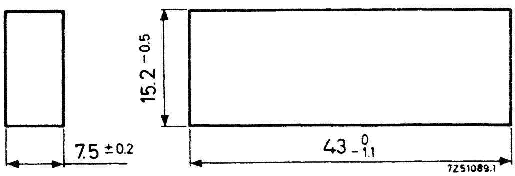
HANNA CURVES

Indicating optimum inductance for a certain airgap and direct current



E- AND I-CORES





The dimensions are according to German specification D.I.N. 41295.

	E42/21/15		I42/7.5/15
Ferroxcube grade	3E1	improved 3E1	3E1
Approximate weight	42g	42g	
Catalog number of E-core	4322 020 34720	4322 020 34850	
Catalog number of I-core			4322 020 37320

A transformer core can be built up by combining an even number of E-cores. A shape that is often chosen is the shell type transformer 42/42/15 composed of two cores type E 42/21/15 or the E-I combination 42/29/15.

Shell type transformer		42/42/15		42/29/15
Dimensional quantities				
mean length of lines of force	l_e =	9.70 cm		6.72 cm
mean area of lines of force	A_e =	1.82 cm^2		1.83 cm^2
	$\Sigma \frac{l_e}{A_e}$ =	5.34 cm^{-1}		3.67 cm^{-1}
effective volume	V_e =	17.6 cm^3		12.3 cm^3
Electrical properties at 25 ± 10 °C:		3E1	improved 3E1	3E1
at Δ = 0:	μ_e =	1910–3140	2575 – 4275*)	> 1820
	A_L =	4425–7380	6000 – 10 000	> 6300
	α =	15.0		≤ 12.6
at 4 kHz and $\hat{B}$ between 15 and 30 gauss	$q_{2\text{-}24\text{-}100}$	≤ 7	≤ 3	$\Omega/(H^{3/2}.mA)$
at 4 kHz and $\hat{B} \leq$ 1 gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 2.5	
at 100 kHz and $\hat{B} \leq$ 1 gauss	$\frac{\tan\delta}{\mu_i} \times 10^6$		≤ 20	

Mechanical force at which the electrical properties are determined is 280 Newton.

Number of turns for L mH N = $\alpha\sqrt{L}$.

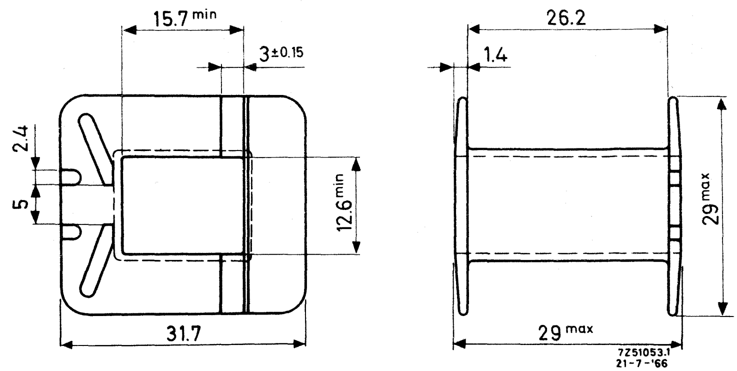
The following E-cores can be delivered with an airgap (ground in each E-core)

catalogue number	material	airgap length in mm
4322 020 34740	3E1	0.25 ± 0.015
4322 020 34750	3E1	0.5 ± 0.015

*) In the temperature range +23 to +70 °C $\mu_e \geq 2575$.

COIL FORMERS

for shell type transformer 42/42/15 (M 42)

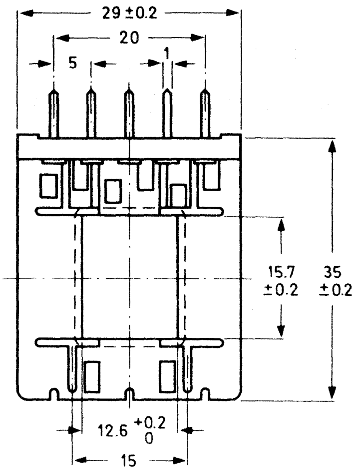


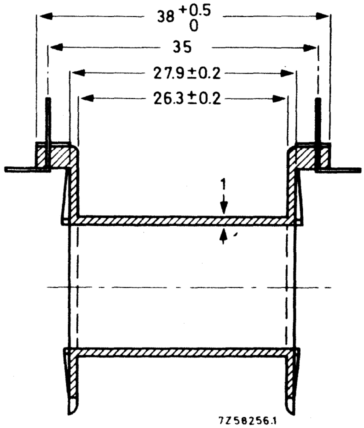
catalog number	4312 021 28622
material minimum window area in mm^2 mean length of turn in cm approximate weight in g maximum temperature in ^oC	reinforced polyamide 178 9.3 4 180

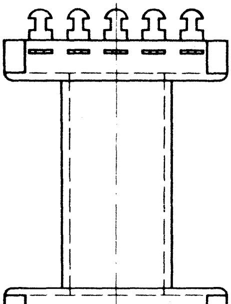
The dimensions are practically according to German specification D.I.N. 41305.

COIL FORMERS
for shell type transformer 42/42/15 (M42)

With soldering pins

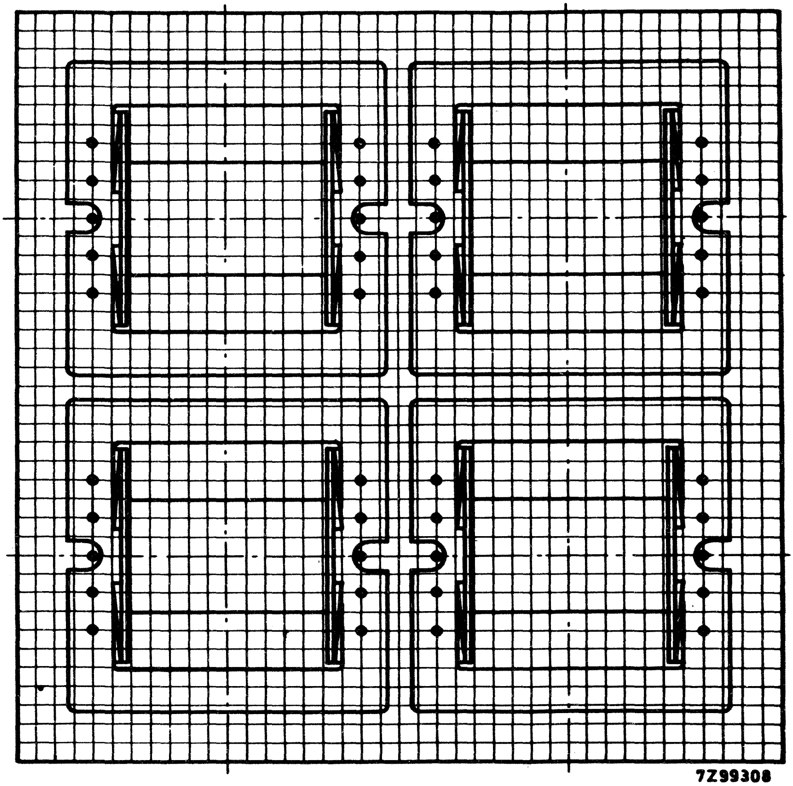






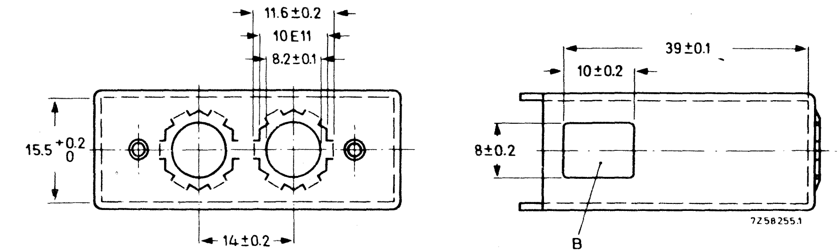
catalogue number	4322 021 31830
material	reinforced polyamide with brass dipsoldered pins
minimum window area in mm^2	178
mean length of turn in cm	9.3
approximate weight in g	4
maximum temperature in ^oC	180

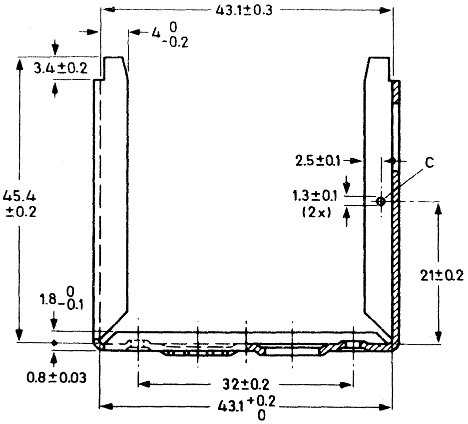
The coil former fits a shell type transformer 42/42/15 (M42). The soldering pins are so arranged as to fit a grid of 2.52 mm. They will fit printed-wiring boards with 0.1 in grid as well as those with a 2.50 mm grid. The pin length is sufficient for a board thickness of up to 3 mm. The board should be provided with holes of 1.3 ± 0.1 mm diameter.



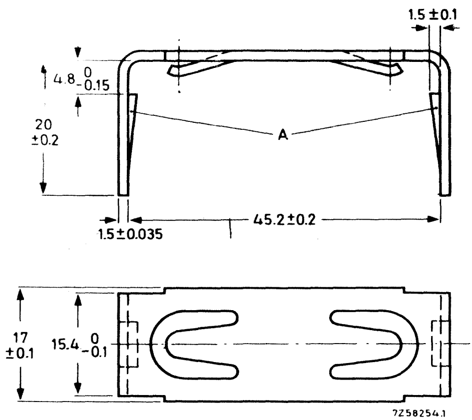
7Z99308

MOUNTING PARTS





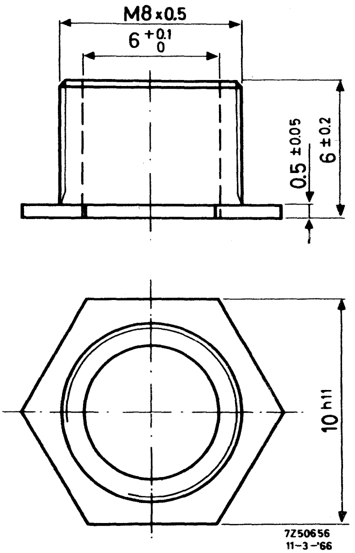
Clasp 8222 294 27280
Material: steel, copper-plated, nickel-plated



Spring 8222 294 27290
Material: phosphorbronze, nickel-plated

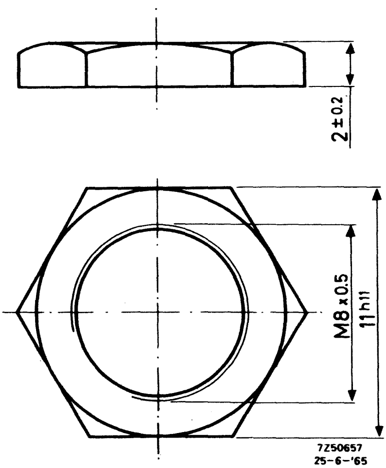
The construction is mounted by pushing the spring over the clasp in such a way that the lips A of the spring catch in the square holes B of the clasp. The mechanical pressure, required to keep the two E-cores together is exercised by means of two lips on top of the spring. No special tool is required for mounting the construction.

The construction can be used in horizontal and vertical position.
If the construction is used in vertical position, two fixing bushes 4322 021 30720 with nuts 4322 021 30710 must be applied in the holes of the clasp.
If used in a horizontal position the clasp can be earthed by means of a copper wire soldered in hole C.



Fixing bush 4322 021 30720

Material: brass, nickel plated



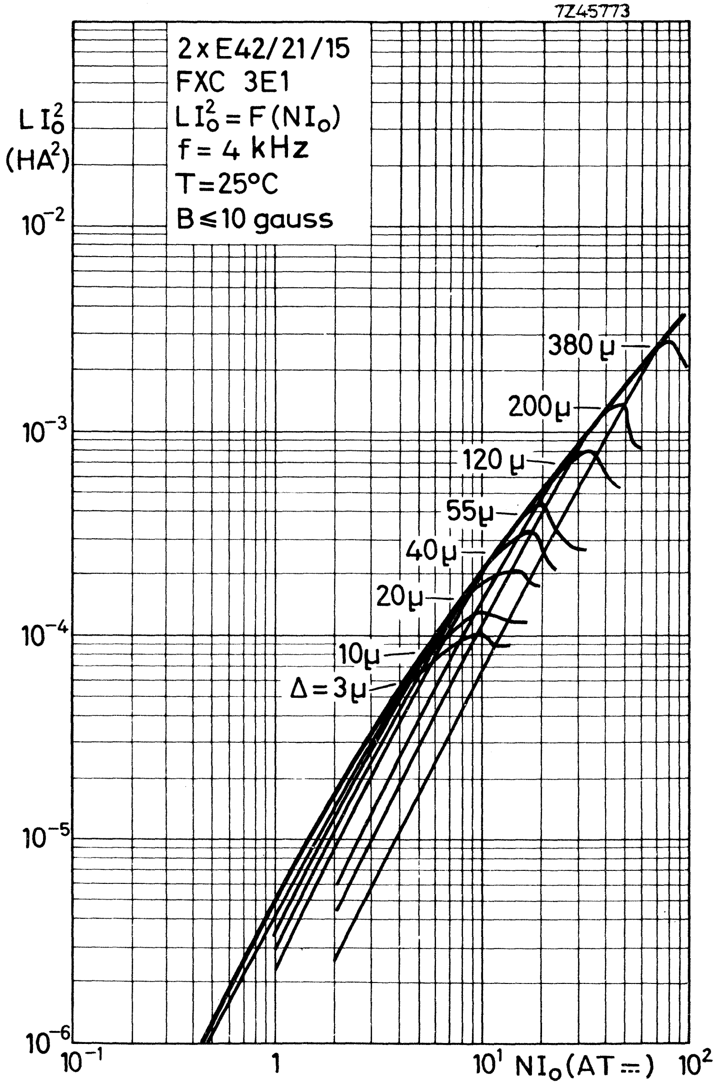
Nut 4322 021 30710

Material: brass, nickel plated

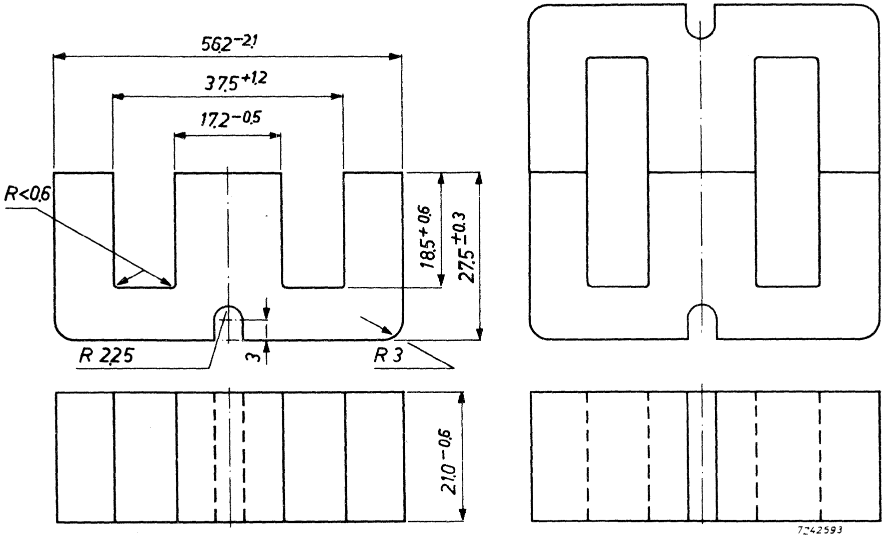
CHARACTERISTIC CURVES

HANNA CURVES

Indicating optimum inductance for a certain airgap and direct current



E-CORE



The dimensions are according to German specification D.I.N. 41295.

Ferroxcube grade	3E1
Approximate weight	115 g
Cat. number of E-cote	4322 020 34780

A transformer core can be built up by combining an even number of E-cores. A shape that is often chosen is the shell type transformer 55/55/21 composed of two cores type E 55/28/21.

shell type transformer	55/55/21

Dimensional quantities:

mean length of lines of force	l_e	=	12.3	cm
mean area of lines of force	A_e	=	3.54	cm^2
	$\Sigma \frac{l_e}{A_e}$	=	3.48	cm^{-1}
effective volume	V_e	=	43.7	cm^3

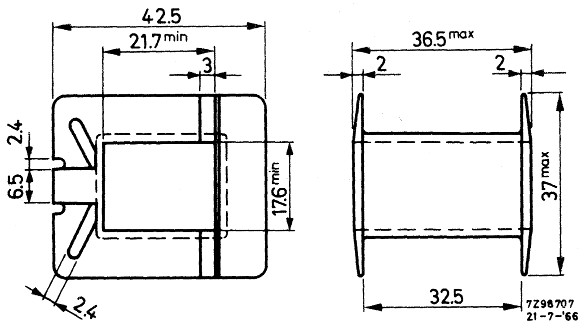
Electrical properties at 25 ±10 °C

at Δ = 0	μ_e	=	1950 - 3250	
	A_L	=	7050-11700	
at Δ = 0	α	$\leq$	11.9	
at 4 kHz and $\hat{B}$ between 15 and 30 gauss	$q_{2-24-100}$	$\leq$	4	$\Omega/(H^{3/2}.mA)$

Mechanical force at which the electrical properties are determined is 550 Newton.

Number of turns for L mH $N = \alpha\sqrt{L}$.

COIL FORMER
for shell type transformer 55/55/21



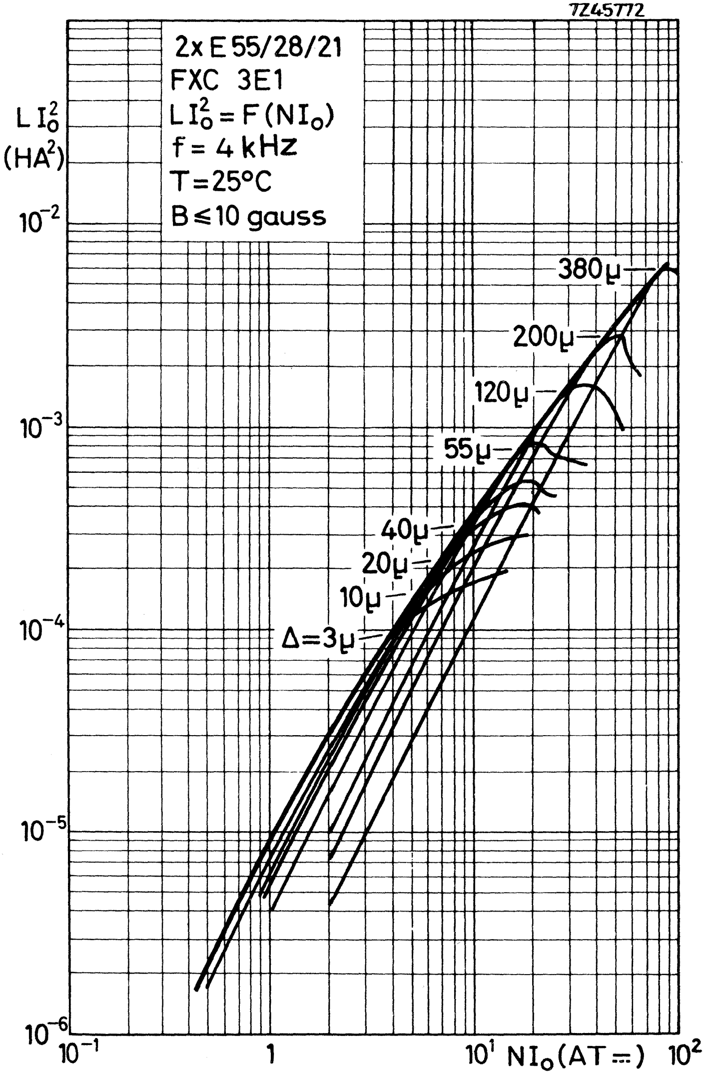
catalog number	4312 021 28711
material	reinforced polyamide
minimum window area in mm^2	250
mean length of turn in cm	11.6
approximate weight in g	9
maximum temperature in ^{o}C	180

The dimensions are according to German specification D.I.N. 41305.

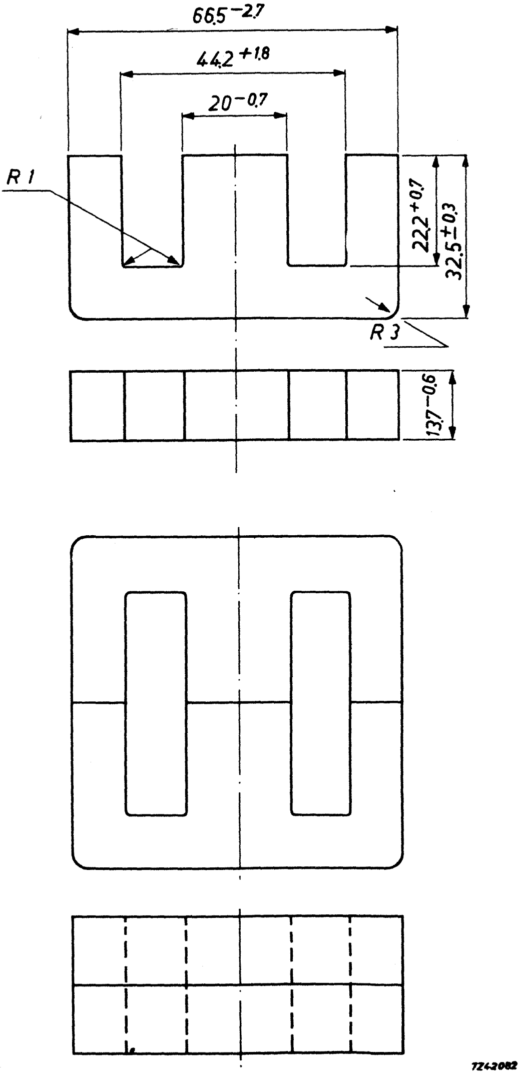
CHARACTERISTIC CURVES

HANNA CURVES

Indicating optimum inductance for a certain airgap and direct current



E-CORE



The dimensions are according to German specification D.I.N. 41295.

Ferroxcube grade 3E 1
Approximate weight 76 g
Type number of E-core 4322 020 34820

→ A transformer core can be built up by combining an even number of E-cores. A shape that is often chosen is the shell type transformer 65/65/27 composed of four cores type E65/32/13.

shell type transformer 65/65/27

Dimensional quantities:

mean length of lines of force l_e = 14.7 cm

mean area of lines of force A_e = 5.32 cm^2

$\Sigma \frac{l_e}{A_e}$ = 2.75 cm^{-1}

effective volume V_e = 78.2 cm^3

Electrical properties at 25 ± 10 °C

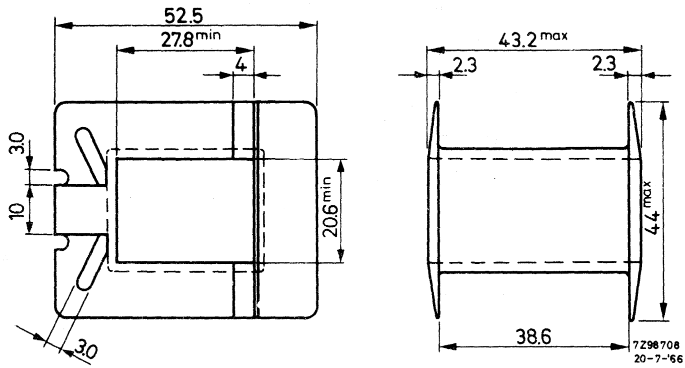
at $\Delta = 0$:

μ_e = 1835-3050
A_L = 8400-14000
$\alpha \leq$ 10.9

at 4kHz and $\hat{B}$ between
15 and 30 gauss $q_{2-24-100} \leq 7$ $\Omega/(H^{3/2}.mA)$

Mechanical force at which the electrical properties are determined is 400 Newton
Number of turns for L mH $N = \alpha\sqrt{L}$.

COIL FORMER
for shell type transformer 65/65/27 (M 65)



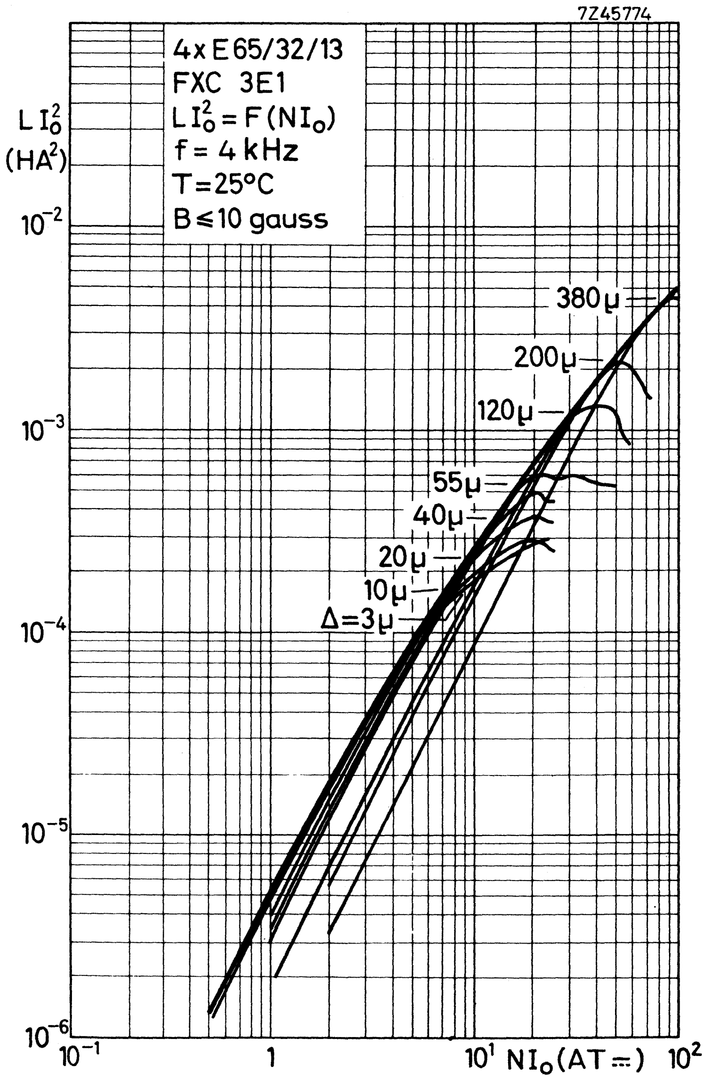
catalog number	4312 021 28721
material	reinforced polyamide
minimum window area in mm^2	394
mean length of turn in cm	15
approximate weight in g	13
maximum temperature in ^oC	180

The dimensions are according to German specification D.I.N. 41305.

CHARACTERISTIC CURVES

HANNA CURVES

Indicating optimum inductance for a certain airgap and direct current



H-CORES

INTRODUCTION

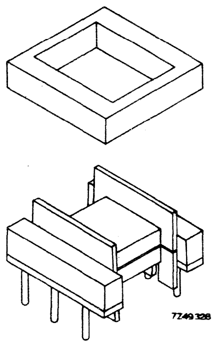
The development of magnetic core materials with high initial permeability for series production opened the way for the construction of transformer cores of very small dimensions without the loss of transformer performance.
One of the problems immediately arising when miniaturizing magnetic cores is that the high initial material permeability practically always is reduced considerably by an unavoidable airgap except when the toroid shape is used. However, for application in transformers the toroid has the disadvantage of being difficult to wind and time consuming in assembly.
The H-core transformer shape overcomes the above mentioned disadvantages with a minimum of component parts and has moreover the advantage that it may be wound on simple conventional winding machines.
The magnetic circuit is closed by a core in the shape of a rectangular window or of a U. The two parts are sufficient to construct a complete transformer suitable for mounting on a printed wiring board, since the coil former, which forms one piece with the H-core, is provided with soldering pins on grid module distances.

Four sets of transformer components of different size are available. Their type designation is H7, H10, H16 and H20. The material grade used is FXC 3E2.

In addition to the well-known applications of ferroxcube cores in transformers in communication systems, an important part of the field of applications of metal laminations in the audio frequency range can be covered with these H-cores.

The high A_L values realised with these small cores combined with the proper winding technique lead to small stray capacitances and small stray inductances, in this way permitting the design of wide band transformers in a small volume.

H-CORE



The H 7-core consists of a ferroxcube H-shape with coil former, a ferroxcube window, a nickel container and a phosphorbronze spring.
All these components are adapted to each other.

The H 7-core can only be supplied as a complete assembly.
Cat. number of the assembly : 4322 020 33020
Approximate weight of the assembly : 0.8 g

The applied ferroxcube material is the high permeable 3E2 grade.

The jointing surfaces are very flat and smoothly lapped.

Dimensional quantities

Mean length of lines of force l_e = 1.75 cm
Mean area of lines of force A_e = 0.0325 cm^2

$$\Sigma \frac{l_e}{A_e} = 54\ \text{cm}^{-1}$$

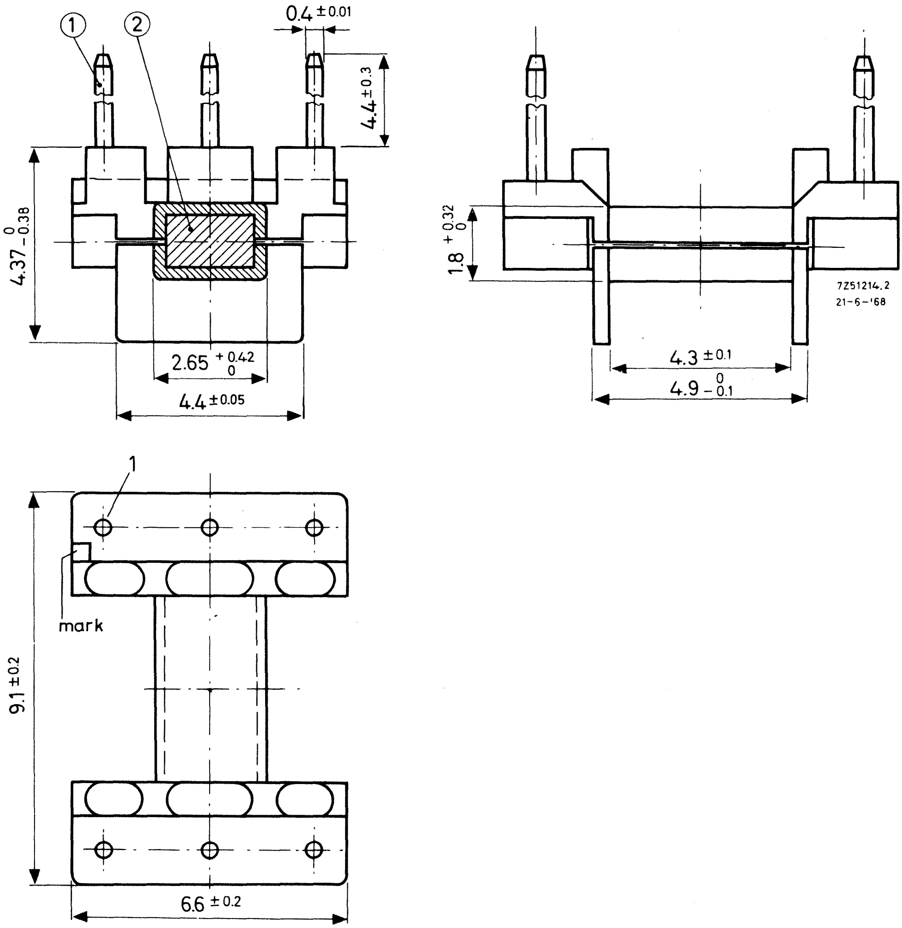
Effective volume V_e = 0.0571 cm^3

Electrical requirements measured with 25 windings of 0.15mm wire, at $\hat{B}$ = 7-10 gauss, f = 4 kHz and a mechanical force of 1.5 Newton in the temperature range from +23 till +70 °C, 24 hours after demagnetisation.

$\mu_e \geq 3000$
$\alpha \leq 37.8$
$A_L \geq 700$

The six soldering pins are arranged so as to fit printed-wiring boards with 0.1" grid as well as those with a 2.50 mm grid. The board should be provided with holes of max. 0.8 + 0.1 mm ϕ.

COIL FORMER



(1) Pins: phosphorbronze, dipsoldered
(2) H-core: ferroxcube

The coil former and the ferroxcube H-shape are combined to one part.

Material coil former	reinforced polyester with phosphorbronze dipsoldered pins
Window area in mm^2	4.2
Mean length of turn in cm	1.34
Max. temperature for dipsoldering	
for 5-6 s in °C	280
for 1-2 s in °C	360-400
Max. working temperature in °C	130

For speeding up the soldering operation of the winding wire to the pins, the use of self fluxing wire is advised. In case a terminal of the winding must be connected to the container, it should be soldered to pin 1 (see figure above).
The side of the coil former where the soldering pins protrude is asymmetrical providing a means for numbering the connections.

In order to avoid damage of the ferroxcube H-shape, care should be taken that during winding the turning couple exercised on this ferroxcube part is not too high.

MOUNTING PARTS

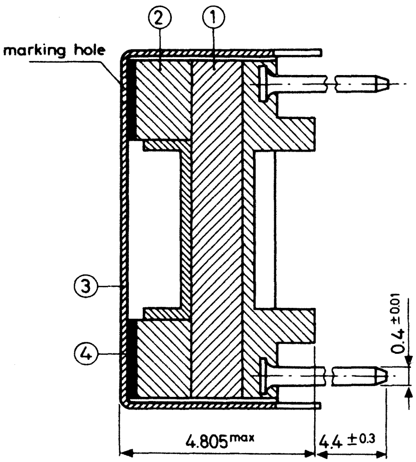


Fig. 1

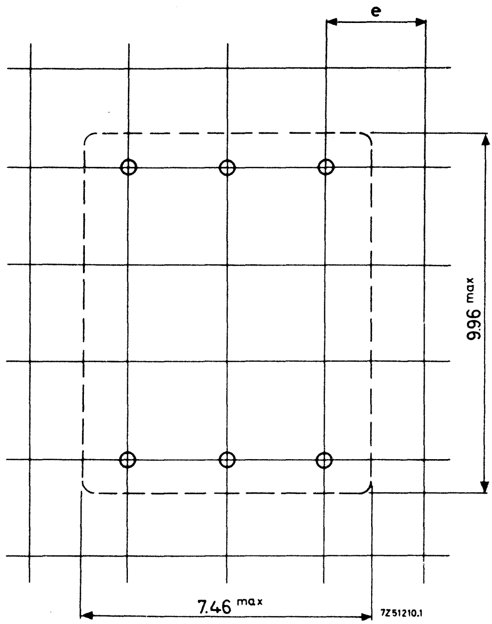


Fig. 2. Hole pattern.
e = 0.1" or 2.50 mm.

The H 7-core is only applied as a complete assembly.
Cat. number of the assembly: 4322 020 33020.

Components according to Fig. 1:
(1) Ferroxcube H-shape with reinforced polyester coil former
(2) Ferroxcube window
(3) Nickel container 4322 021 20100
(4) Phosphorbronze spring 4322 021 20380

Take care that the jointing surfaces of the two core parts are very clean.

The silver reference lines on one side of the H-shape and on one side of the window should coincide. If no reference lines are given, the parts may be arbitrary positioned.

When glueing is desired,apply a suitable adhesive around the jointing surfaces of the H-shape and the window (see Fig. 3). The area where the adhesive is to be applied should first be degreased thoroughly. A suitable adhesive is e.g. Araldit type D, with Versamide 140, mixing ratio is 70 : 30; curing time at least 24 hours at room temperature. There is a marking hole on the top side of the container (see Fig. 1). This hole must be in one line with soldering pin 1. This pin can easily be recognised by the asymmetrical shape of the coil former under side.

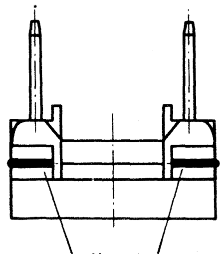
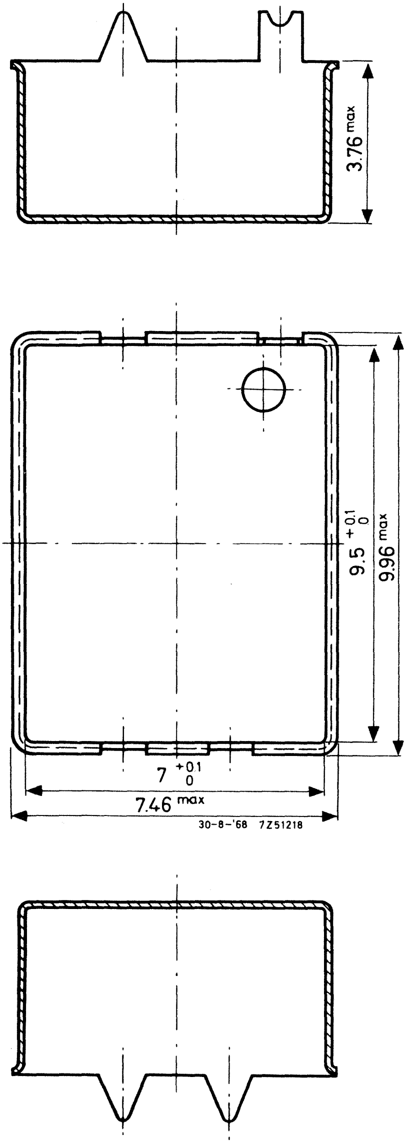
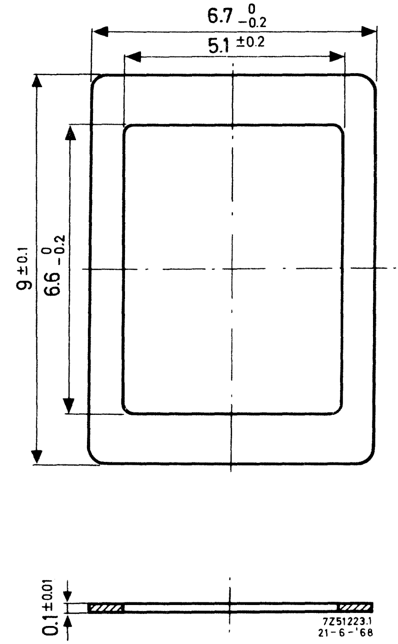


Fig. 3

If the container must be earthed, the longer (tin-plated) lip must be soldered to pin 1 after bending the lips.
For bending the container lips a simple tool (placed in a press with cranked levers) has been developed.
This tool can not be supplied, however drawings of this tool are supplied on request under catalog number 4322 058 00110.



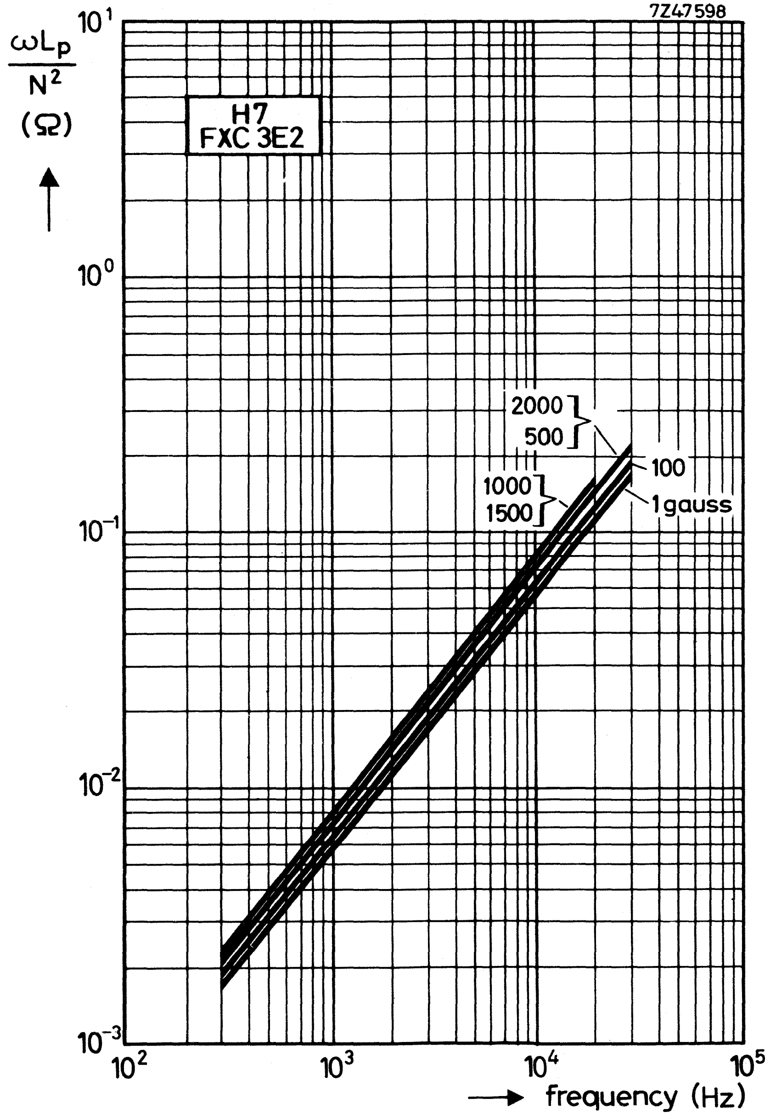
(3) Container 4322 021 20100
Material: nickel, terne-plated

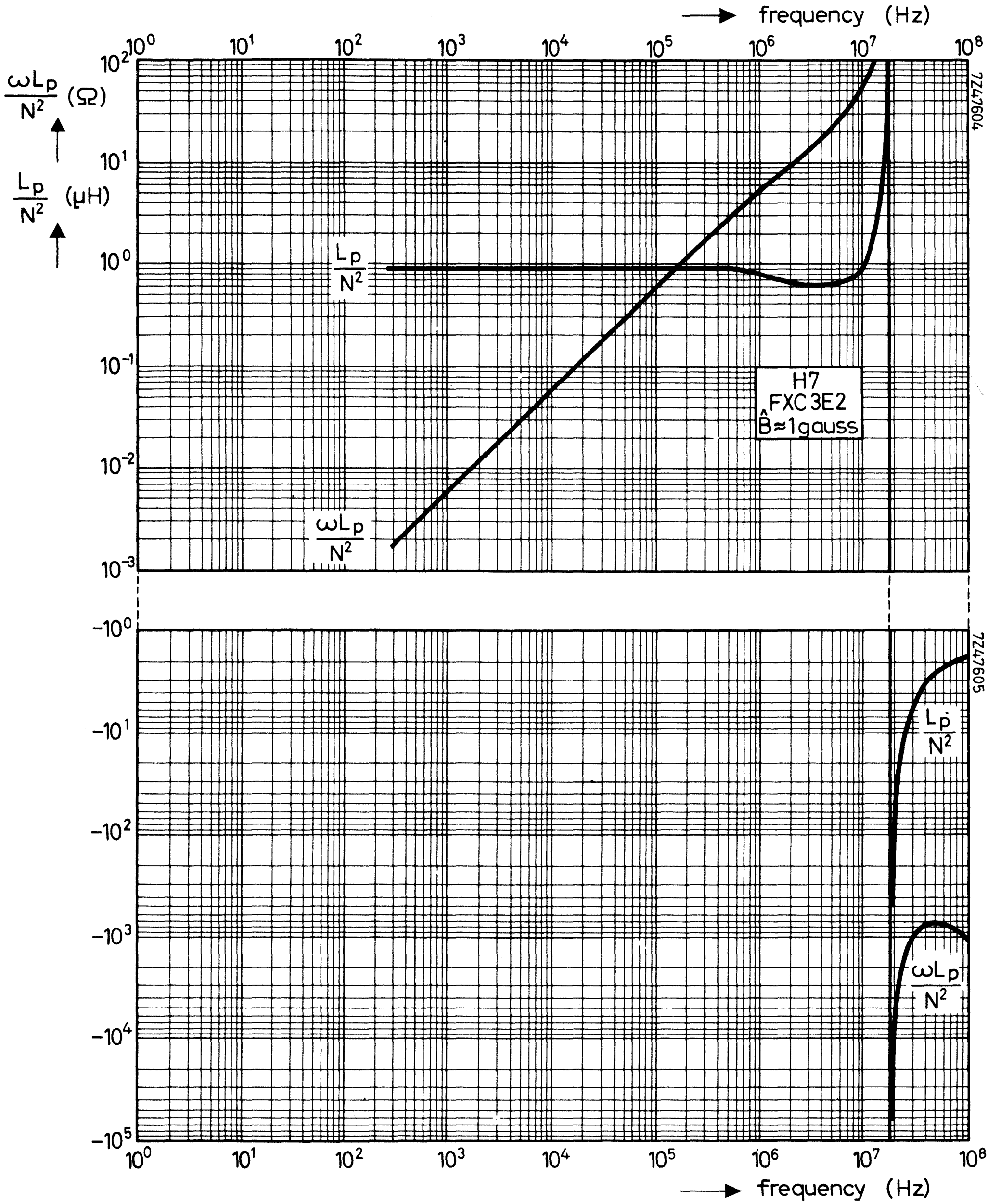


(4) Spring 4322 021 20380
Material: phosphorbronze, nickel-plated

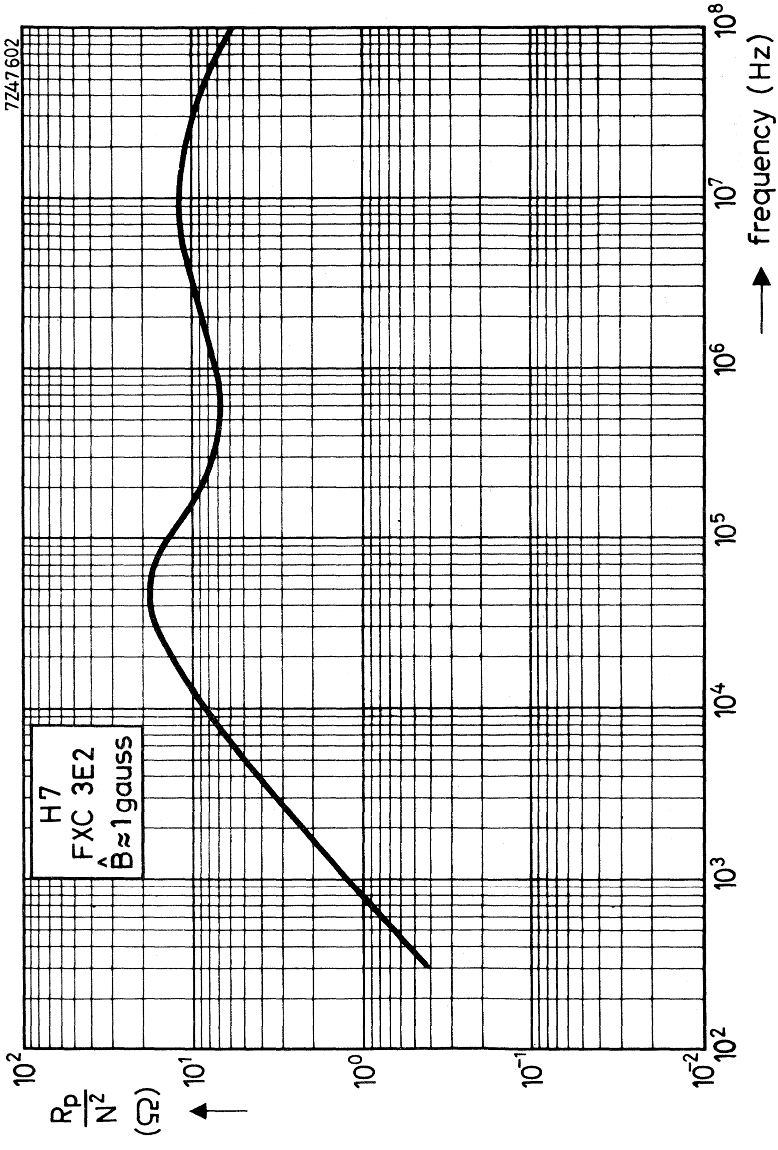
CHARACTERISTIC CURVES

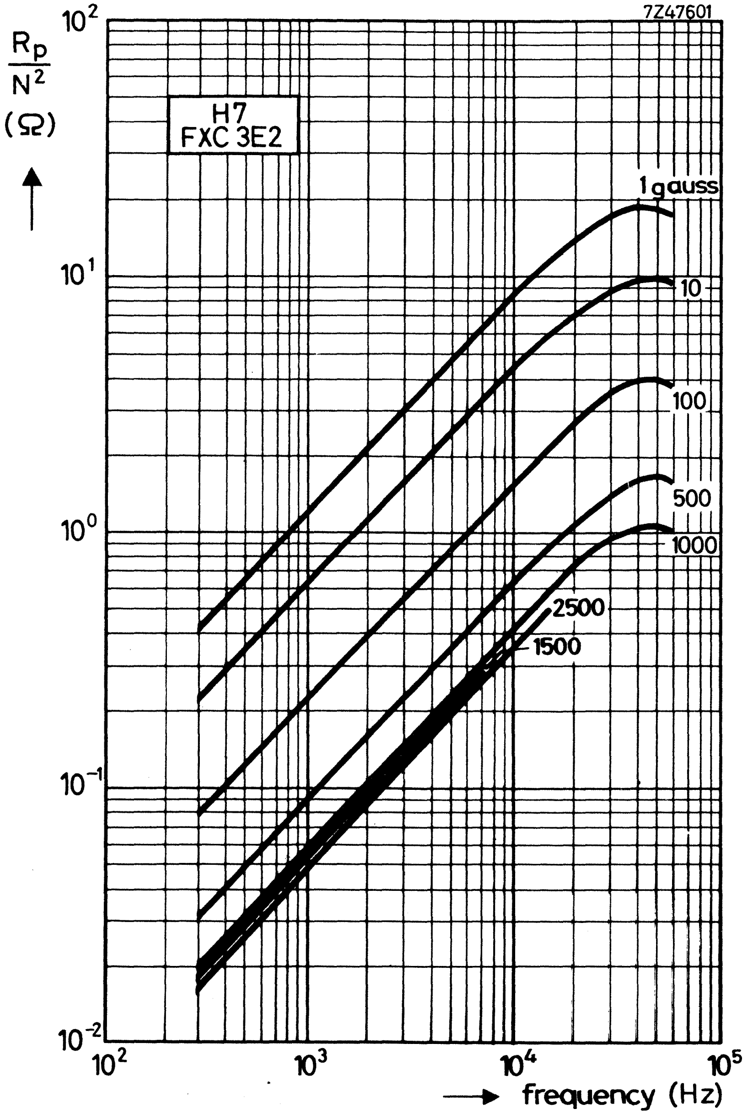
INDUCTANCE AS A FUNCTION OF THE FREQUENCY (typical values)

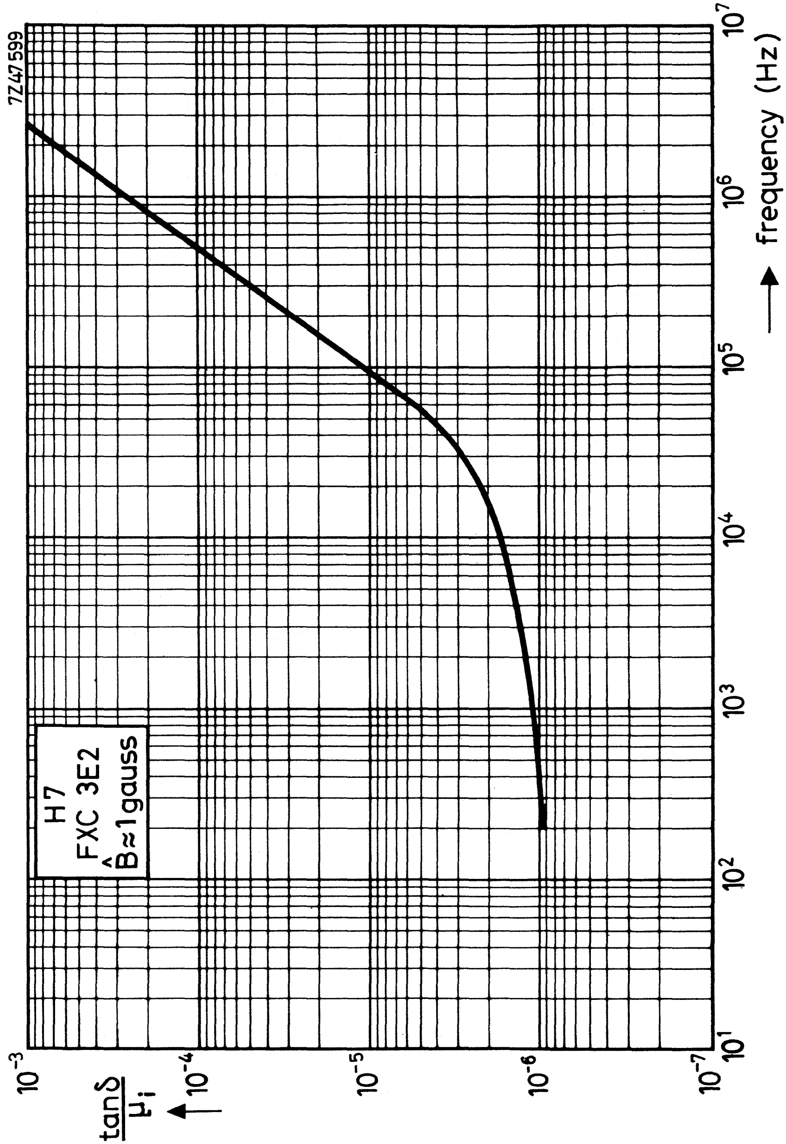



frequency (Hz)
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8
$\frac{\omega L_p}{N^2}$ (Ω)
$\frac{L_p}{N^2}$ (μH)
10^2 10^1 10^0 10^{-1} 10^{-2} 10^{-3}
$\frac{L_p}{N^2}$
$\frac{\omega L_p}{N^2}$
H7
FXC 3E2
$\hat{B} \approx 1$ gauss
7Z47604
-10^0 -10^1 -10^2 -10^3 -10^4 -10^5
7Z47605
$\frac{L_p}{N^2}$
$\frac{\omega L_p}{N^2}$
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8
frequency (Hz)

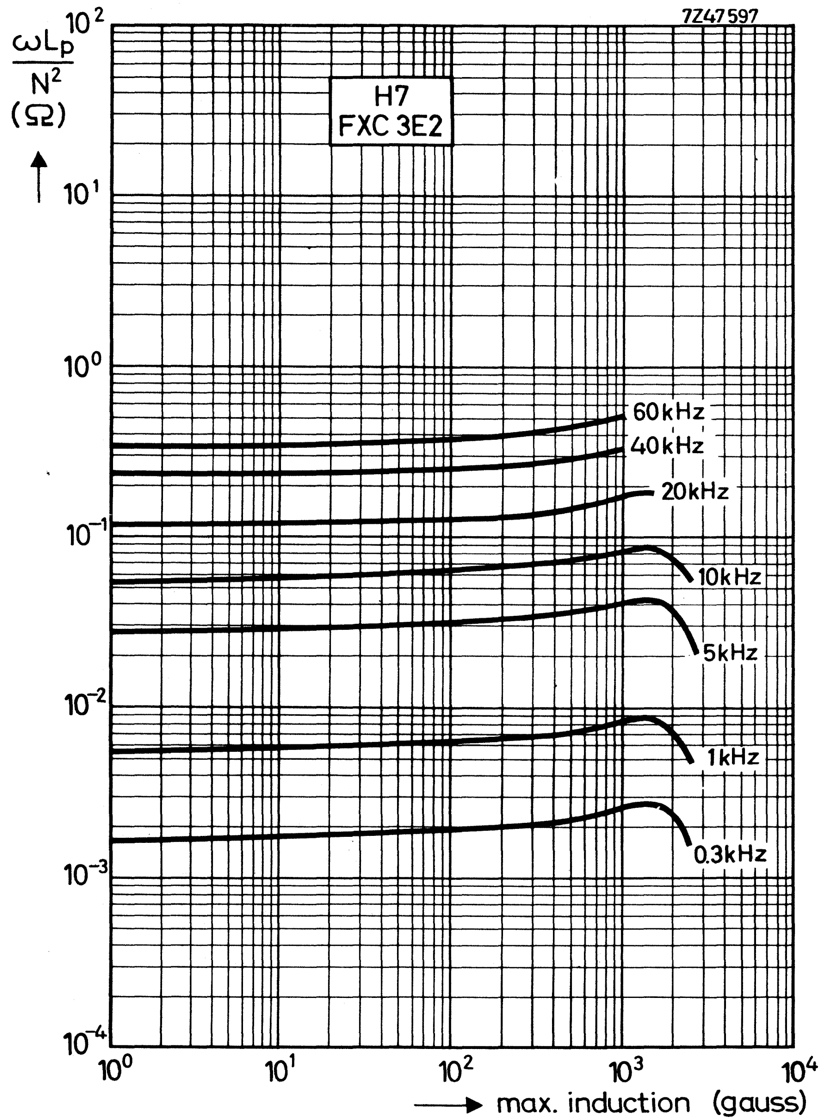
LOSSES AS A FUNCTION OF THE FREQUENCY (typical values)



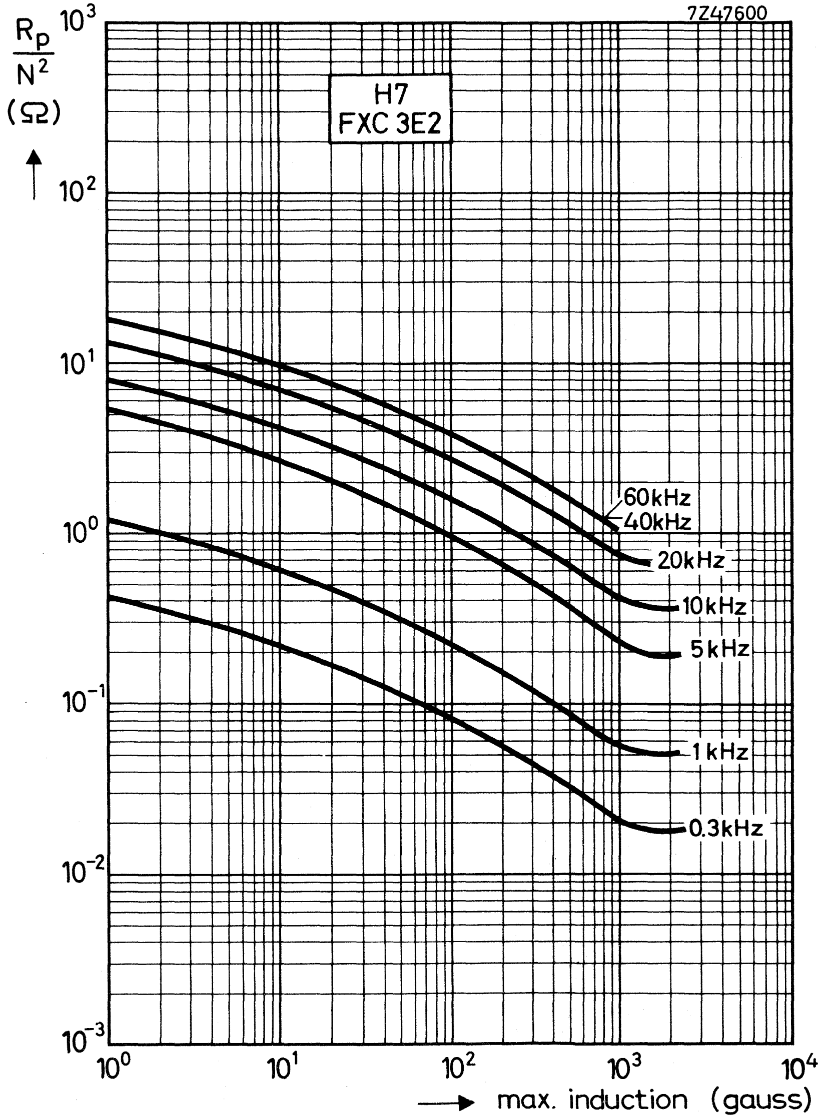

7Z47601
H7
FXC 3E2
$\frac{R_p}{N^2}$ (Ω)
10^2
10^1
10^0
10^{-1}
10^{-2}
1 gauss
10
100
500
1000
2500
1500
10^2
10^3
10^4
10^5
frequency (Hz)


7Z47599
H7
FXC 3E2
B̂≈1gauss
frequency (Hz)
tan δ / μi
10^-3
10^-4
10^-5
10^-6
10^-7
10^1
10^2
10^3
10^4
10^5
10^6
10^7

INDUCTANCE AS A FUNCTION OF THE INDUCTION (typical values)

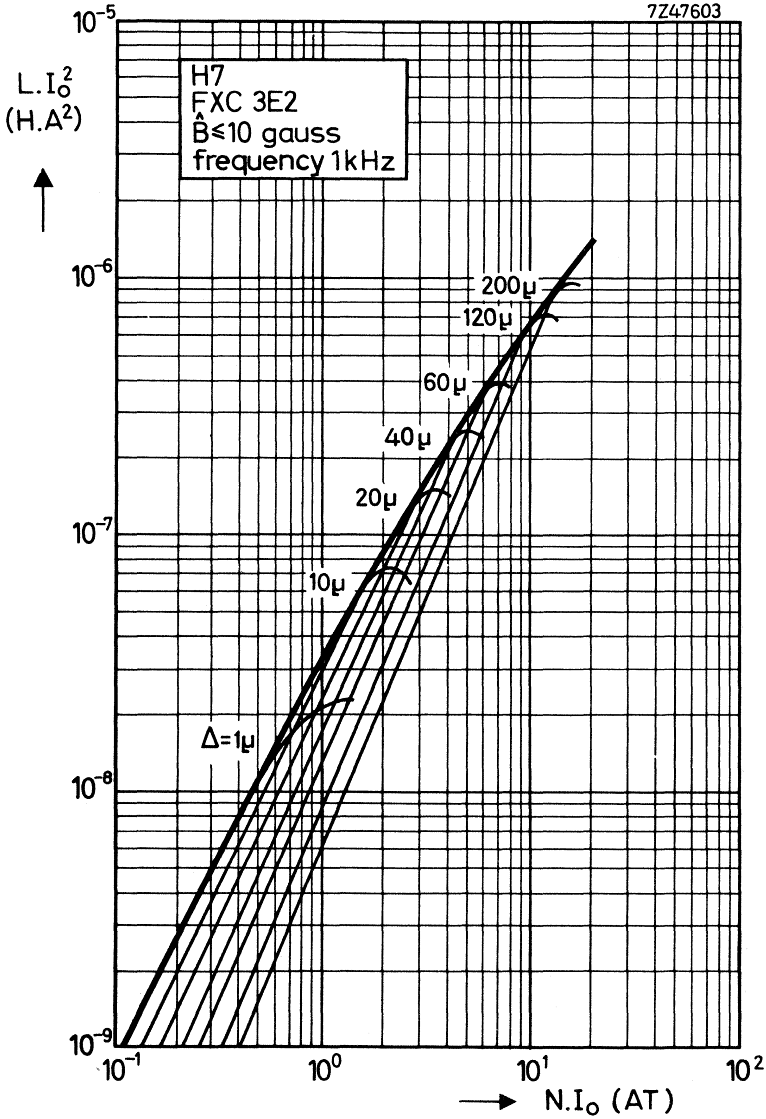


LOSSES AS A FUNCTION OF THE INDUCTION (typical values)

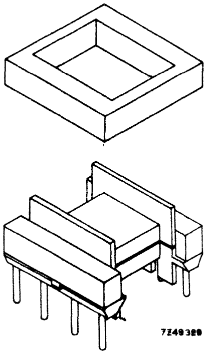


HANNA CURVE (typical values)

Indicating optimum inductance for a certain airgap and direct current.



H-CORE



The H 10-core consists of a ferroxcube H-shape with coil former, a ferroxcube window, a brass container and a phosphorbronze spring.
All these components are adapted to each other.

The H 10-core can only be supplied as a complete assembly.
Cat. number of the assembly : 4322 020 33010
Approximate weight of the assembly : 2.0 g

The applied ferroxcube material is the high permeable 3E2 grade.

The jointing surfaces are very flat and smoothly lapped.

Dimensional quantities

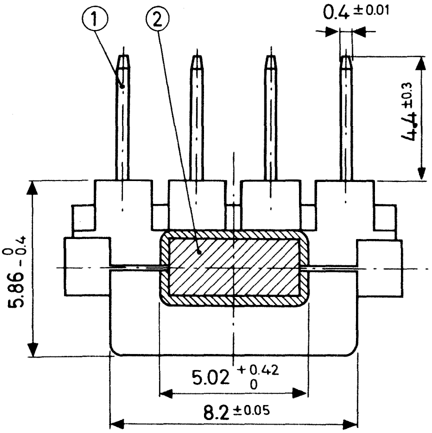
Mean length of lines of force $l_e = 2.25$ cm
Mean area of lines of force $A_e = 0.075$ cm^2
$\Sigma \frac{l_e}{A_e} = 30$ cm^{-1}
Effective volume $V_e = 0.17$ cm^3

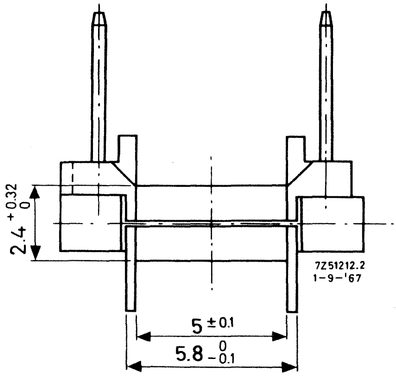
Electrical requirements, measured with 20 windings of 0.20 mm wire, at $\hat{B} = 7\text{–}10$ gauss,

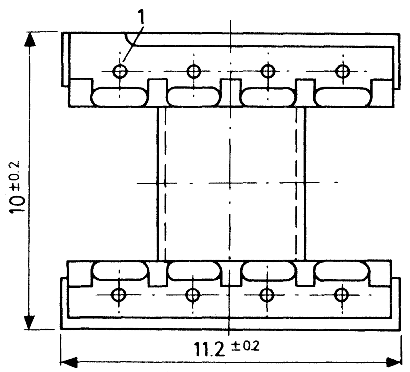
f = 4kHz and a mechanical force of 1.5 Newton in the temperature range from +23 till +70 °C, 24 hours after demagnetisation.
$\mu_e \geq 3820$
$\alpha \leq 25.0$
$A_L \geq 1600$

The eight soldering pins are arranged so as to fit printed-wiring boards with 0.1" grid as well as those with a 2.50 mm grid. The board should be provided with holes of max. 0.8 + 0.1 mm ϕ.

COIL FORMER







(1) Pins: phosphorbronze, dipsoldered
(2) H-core: ferroxcube

The coil former and the ferroxcube H-shape are combined to one part.

Material of coil former	reinforced polyester with phosphorbronze dipsoldered pins
Window area in mm^2	7.6
Mean length of turn in cm	2.17
Max. temperature for dipsoldering	
for 5-6 s in °C	280
for 1-2 s in °C	360 - 400
Max. working temperature in °C	130

For **speeding** up the soldering operation of the winding wire to the pins, the use of self fluxing wire is advised. In case a terminal of the winding must be connected to the container, it should be soldered to pin 1 (see figure above).
The side of the coil former where the soldering pins protrude is asymmetrical providing a means for numbering the connections.

In order to avoid damage of the ferroxcube H-shape, care should be taken that during winding the turning couple exercised on this ferroxcube part is not too high.

MOUNTING PARTS

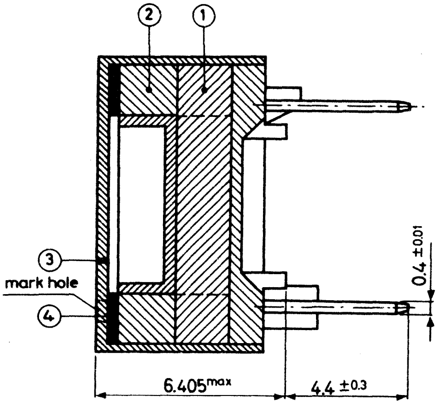


Fig. 1

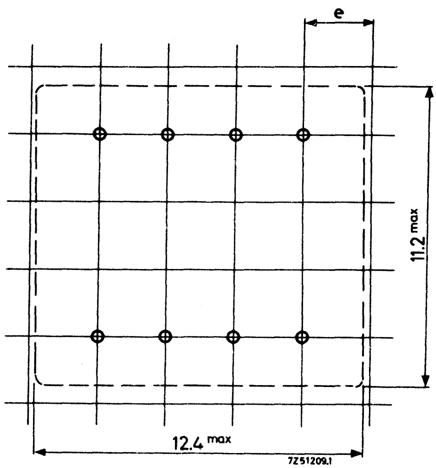


Fig. 2. Hole pattern.
e = 0.1" or 2.50 mm.

The H 10-core is only applied as a complete assembly.
Cat. number of the assembly: 4322 020 33010

Components according to Fig. 1:
(1) Ferroxcube H-shape with reinforced polyester coil former
(2) Ferroxcube window
(3) Brass container 4322 021 20020
(4) Phosphorbronze spring 4322 021 20390

Take care that the jointing surfaces of the two core parts are very clean.

The silver reference lines on one side of the H-shape and on one side of the window should coincide. If no reference lines are given, the parts may be arbitrary positioned.

When glueing is desired, apply a suitable adhesive around the jointing surfaces of the H-shape and the window (see Fig. 3). The spots where the adhesive is to be applied should first be degreased thoroughly. A suitable adhesive is e.g. Araldit type D, with Versamide 140, mixing ratio is 70 : 30: curing time at least 24 hours at room temperature.
There is a marking hole on the top side of the container (see Fig. 1). This hole must be in one line with soldering pin 1. This pin can easely be recognised by the asymmetrical shape of the coil former under side.

If the brass container must be earthed, the longer (tin-plated) lip must be soldered to pin 1 after bending the lips.
For bending the container lips, a simple tool (placed in a press with cranked levers) has been developed.
This tool can not be supplied, however drawings of this tool are supplied on request under cat. number 4322 058 00120.

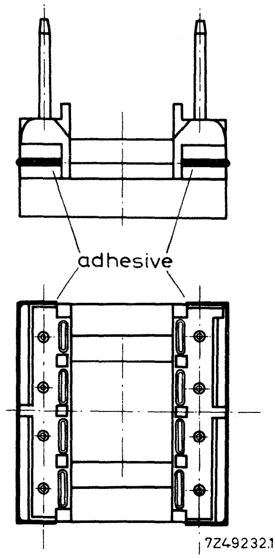
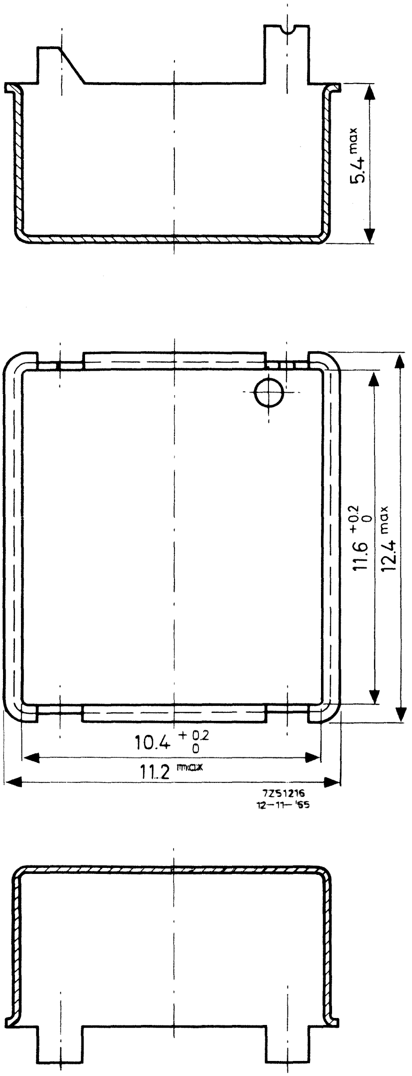
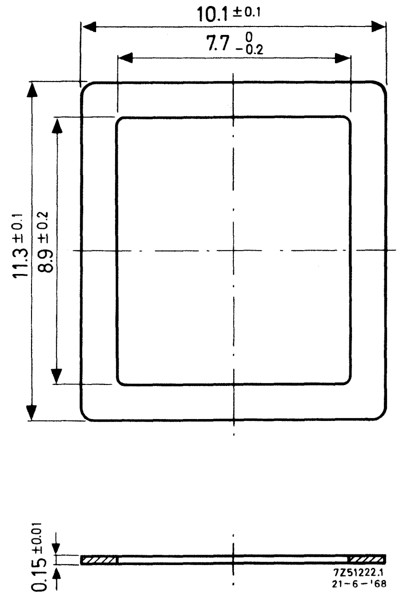


Fig. 3



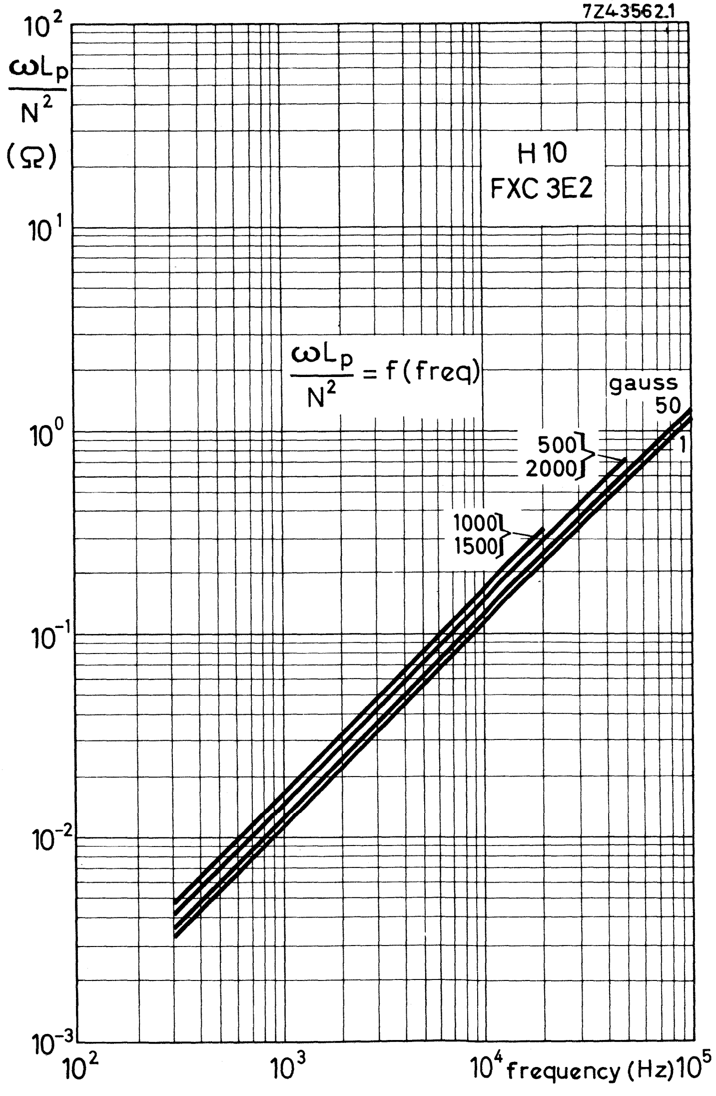
(3) Container 4322 021 20020
Material: brass, nickel-plated

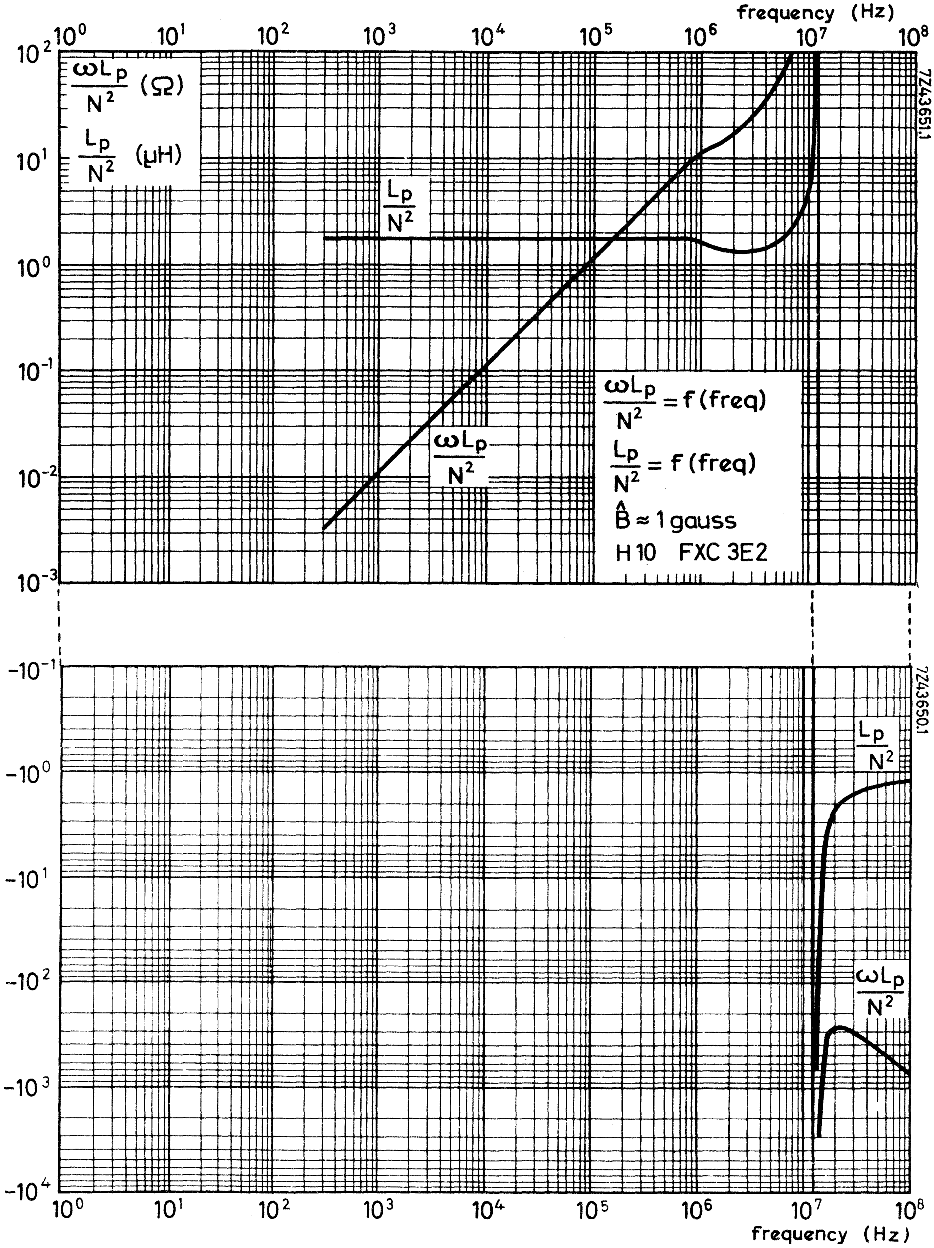


(4) Spring 4322 021 20390
Material: phosphorbronze, nickel-plated

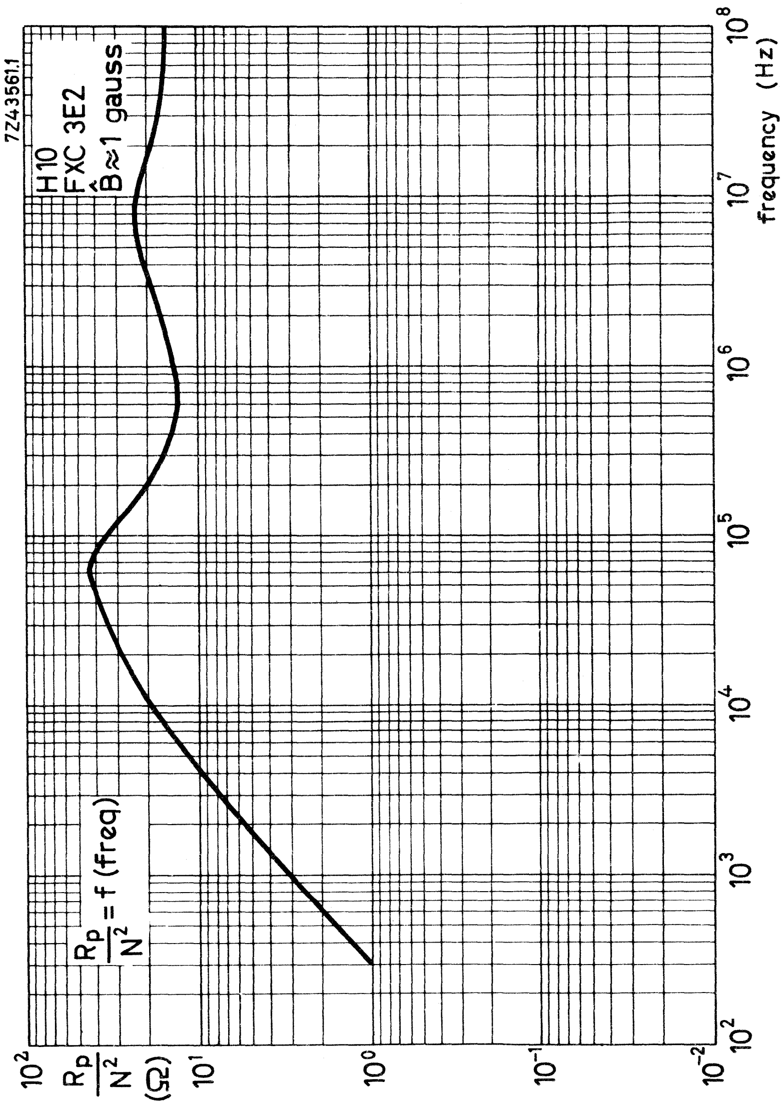
CHARACTERISTIC CURVES

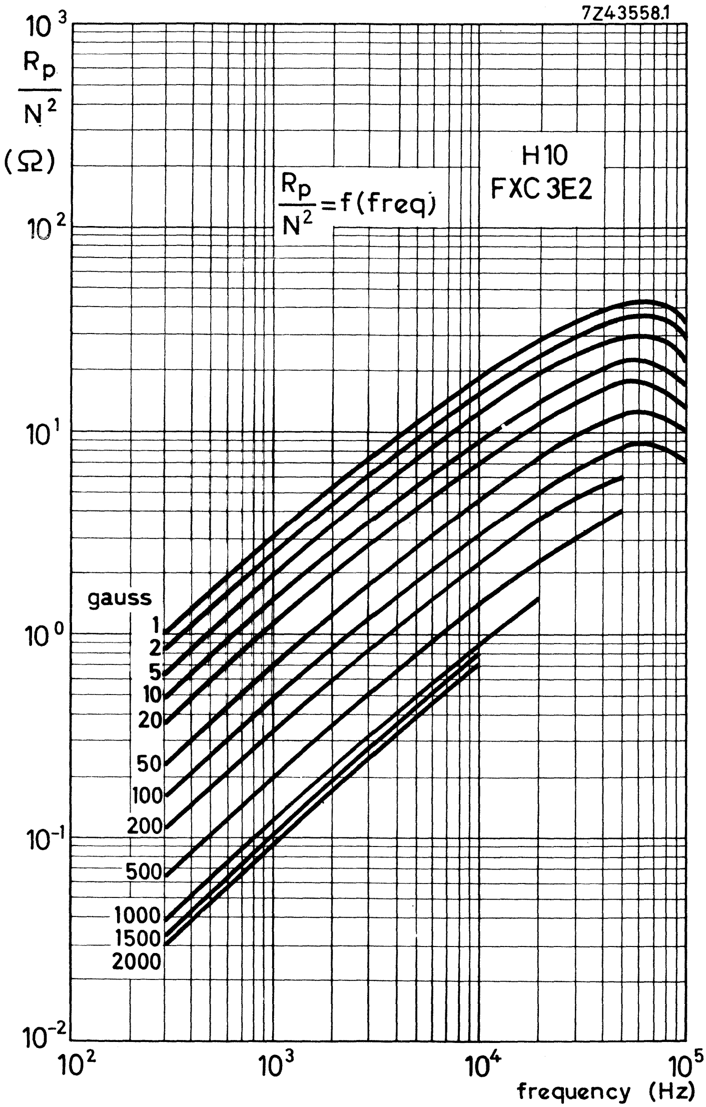
INDUCTANCE AS A FUNCTION OF THE FREQUENCY (typical values)

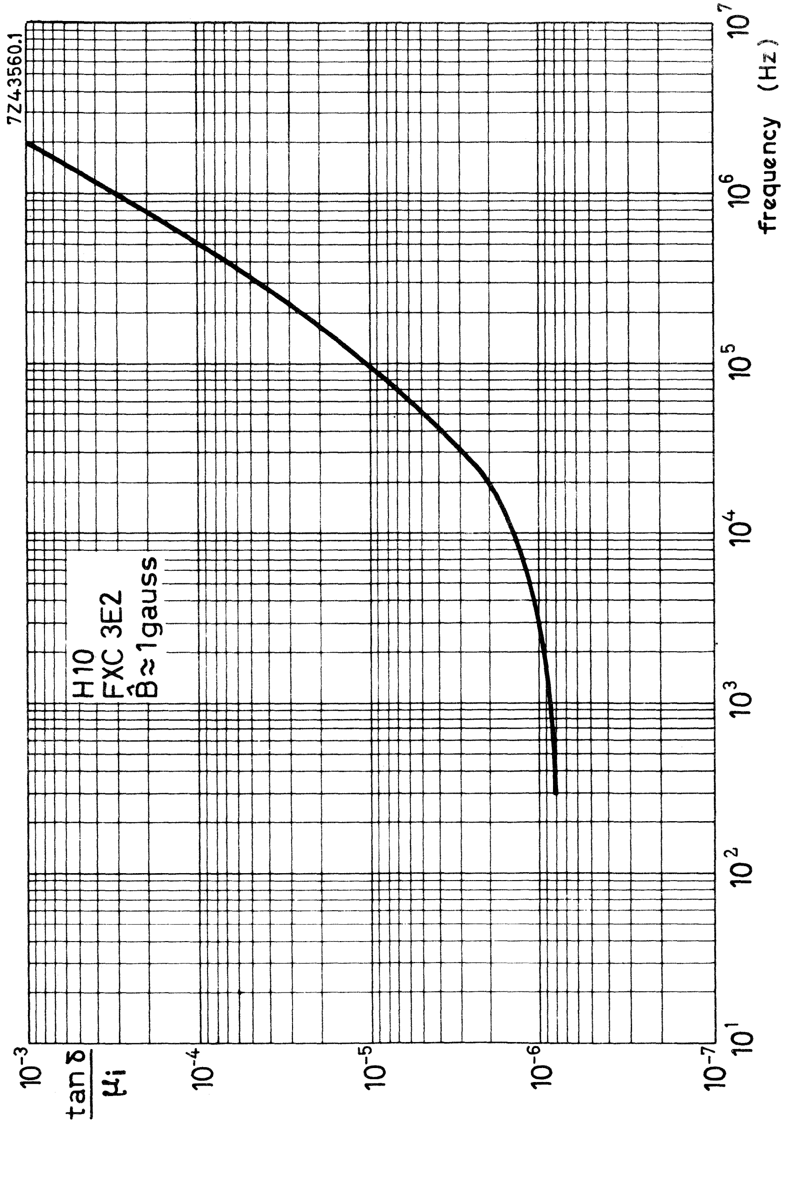



frequency (Hz)
ωLp/N² (Ω)
Lp/N² (μH)
Lp/N²
ωLp/N²
ωLp/N² = f (freq)
Lp/N² = f (freq)
B̂ ≈ 1 gauss
H 10 FXC 3E2
7Z43651.1
7Z43650.1
Lp/N²
ωLp/N²
frequency (Hz)

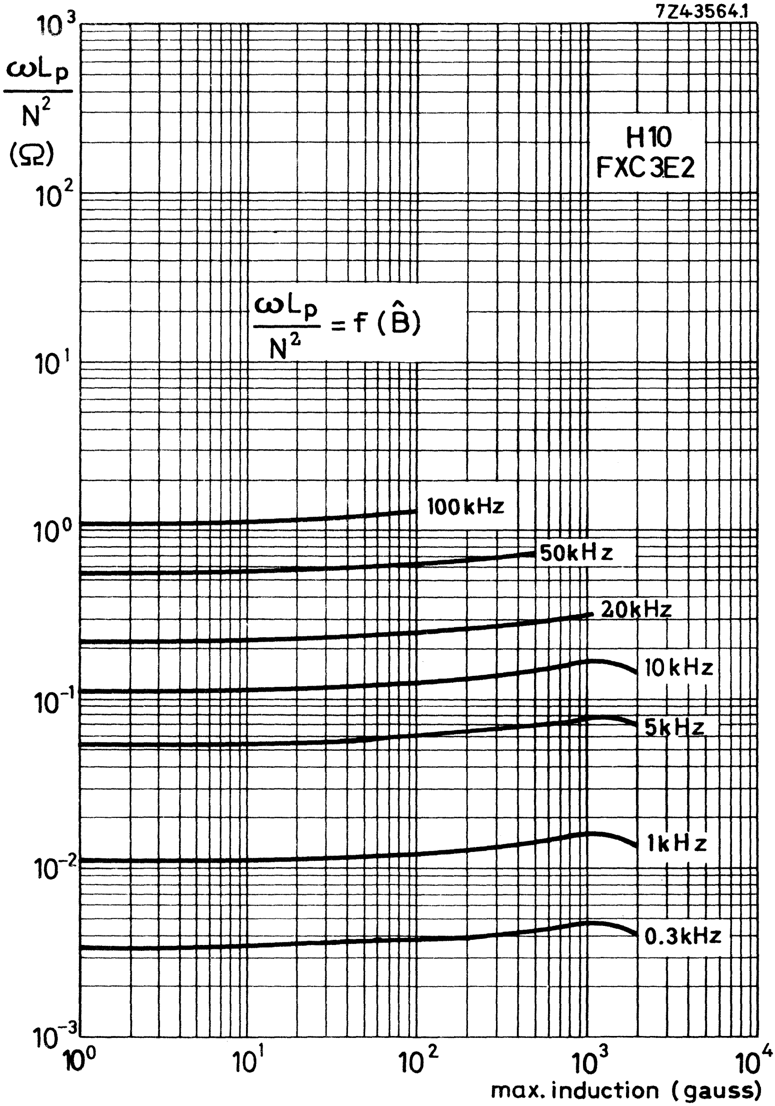
LOSSES AS A FUNCTION OF THE FREQUENCY (typical values)



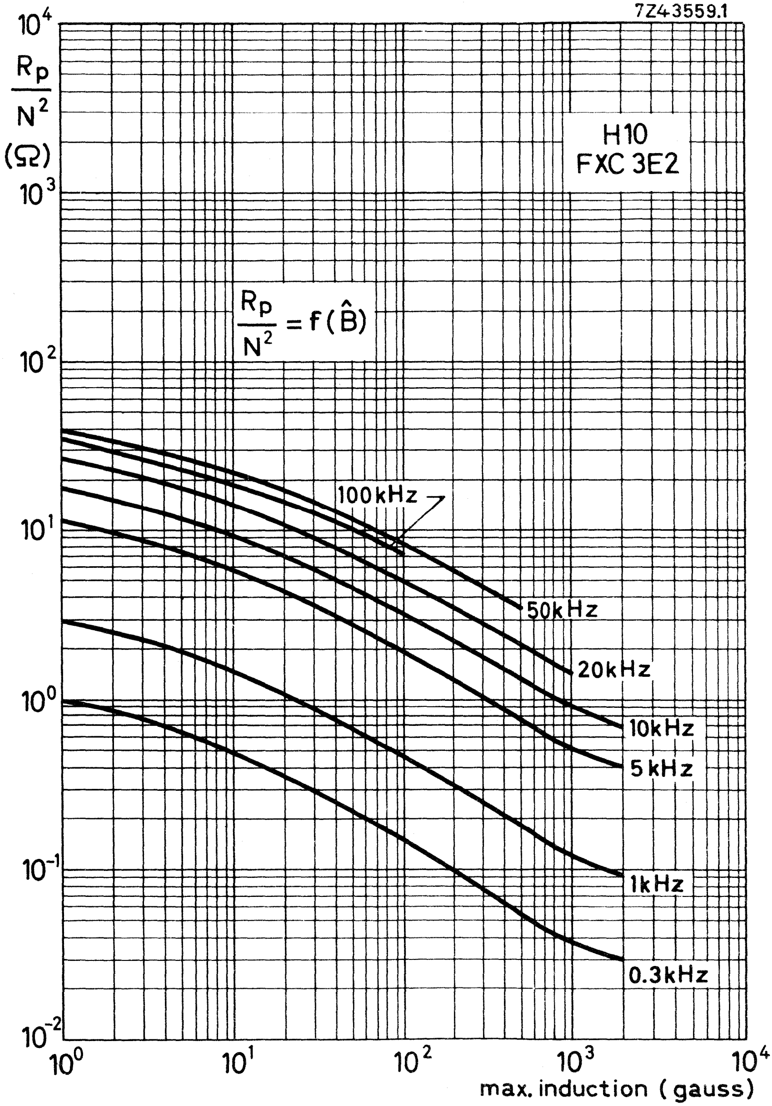

7Z43558.1
10^3
$\frac{R_p}{N^2}$
(Ω)
10^2
10^1
10^0
10^{-1}
10^{-2}
H10
FXC 3E2
$\frac{R_p}{N^2} = f(freq)$
gauss
1
2
5
10
20
50
100
200
500
1000
1500
2000
10^2
10^3
10^4
10^5
frequency (Hz)


7Z43560.1
H10
FXC 3E2
$\hat{B} \approx 1$gauss
$\frac{\tan\delta}{\mu_i}$
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
frequency (Hz)

INDUCTANCE AS A FUNCTION OF THE INDUCTION (typical values)

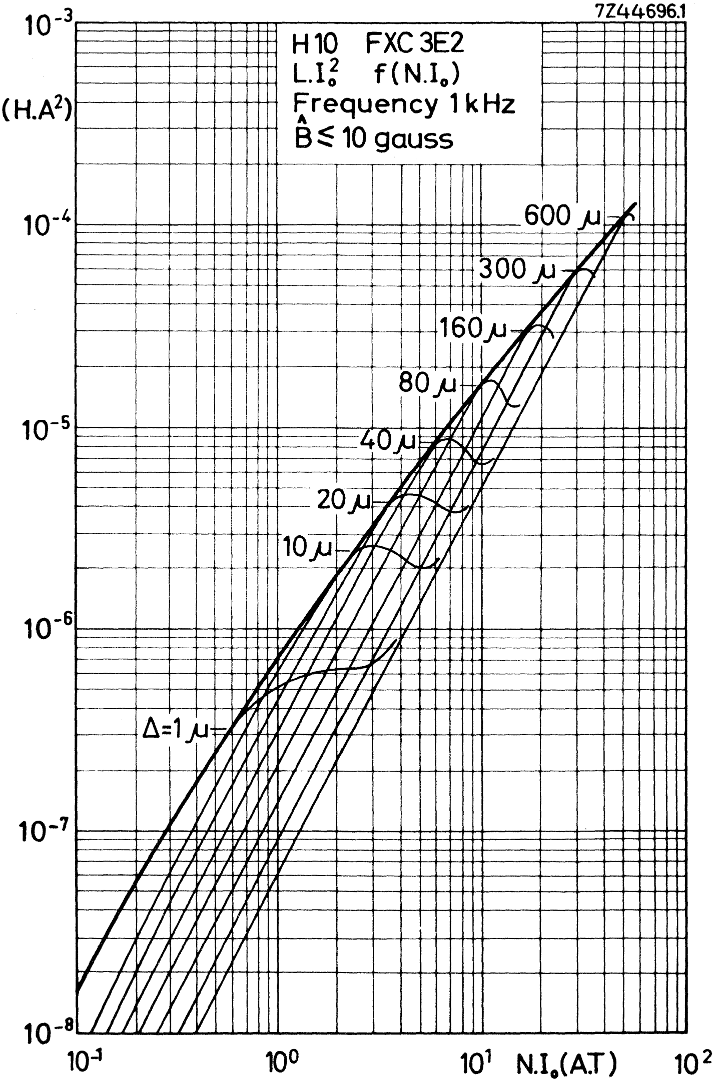


LOSSES AS A FUNCTION OF THE INDUCTION (typical values)

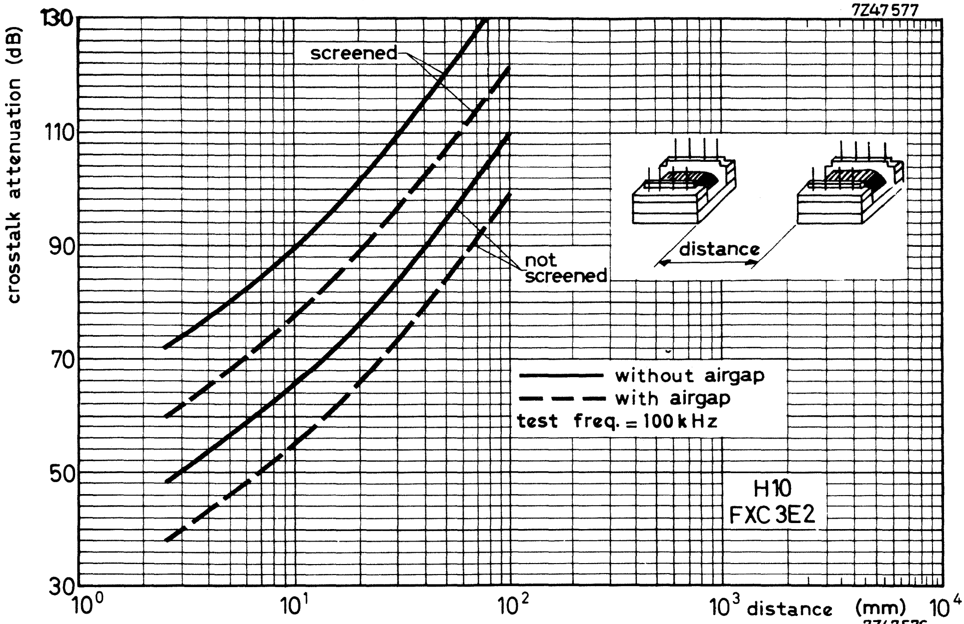


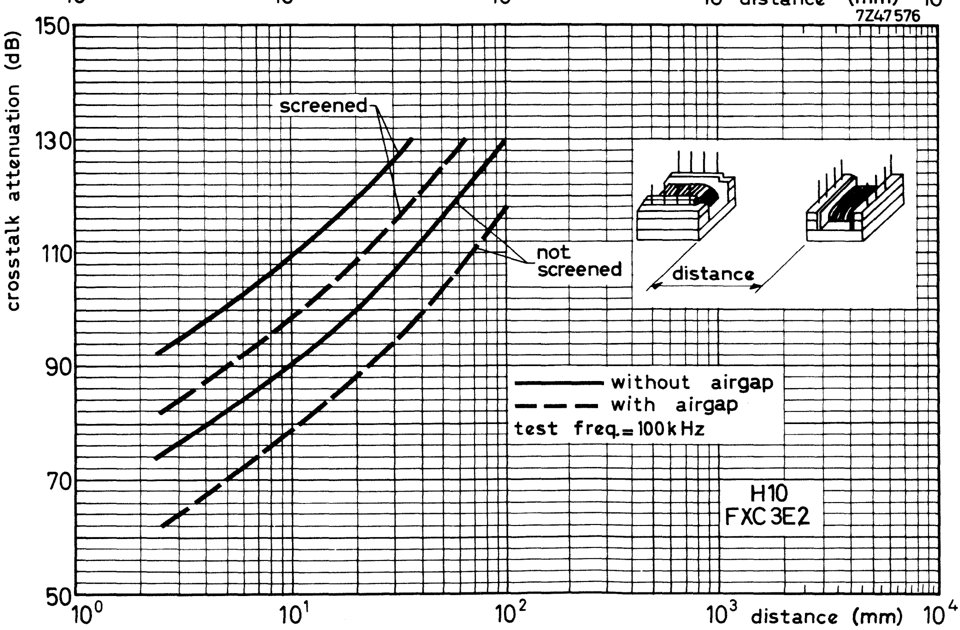
HANNA CURVE (typical values)

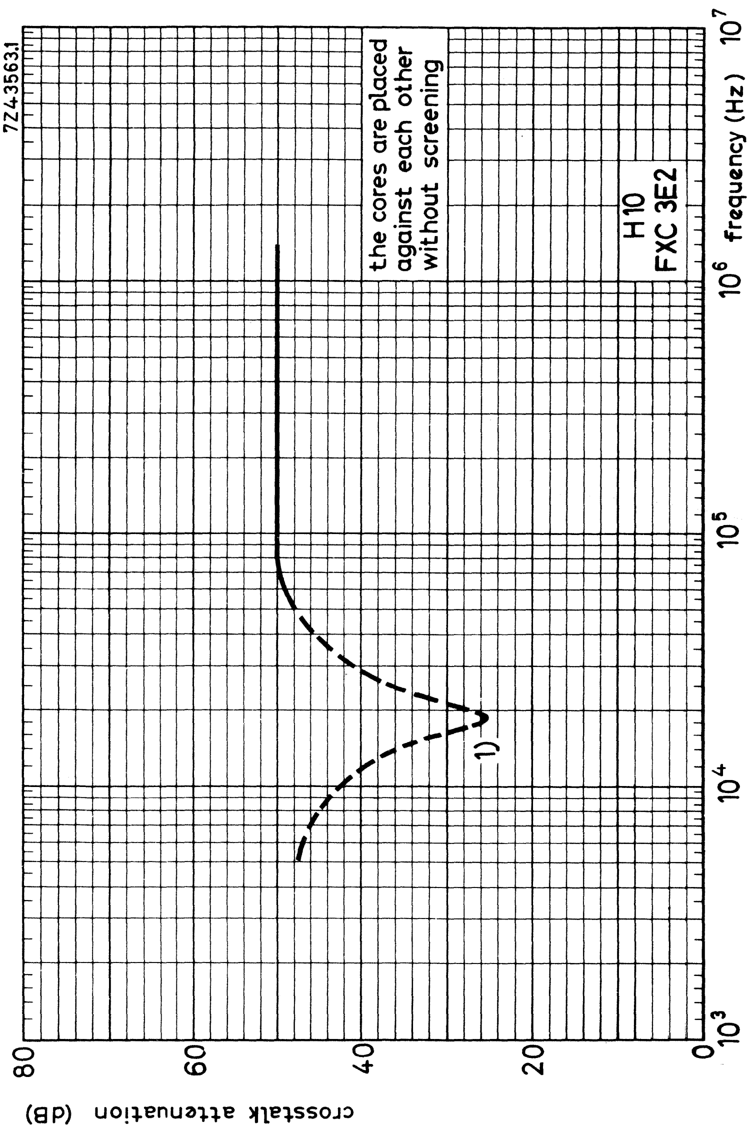
Indicating optimum inductance for a certain airgap and direct current



CROSS TALK ATTENUATION (typical values)

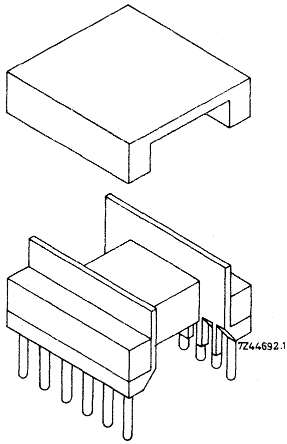






1) This dip does not depend on the magnetic circuit. It is caused by resonances of the inductance and stray capacitance of the two components in the test circuit.

H-CORE



The H 16-core consists of a ferroxcube H-shape with coil former, a ferroxcube U-shape, a brass container and a phosphorbronze spring.
All these components are adapted to each other.

The H 16-core can only be supplied as a complete assembly.

Cat. number of the assembly : 4322 020 33030
Approximate weight of the assembly: 9.5 g

The applied ferroxcube material is the high permeable 3E2 grade.

The jointing surfaces are very flat and smoothly lapped.

Dimensional quantities

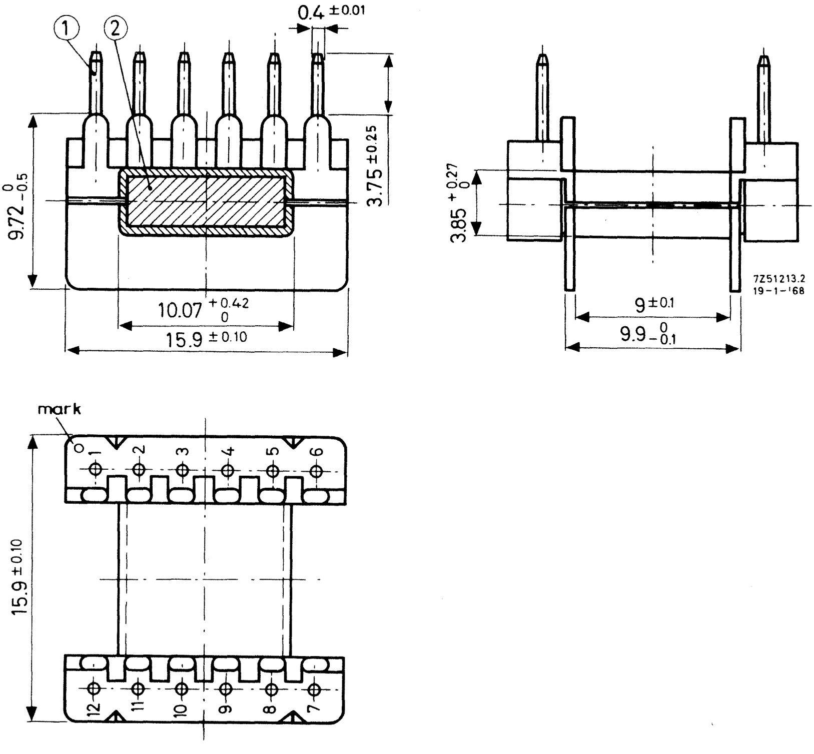
Mean length of lines of force	l_e	= 3.57 cm
Mean area of lines of force	A_e	= 0.349 cm^2
	$\Sigma \frac{l_e}{A_e}$	= 10.2 cm^{-1}
Effective volume	V_e	= 1.24 cm^3

Electrical requirements, measured with 30 windings of 0.25 mm wire, at $\hat{B}$ = 7-10 gauss, f = 4 kHz and a mechanical force of 1.5 Newton in the temperature range from +23 till +70 °C, 24 hours after demagnetisation.

μ_e >
α <
A_L >4500

The twelve soldering pins are arranged so as to fit printed-wiring boards with 0.1" grid as well as those with a 2.50 mm grid. The board should be provided with holes of max. 0.8+0.1 mm ϕ

COIL FORMER



(1) Pins: phosphorbronze, dipsoldered
(2) H-core: ferroxcube

The coil former and the ferroxcube H-shape are combined to one part.

Material of coil former	reinforced polyester with phosphorbronze dipsoldered pins
Window in mm^2	
Mean length of turn in cm	3.96
Max. temperature for dipsoldering	
for 5-6 s in °C	280
for 1-2 s in °C	360-400
Max. working temperature in °C	130

For speeding up the soldering operation of the winding wire to the pins, the use of self fluxing wire is advised. In case a terminal of the winding must be connected to the container, it should be soldered to pin 1 (see figure above).

In order to avoid damage of the ferroxcube H-shape, care should be taken that during winding the turning couple exercised on this ferroxcube part is not too high.

MOUNTING PARTS

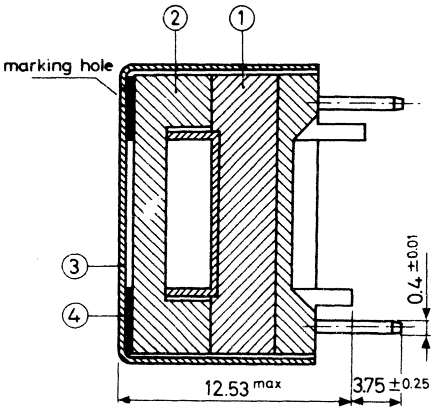


Fig. 1

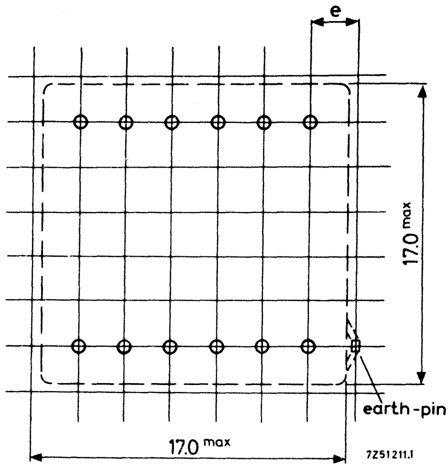


Fig. 2. Hole pattern.
e = 0.1" or 2.50 mm.

The H 16-core is only applied as a complete assembly.
Catalog number of the assembly: 4322 020 33030

Components according to Fig. 1.
(1) Ferroxcube H-shape with reinforced polyester coil former
(2) Ferroxcube U-shape
(3) Brass container 4322 021 20180
(4) Phosphorbronze spring 4322 021 20400

Take care that the jointing surfaces of the two core parts are very clean.

The silver reference lines on one side of the H-shape and on one side of the U-shape should coincide. If no reference lines are given, the parts may be arbitrary positioned.

When glueing is desired, apply a suitable adhesive around the jointing surfaces of the H-shape and the U-shape (see Fig. 3). The spots where the adhesive is to be applied should first be degreased thoroughly. A suitable adhesive is e.g. Araldit type D, with Versamide 140, mixing ratio 70 : 30; curing time at least 24 hours at room temperature.
Each pin is marked with a figure. There is also a marking hole on the top side of the container. This marking hole must be in one line with soldering pin 1.

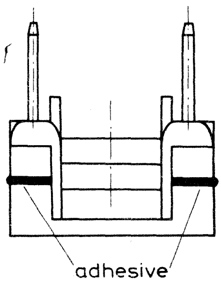
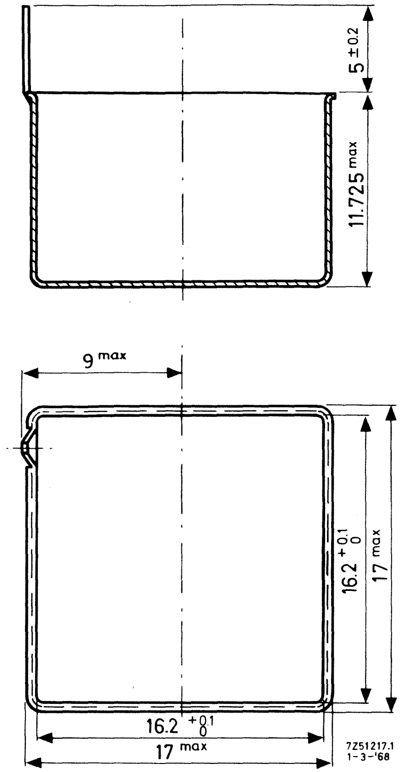


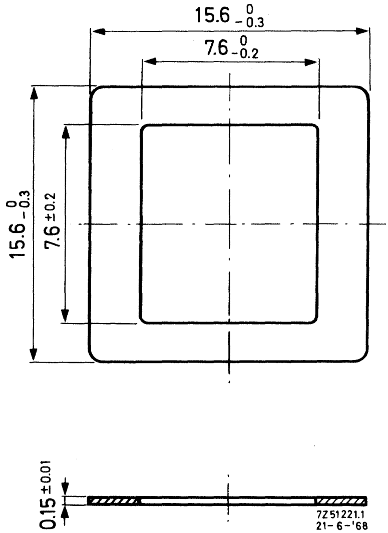
Fig. 3

If wanted the brass container can be earthed by means of the earth pin (see Fig. 2).

For closing the container, a simple tool (placed in a press with cranked levers) has been developed. This tool can not be supplied, however drawings of this tool are supplied on request under catalogue number 4322 058 00140.



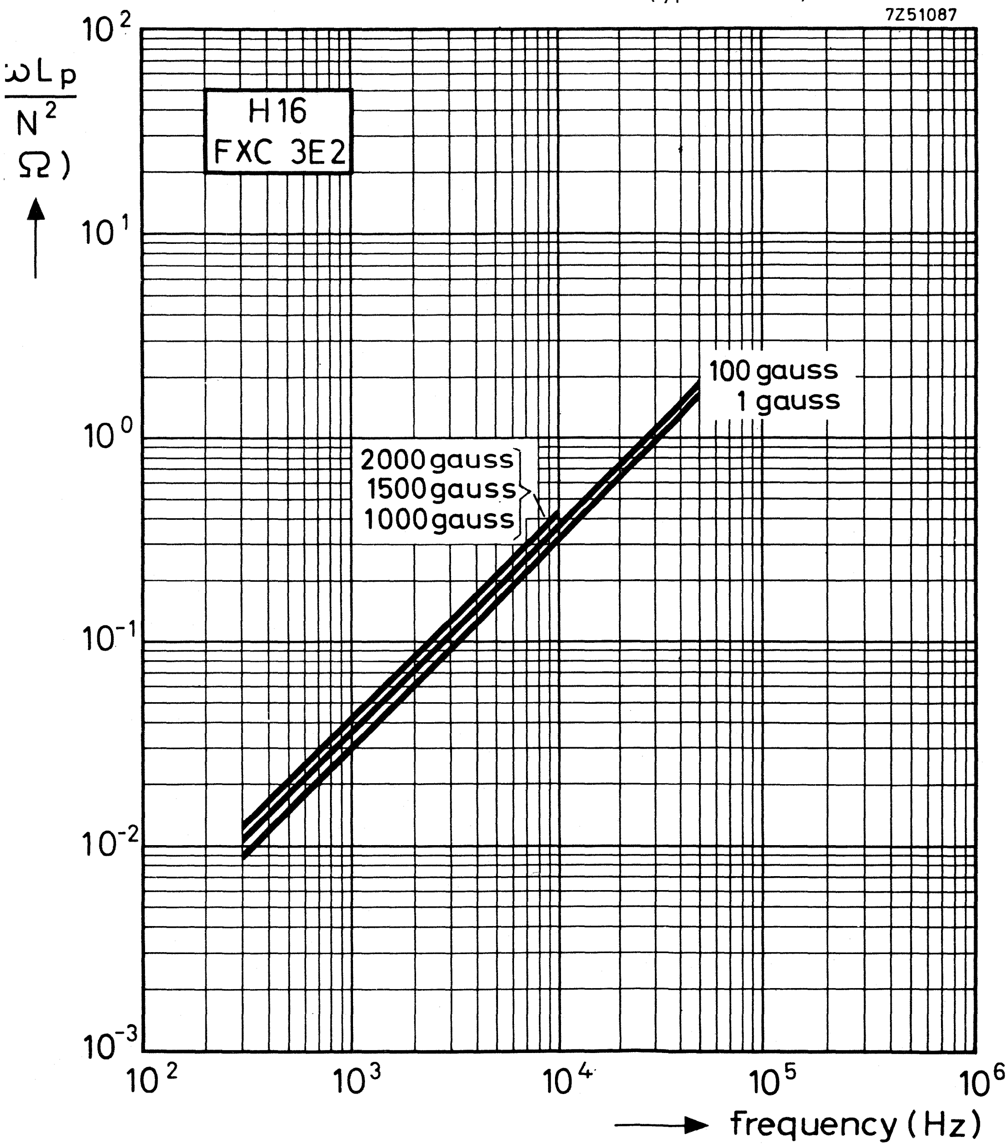
(3) Container 4322 021 20180
Material: brass, nickel-plated

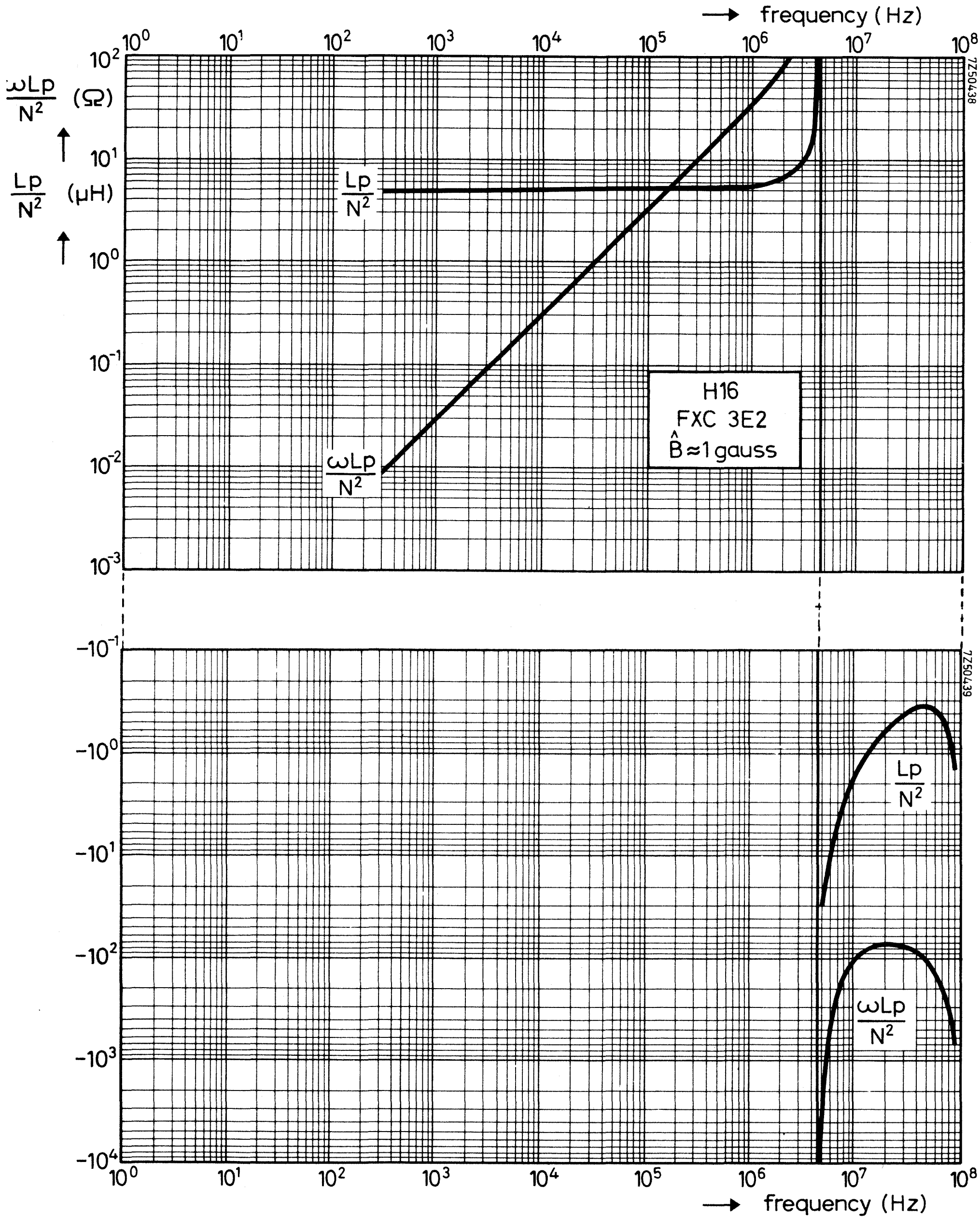


(4) Spring 4322 021 20400
Material: phosphorbronze, nickel-plated

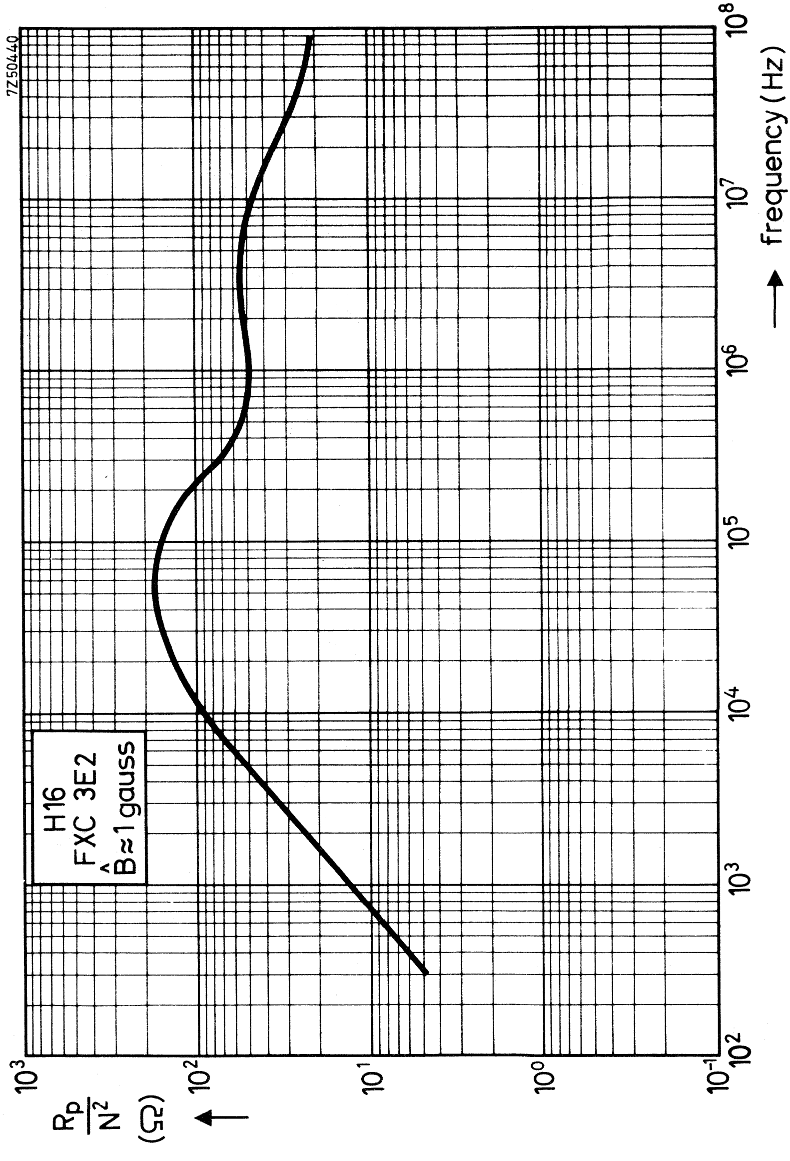
CHARACTERISTIC CURVES

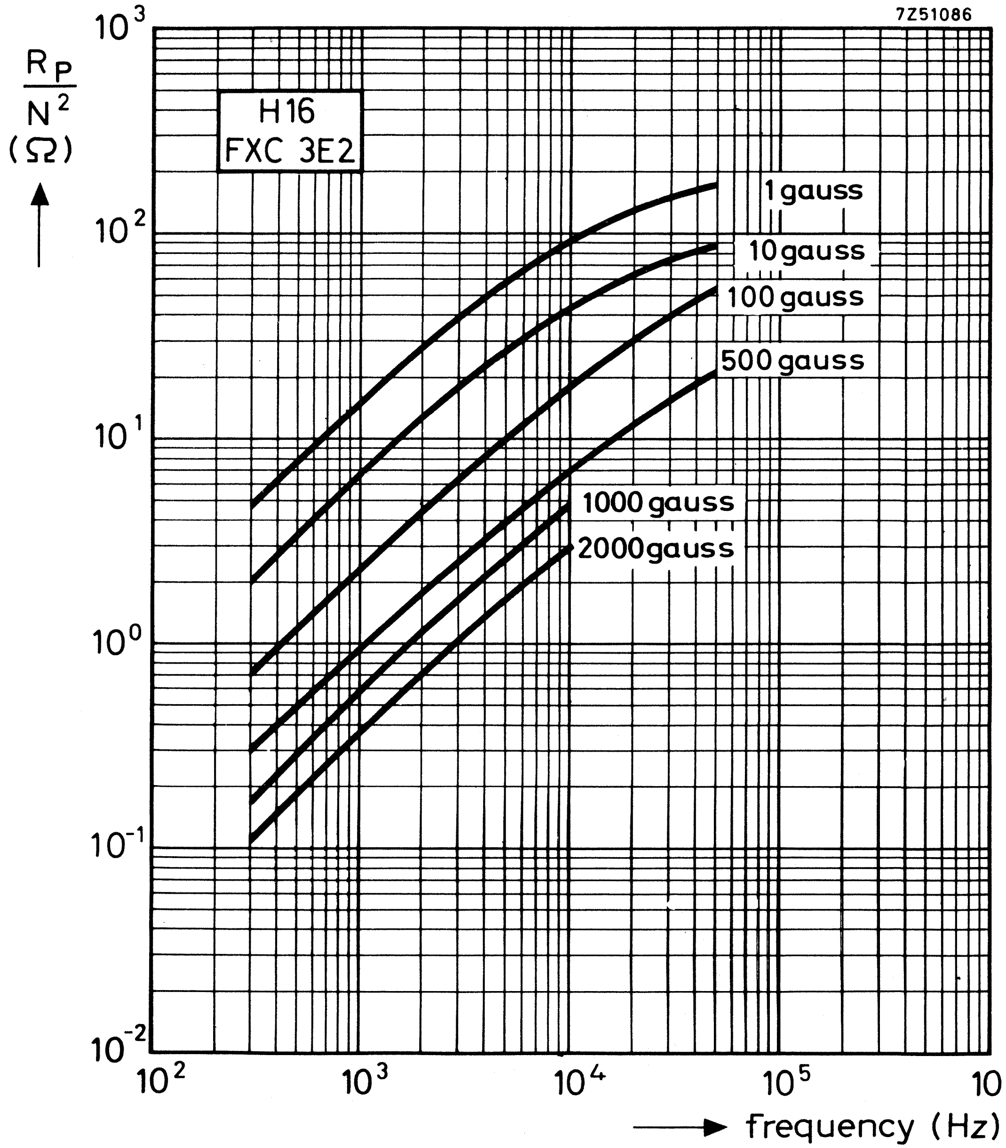
INDUCTANCE AS A FUNCTION OF THE FREQUENCY (typical values)

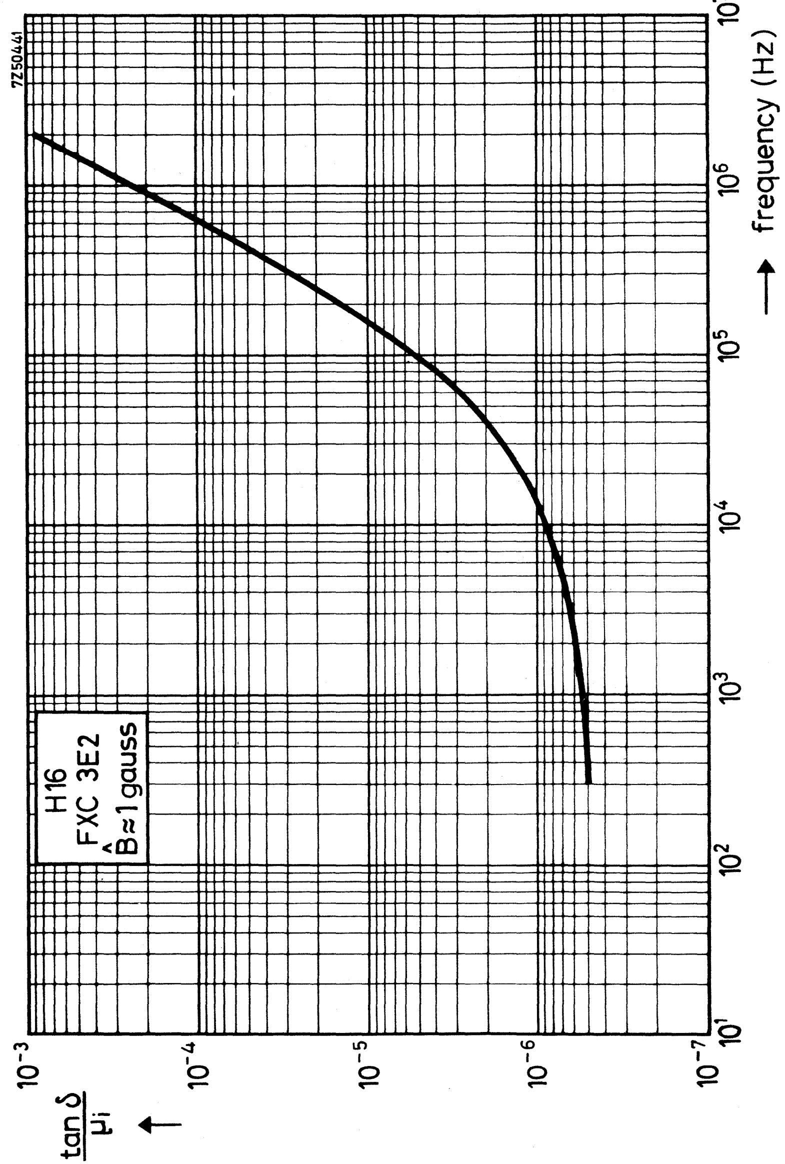



→ frequency (Hz)
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8
$\frac{\omega Lp}{N^2}$ (Ω)
$\frac{Lp}{N^2}$ (μH)
10^2 10^1 10^0 10^{-1} 10^{-2} 10^{-3}
7Z50438
$\frac{Lp}{N^2}$
$\frac{\omega Lp}{N^2}$
H16
FXC 3E2
$\hat{B}\approx 1$ gauss
-10^{-1} -10^0 -10^1 -10^2 -10^3 -10^4
7Z50439
$\frac{Lp}{N^2}$
$\frac{\omega Lp}{N^2}$
10^0 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8
→ frequency (Hz)

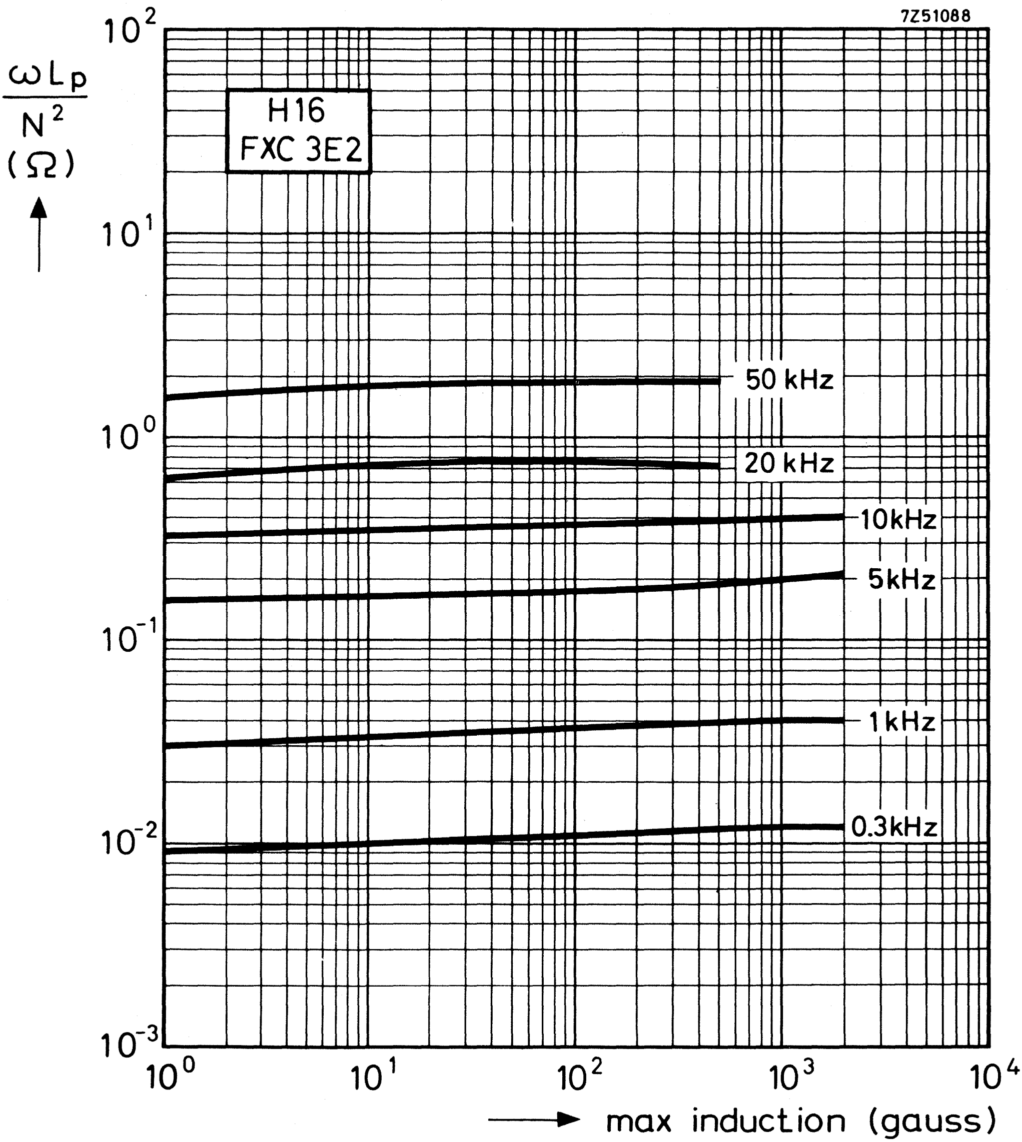
LOSSES AS A FUNCTION OF THE FREQUENCY (typical values)



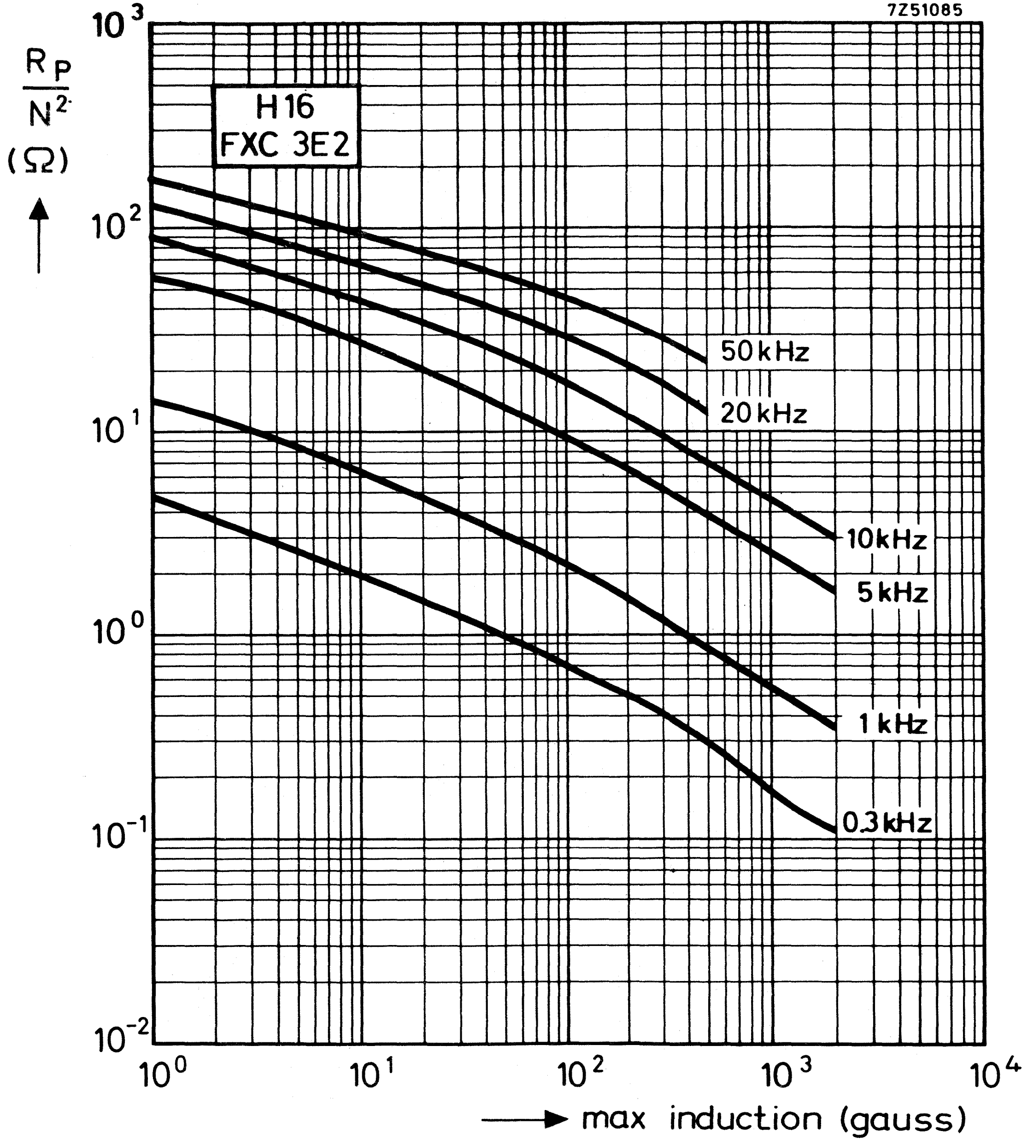

7Z51086
H 16
FXC 3E2
$\frac{R_P}{N^2}$ (Ω)
1 gauss
10 gauss
100 gauss
500 gauss
1000 gauss
2000 gauss
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^2
10^3
10^4
10^5
frequency (Hz)


7Z50441
H16
FXC 3E2
B̂≈1 gauss
frequency (Hz)
tan δ / μi
10^-3
10^-4
10^-5
10^-6
10^-7
10^1
10^2
10^3
10^4
10^5
10^6
10^7

INDUCTANCE AS A FUNCTION OF THE INDUCTION (typical values)

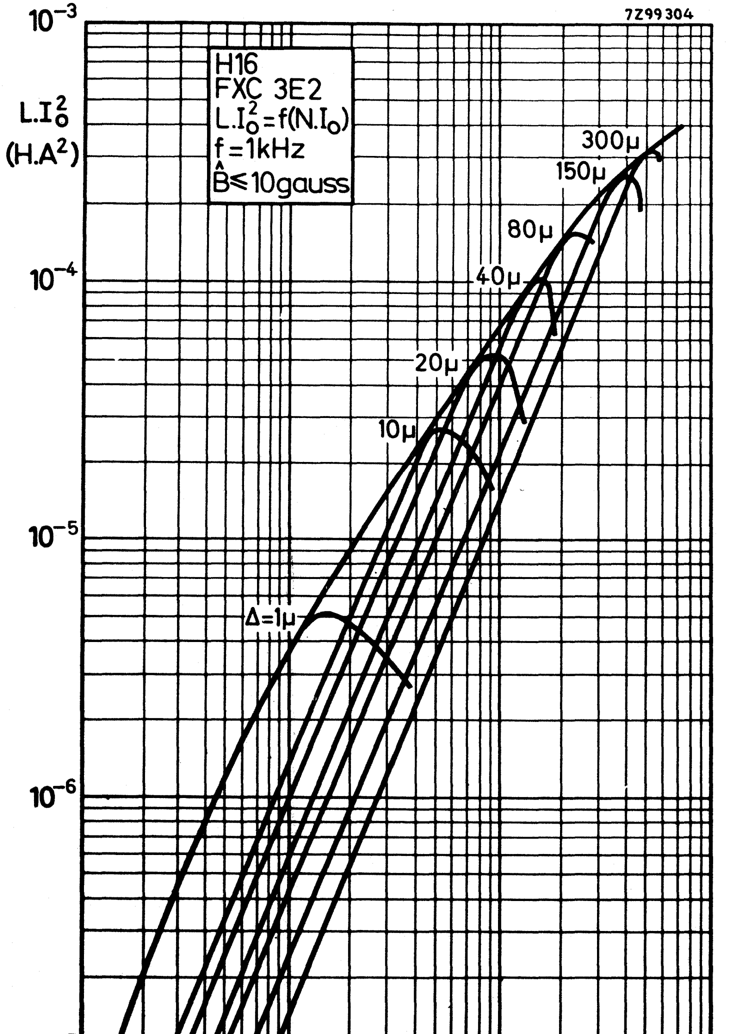


LOSSES AS A FUNCTION OF THE INDUCTION (typical values)

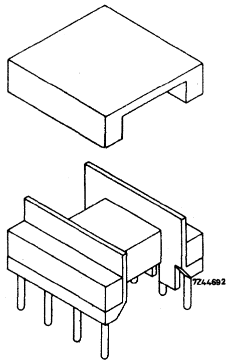


HANNA CURVE (typical values)

Indicating optimum inductance for a certain airgap and direct current



H-CORE



The H 20-core consists of a ferroxcube H-shape with coil former, a ferroxcube U-shape, a brass container and a phosphorbronze spring.
All these components are adapted to each other.

The H 20-core can only be supplied as a complete assembly.
Cat. number of the assembly : 4322 020 33000
Approximate weight of the assembly : 15.2 g

The applied ferroxcube material is the high permeable 3E2 grade.

The jointing surfaces are very flat and smoothly lapped.

Dimensional quantities

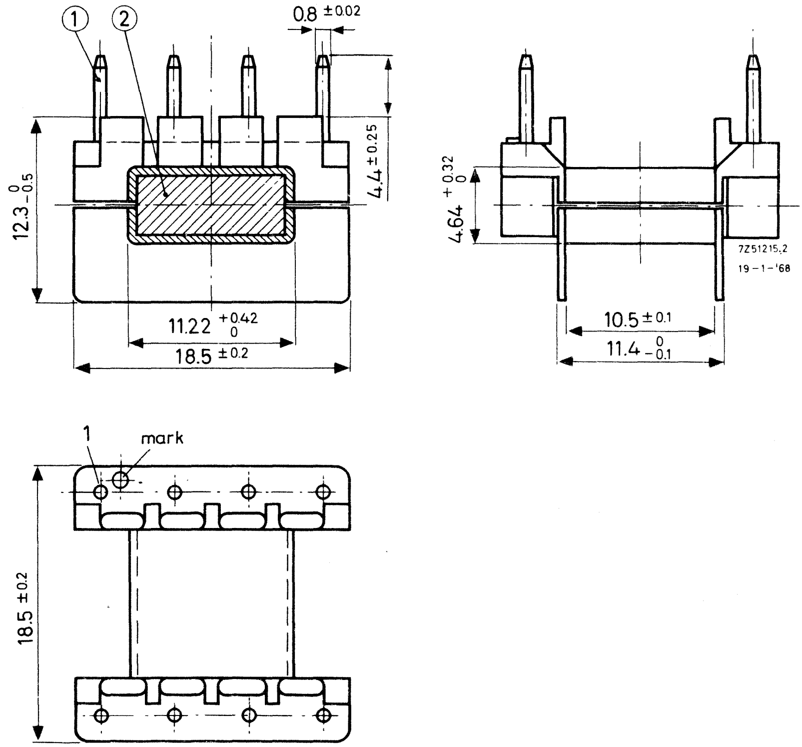
Mean length of lines of force	$l_e = 4.12$ cm
Mean area of lines of force	$A_e = 0.47$ cm^2
	$\Sigma \frac{l_e}{A_e} = 8.8$ cm^{-1}
Effective volume	$V_e = 1.93$ cm^3

Electrical requirements, measured with 30 windings of 0.30 mm wire, at $\hat{B} = 7-10$ gauss, f = 4 kHz and a mechanical force of 1.5 Newton in the temperature range from +23 till +70 °C, 24 hours after demagnetisation

$\mu_e \geq 3850$
$\alpha \leq 13.4$
$A_L \geq 5500$

The eight soldering pins are arranged so as to fit printed-wiring boards with 0.1" grid as well as those with a 2.50 mm grid. The board should be provided with holes of max. 1.3 ± 0.15 mm φ.

COIL FORMER



(1) Pins: phosphorbronze, dipsoldered
(2) H-core: ferroxcube

The coil former and the ferroxcube H-shape are combined to one part.

Material of coil former	reinforced polyester with phosphorbronze dipsoldered pins
Window area in mm^2	38.5
Mean length of turn in cm	4.68
Max. temperature for dipsoldering	
for 5-6 s in °C	280
for 1-2 s in °C	360-400
Max. working temperature in °C	130

For speeding up the soldering operation of the winding wire to the pins, the use of self fluxing wire is advised. In case a terminal of the winding must be connected to the container, it should be soldered to pin 1 (see figure above).

In order to avoid damage of the ferroxcube H-shape, care should be taken that during winding the turning couple exercised on this ferroxcube part is not too high.

MOUNTING PARTS

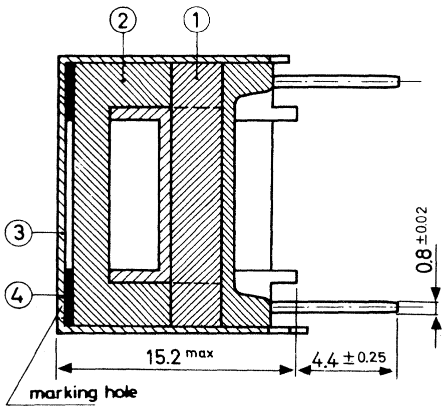


Fig. 1

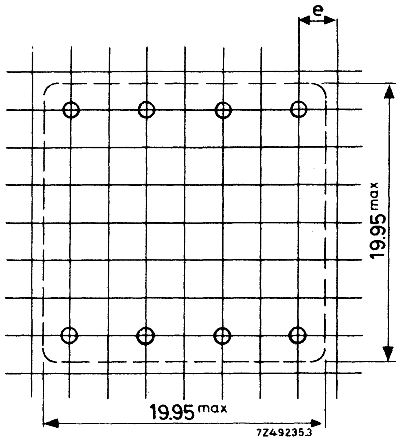


Fig.2. Hole pattern.
e = 0.1" or 2.50 mm.

The H 20-core is only applied as a complete assembly.
Cat. number of the assembly: 4322 020 33000

Components according to Fig. 1:
(1) Ferroxcube H-shape with reinforced polyester coil former
(2) Ferroxcube U-shape
(3) Brass container 4322 021 20000
(4) Phosphorbronze spring 4322 021 20410

Take care that the jointing surfaces of the two core parts are very clean.

The silver reference lines on one side of the H-shape and on one side of the U-shape should coincide. If no reference lines are given, the parts may be arbitrary positioned.

When glueing is desired apply a suitable adhesive around the jointing surfaces of the H-shape and the U-shape (see Fig.3). The spots where the adhesive is to be applied should first be degreased thoroughly. A suitable adhesive is e.g. Araldit type D, with Versamide 140, mixing ratio is 70 : 30; curing time at least 24 hours at room temperature.
Each pin is marked with a figure. There is also a marking hole on the top side of the container. This marking hole must be in one line with soldering pin 1.

If wanted the brass container can be earthed. To that purpose one of the container lips has a somewhat other shape and is tin-plated as well. This lip has to be soldered to pin 1 after bending the lips. If the container has not to be earthed, the tin-plated lip has to be cut down.
For bending the container lips, a simple tool (placed in a press with cranked levers) has been developed. This tool can not be supplied, however drawings of this tool are supplied on request under catalog number 4322 058 00130.

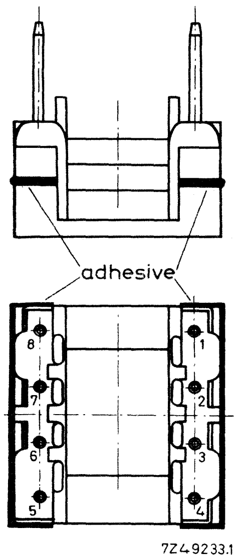
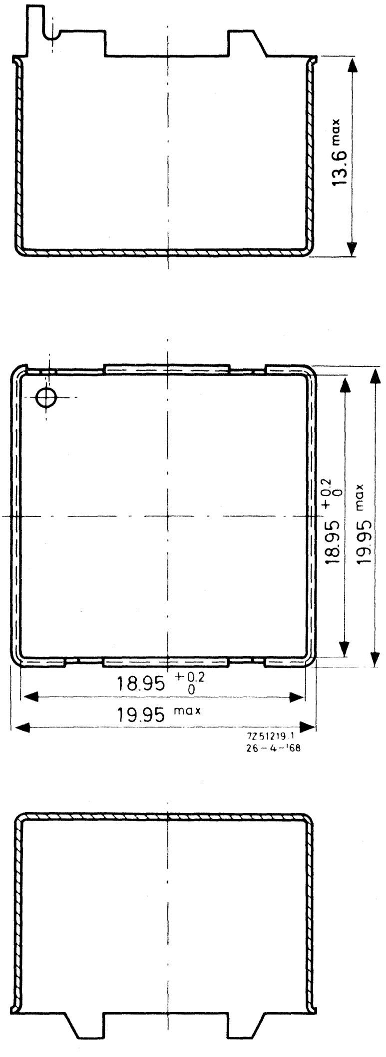
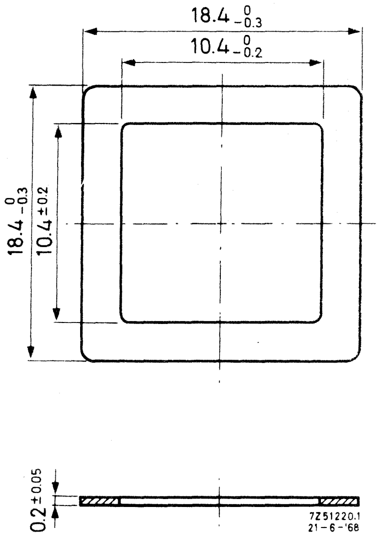


Fig. 3



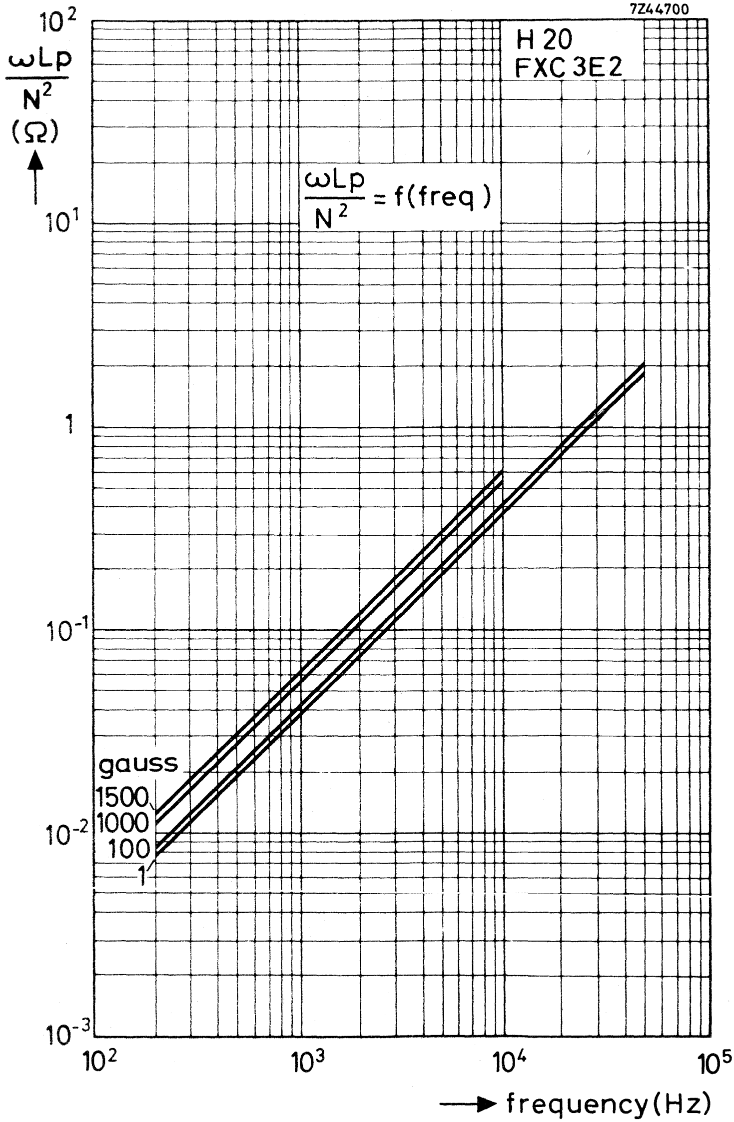
(3) Container 4322 021 20000
Material: brass, nickel-plated

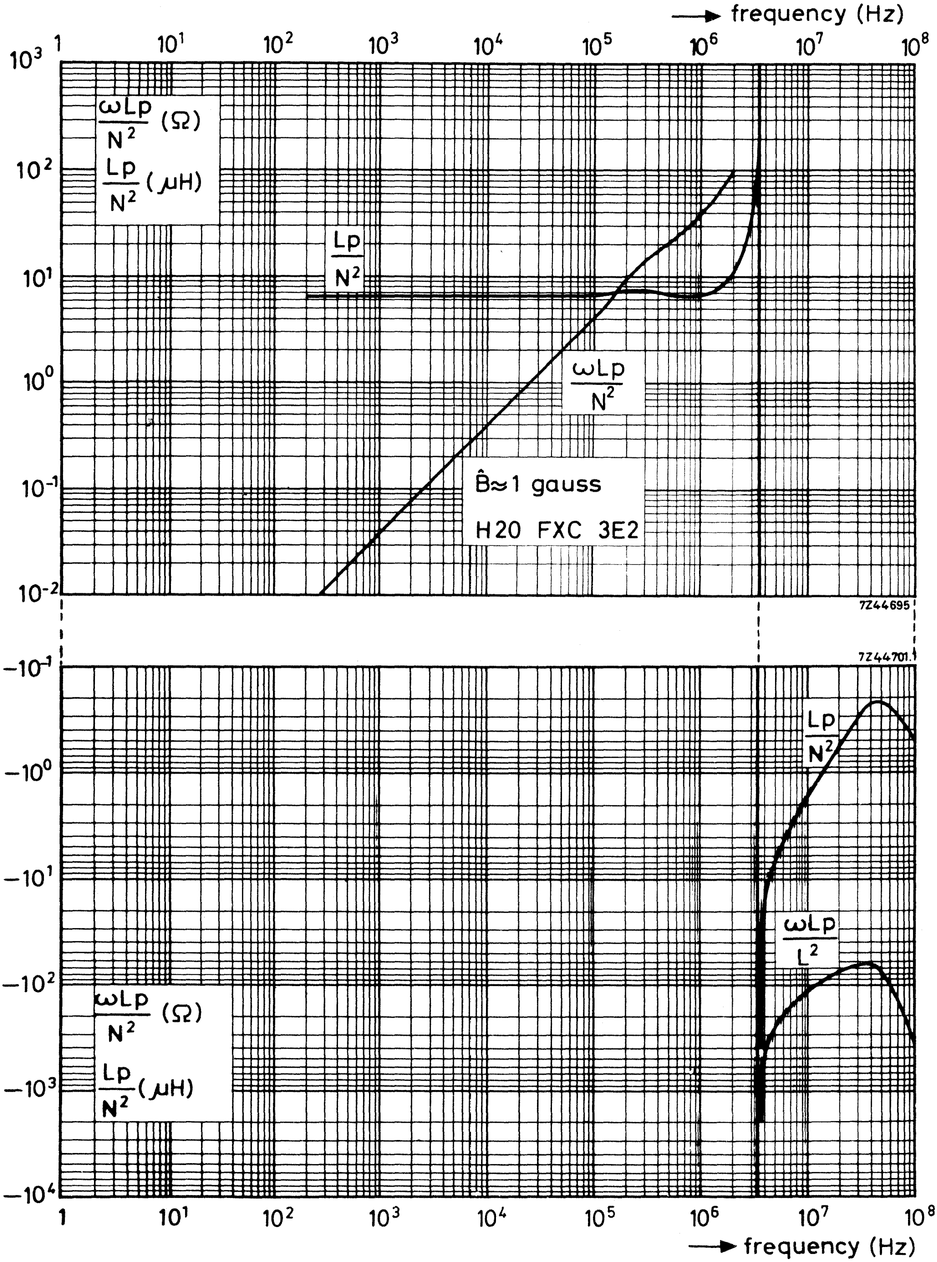


(4) Spring 4322 021 20410
Material: phosphorbronze, nickel-plated

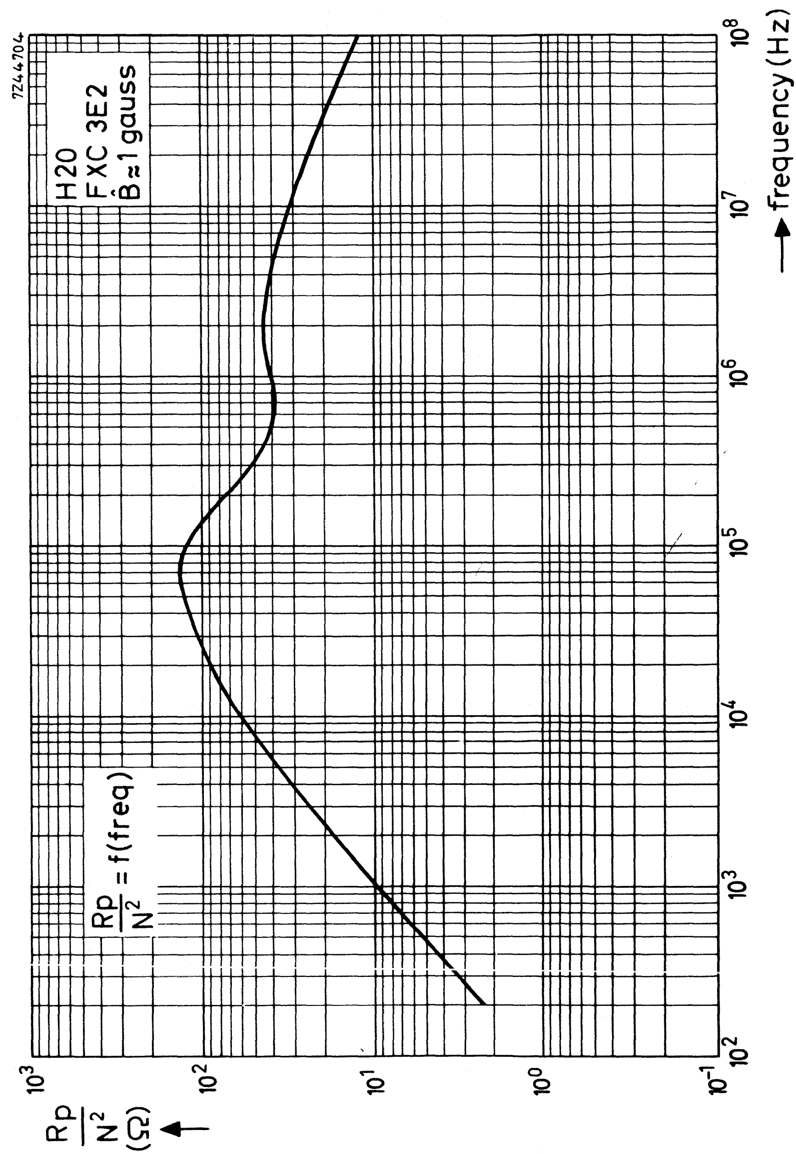
CHARACTERISTIC CURVES

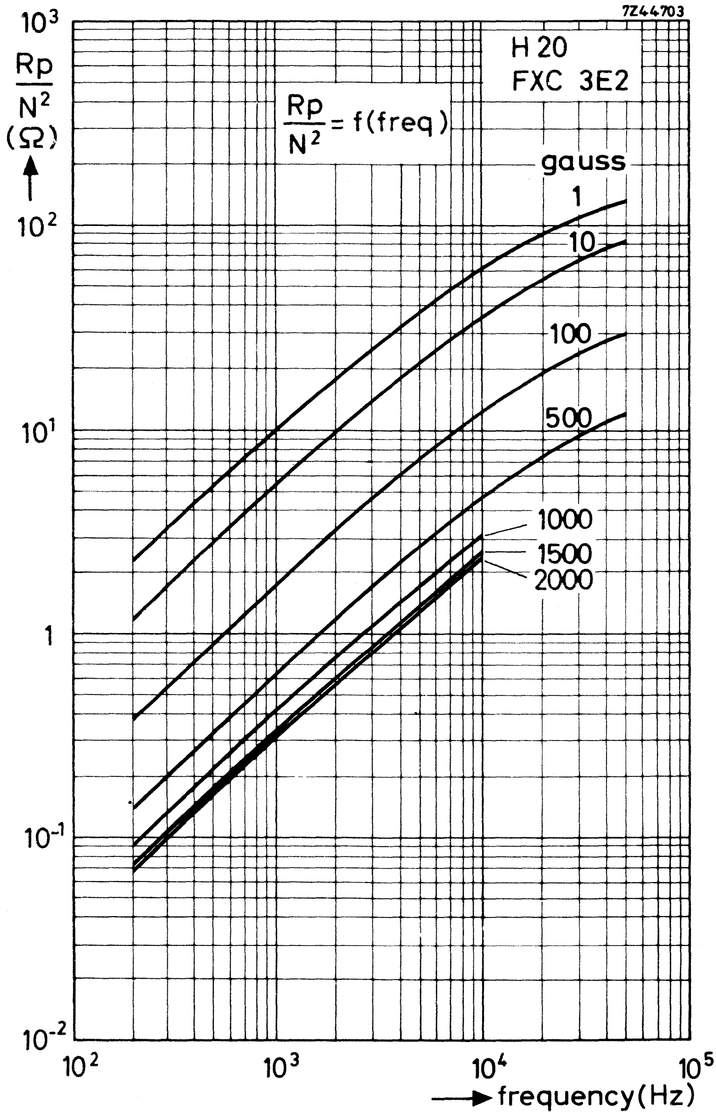
INDUCTANCE AS A FUNCTION OF THE FREQUENCY (typical values)

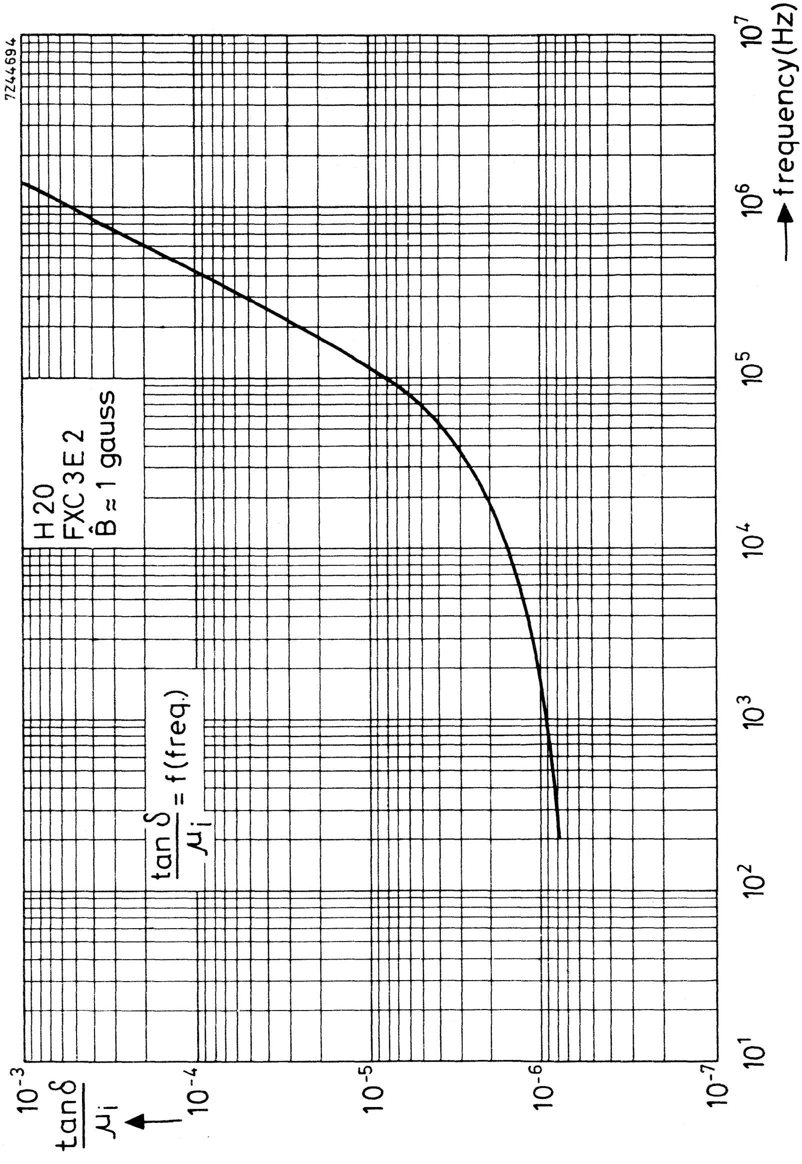



frequency (Hz)
1
10¹
10²
10³
10⁴
10⁵
10⁶
10⁷
10⁸
10³
10²
10¹
10⁰
10⁻¹
10⁻²
ωLp/N² (Ω)
Lp/N² (μH)
Lp/N²
ωLp/N²
B̂≈1 gauss
H20 FXC 3E2
7Z44695
7Z44701.1
−10⁻¹
−10⁰
−10¹
−10²
−10³
−10⁴
Lp/N²
ωLp/L²
ωLp/N² (Ω)
Lp/N² (μH)
frequency (Hz)

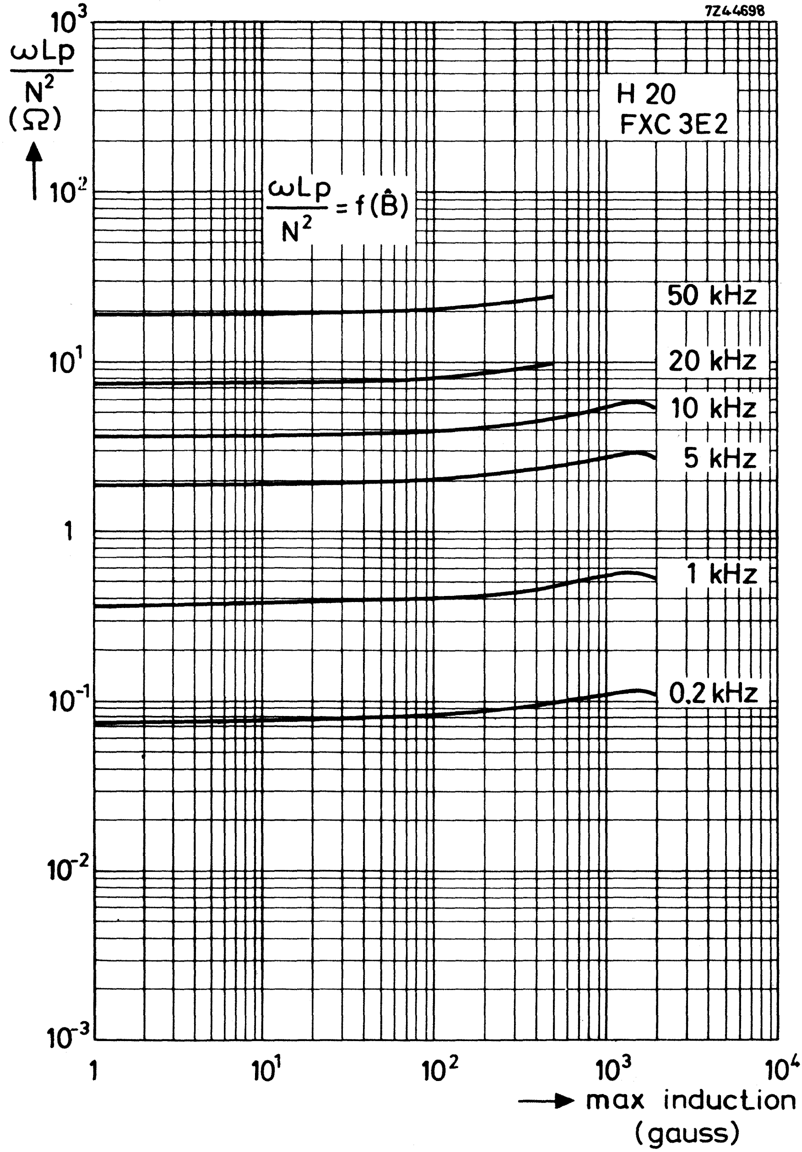
LOSSES AS A FUNCTION OF THE FREQUENCY (typical values)



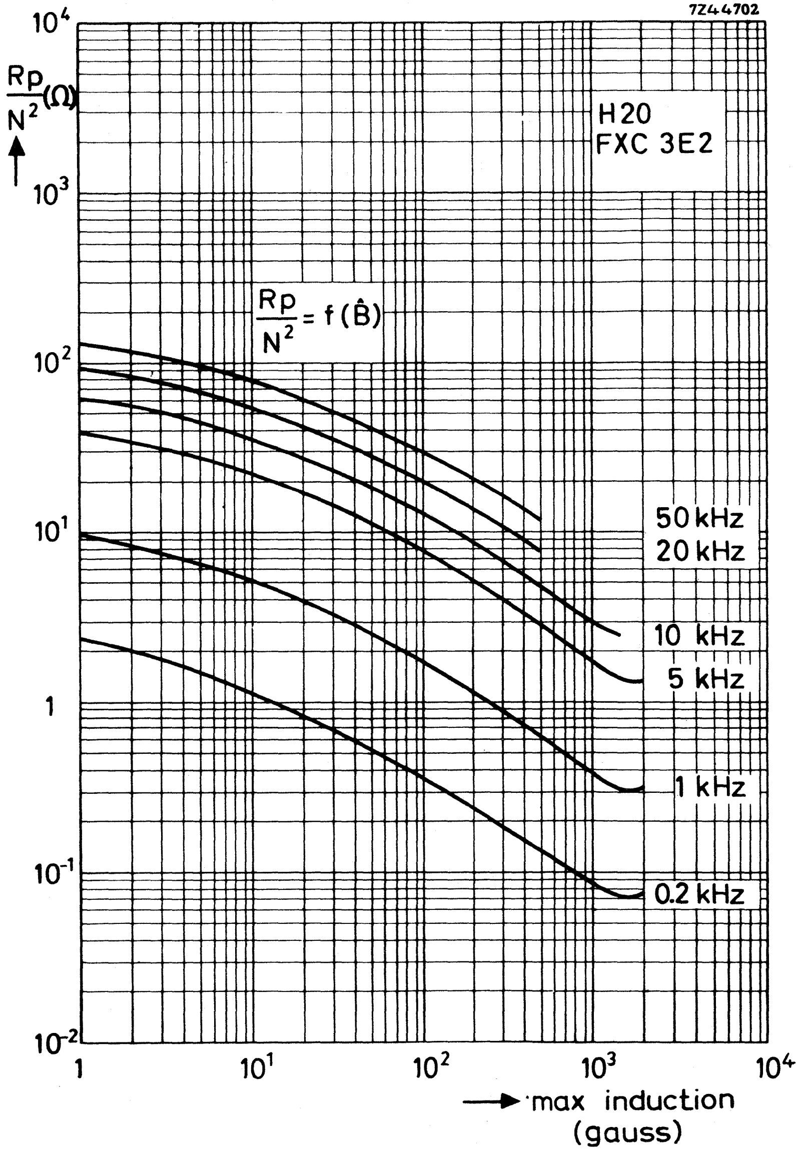

7Z44703
H 20
FXC 3E2
$\frac{Rp}{N^2} = f(freq)$
$\frac{Rp}{N^2}$ (Ω)
gauss
1
10
100
500
1000
1500
2000
10^3
10^2
10^1
1
10^{-1}
10^{-2}
10^2
10^3
10^4
10^5
frequency(Hz)


7Z44694
H 20
FXC 3 E 2
$\hat{B} \approx 1$ gauss
$\frac{\tan\delta}{\mu_i} = f(\text{freq.})$
$\frac{\tan\delta}{\mu_i}$
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
frequency (Hz)

INDUCTANCE AS A FUNCTION OF THE INDUCTION (typical values)

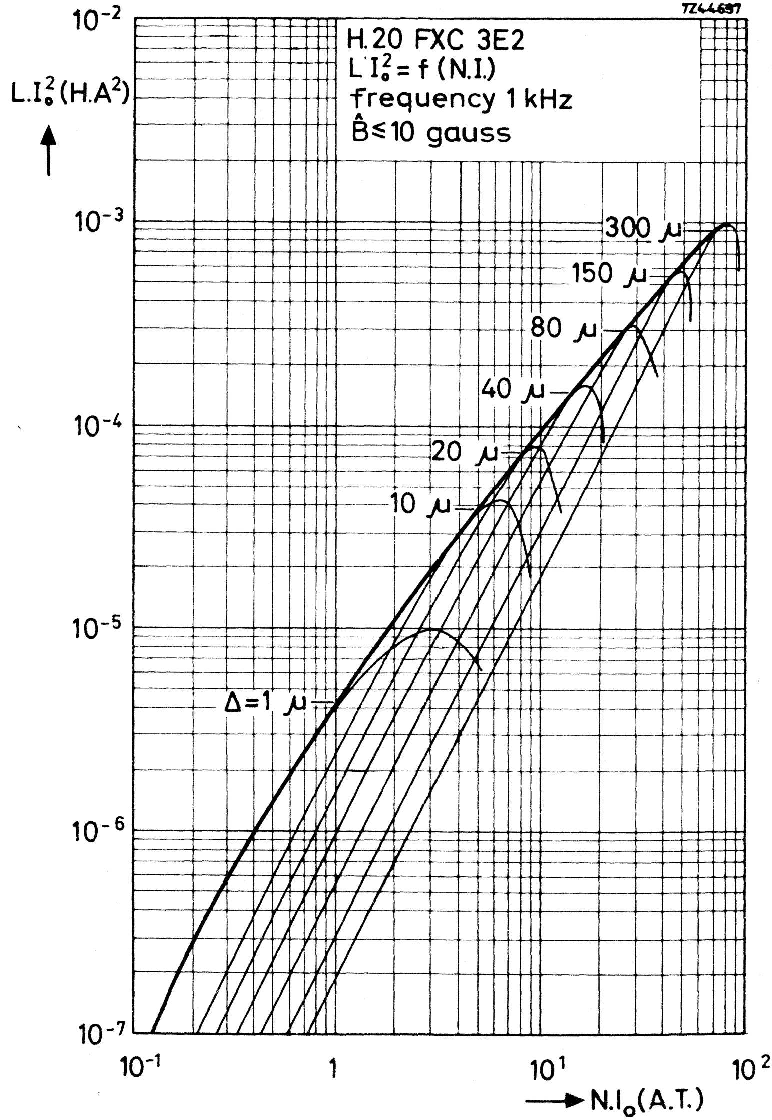


LOSSES AS A FUNCTION OF THE INDUCTION (typical values)



HANNA CURVE (typical values)

Indicating optimum inductance for a certain airgap and direct current.



CROSS CORES

INTRODUCTION

Ferroxcube cross cores have been especially developed for transformers to be used on printed-wiring boards. To this end these cores have coil formers with soldering pins which are positioned according to a grid. The height of the cores is restricted due to the small available distance between two printed-wiring boards.

The optimal height of the cross cores is approximately 0.8x the side of the square bottom surface. (In some cases a somewhat lower height than the optimal one is chosen to adapt the core to currently used heights in equipment design).

The maximum height of the assembled cross core is given under "Mounting parts".

To save space on the mounting board the connection pins of the coil former have been designed to fit within the waste space enclosed by the outer dimensions of the core (see hatched parts in Fig.2). This could be achieved, without loosing much of the dimensional quantities of the magnetic circuit with respect to potcores, by giving the core the X-shape.

The coilformers of the cross cores have the advantage that the fragile lead-out wires can be soldered to the pins directly after winding, resulting in less rejects by wire damage at the production.

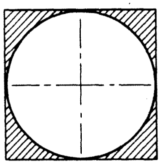


fig.1

7Z43008

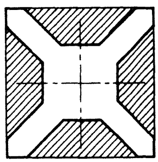


fig.2

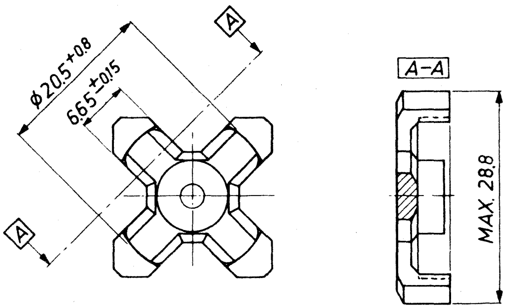
ASSEMBLY

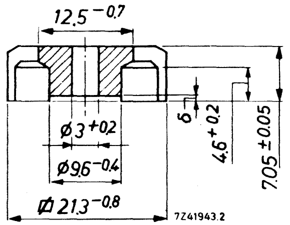
Special tools have been designed which first centre the cross core halves and afterwards bend the lips of the containers.
These tools are not supplied, however drawings of the tools are supplied on request. For cat. numbers of these tools, see table below.

core type	catalog number of recommended tool
X 22	4322 058 00080
X 30	4322 058 00090
X 35	4322 058 00100

See also the remarks with regard to the mounting parts of the cross cores.

CROSS CORES





Dimensions in mm

Two types of core halve can be supplied:
(1) without air-gap, and
(2) with air-gap. Standardised air-gap lengths in each core half are:
0.02, 0.05, 0.15 and 0.25 mm.

The dimensions of the cross cores meet the following specifications: I.E.C. 226 (international) and C.C.T.U. 06-10 (France).

Cross core halves and associated parts are ordered by their 12-digit catalog number.

CORE HALVES WITHOUT AIR GAP

Versions

ferroxcube grade	catalog number
3B7	3522 200 08770
3H1	4322 020 23510
3E1	3522 200 03470
3D3	3522 200 03480
4C6	3522 200 03490
improved 3E1	4322 020 23530

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I

	at temp. (°C)	grade 3B7	3H1	3E1	3D3	4C6	impr. 3E1
T.F. x 10^6	+5 to +23	-	+0.5 to +1.5	-	-	-2 to +4	-
	+23 to +55	-	+0.5 to +1.5	-	-	0 to +6	-
	+23 to +70	-0.6 to +0.6	+0.5 to +1.5 1)	-	0 to +2	-	-
D.F. x 10^6 (10-100 min)	23 ± 1	≤ 4.3	≤ 4.3	-	≤ 12	≤ 10	-

For the combination of two cross core halves randomly chosen from a batch and pressed together with a force of 120 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II

	at $\hat{B}$ (Gs)	at freq. (MHz)	grade 3B7	3H1	3E1	3D3	4C6	impr. 3E1
μ_e	≤ 1	0.004	≥ 1440	≥ 1440	≥ 1495	-	-	2000-3325 2)
	≤ 1	0.1	-	-	-	≥ 550	≥ 93	-
α	≤ 1	0.004	≤ 17.8	≤ 17.8	≤ 17.5	-	-	-
	≤ 1	0.1	-	-	-	≤ 28.8	≤ 70	-
A_L	≤ 1	0.004	-	-	-	-	-	4350-7250
$\frac{\tan\delta}{\mu_i}$ x 10^6	≤ 1	0.004	≤ 1.6	≤ 1.2	-	-	-	≤ 2.5
	≤ 1	0.1	≤ 6	≤ 5	-	≤ 8	-	≤ 20
	≤ 1	0.5	-	-	-	≤ 14	-	≤ 200
	≤ 1	1	-	-	-	-	-	-
	≤ 1	2	-	-	-	-	≤ 40	-
	≤ 1	10	-	-	-	-	≤ 100	-
q2-24-100	15-30	0.004	≤ 1.8	≤ 1.8	≤ 6.0	-	-	3.0
	3-12	0.1	-	-	-	≤ 3.0	≤ 10	-

Weight per half core 6 g approx.

Mean length of line of force l_e = 3.80 cm (two halves)

A_e = 0.66 cm^2 (two halves)

$\Sigma \frac{l_e}{A_e}$ = 5.75 cm^{-1} (two halves)

V_e = 2.51 cm^3 (two halves)

1) Orientation value

2) In the temperature range +23 to +70 °C $\mu_e \geq 2000$

CORE HALVES WITH AIR GAP

ferroxcube grade	air gap length in mm	catalog number
3H1	0.02 ± 0.01	4322 020 23710
3H1	0.05 ± 0.015	4322 020 23720
3H1	0.15 ± 0.015	4322 020 23730
3H1	0.25 ± 0.015	4322 020 23740
3E1	0.15 ± 0.015	4322 020 23700

The electrical properties are measured on cores without air gap.

PRE-ADJUSTED CROSS CORES

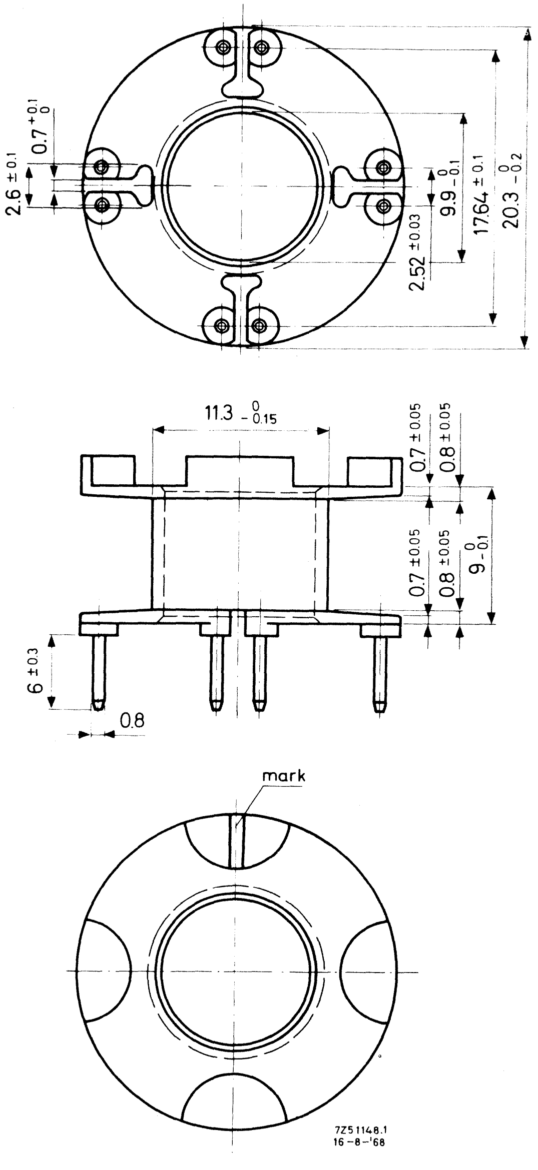
With nut : catalog number 4322 022 6. . . .
Without nut: catalog number 4322 022 4. . . .

Cross cores with standard A_L factors

A_L	corresponding μ_e-value	tolerance on inductance (%)	catalog number 4322 022 6. . . ., with nut 4322 022 4. . . ., without nut
			grade 3H1
160	73	± 1	5250
250	115	± 1.5	5260
400	180	± 2	5280
630	290	± 3	5300

Inductance $L = N^2 A_L$ (in 10^{-9} H)

COIL FORMER


0.7 +0.1 0
2.6 ±0.1
9.9 0 −0.1
17.64 ±0.1
20.3 0 −0.2
2.52 ±0.03
11.3 0 −0.15
0.7 ±0.05
0.8 ±0.05
0.7 ±0.05
0.8 ±0.05
9 0 −0.1
6 ±0.3
0.8
mark
7Z51148.1
16−8−'68

catalog number	4322 021 31770
Material	reinforced polyester
Window area in mm^2	33.5
Mean length of turn in cm	4.9
Max temperature for dipsoldering for 5-6 s in °C	280
Max. working temperature in °C	130
Force for pulling out pins during 1 min at 25°C in N	≥ 15
Max. test voltage (50 Hz) between pins during 2 min in V_{rms}	500

$$\frac{R_o}{L} = \frac{1}{\mu_e} \times \frac{1}{f_{cu}} \times 9.9 \times 10^3\ \Omega/H$$

INDUCTANCE ADJUSTORS

ADJUSTORS

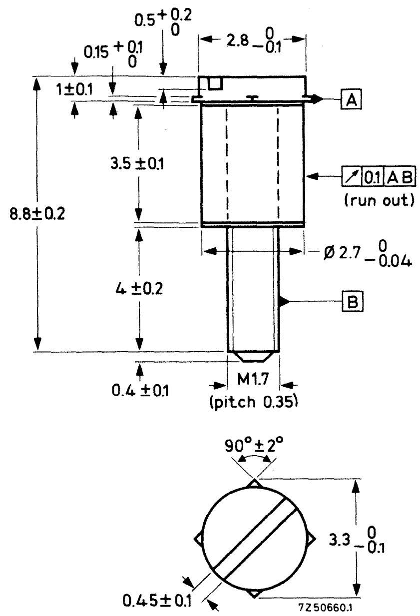


Fig. A

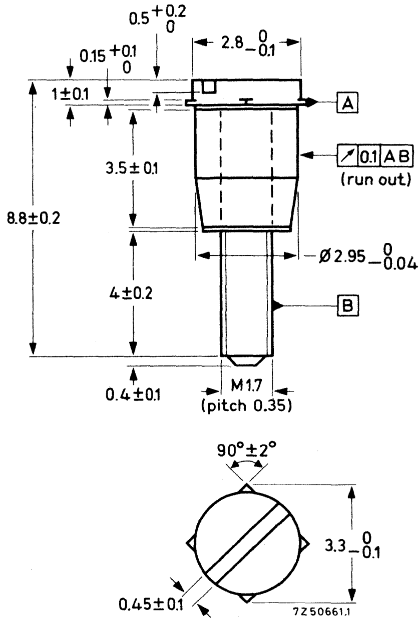


Fig. B

The tolerances on inductance of the pre-adjusted cross cores (without adjustor) are given in section "cross cores", paragraph "Pre-adjusted cross cores". After inserting a coil (impregnated or not) in an electrical circuit, its inductance can be adjusted to the required value with an accuracy < 0.03% by means of a continuous inductance adjustor. Such an adjustor increases the inductance of the coil, see "Adjustment curves". The adjustor is screwed through the cross core into the nut and is held in position by the four protrusions near the top of the adjustor. For special requirements a bigger or smaller adjustment range may be obtained by using an adjustor belonging to the next higher or lower effective permeability.
The influence of the adjustors on the variability of the inductance is negligible.
The maximum permissible temperature is 110 °C.
Table II shows the type of adjustor recommended for different cross cores.
The adjustors are packed in bags of 100, so please order in multiples of 100.

Table I, available types:

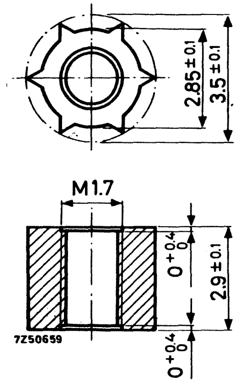
Fig.	colour	catalogue number
A	brown	4322 021 30730
B	white	4322 021 30970
B	grey	4322 021 31080

Table II, recommended application:

A_L	catalogue number grade 3H1
160	4322 021 30970
250	4322 021 30970 or 4322 021 30730
400	4322 021 30730 or 4322 021 31080
630	4322 021 31080
1000	4322 021 31080

NUT FOR ADJUSTOR

These data are given for those manufacturers who prefer to insert the nut themselves.

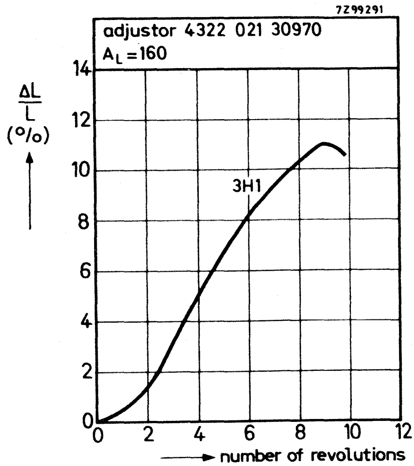


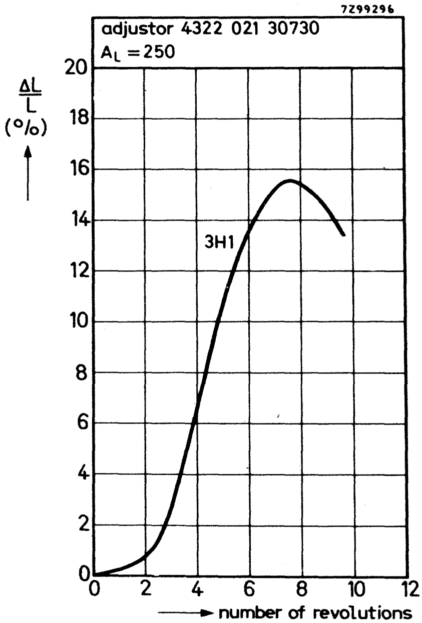
Catalogue number	4322 021 30140
Material	polycarbonate
Maximum impregnation temperature during 24 hours	120 °C
Recommended distance from mating surface to nut	2.3 ± 0.15 mm

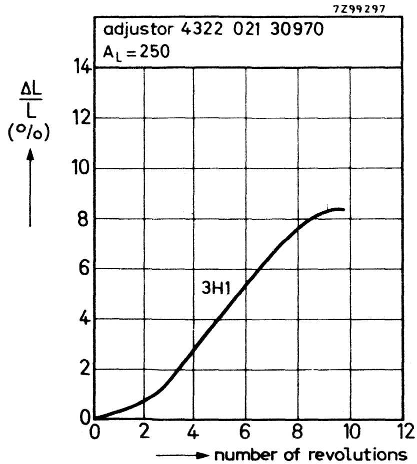
For more information see Potcores General, paragraph "Inserting the nut for the adjustor" (core type P18/11).

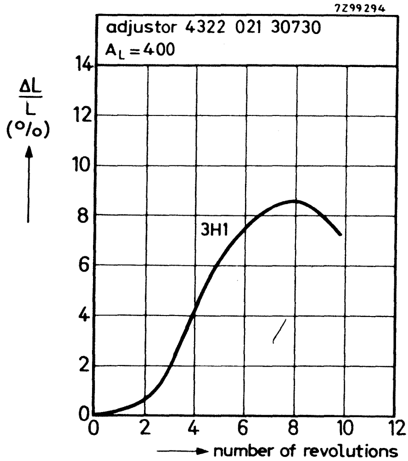
The nuts are packed in bags of 100, so please order in multiples of 100.

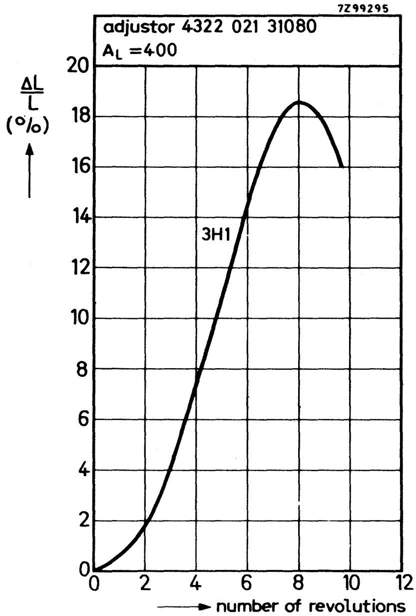
ADJUSTMENT CURVES

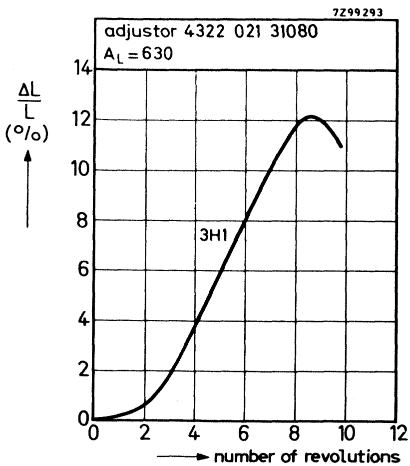


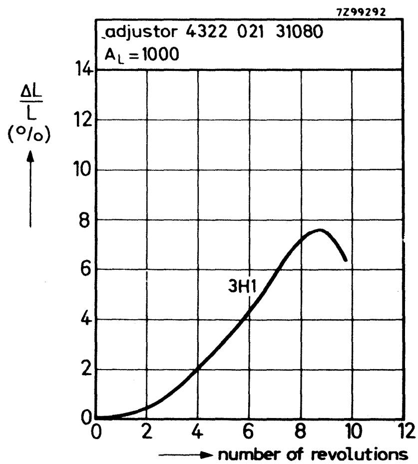




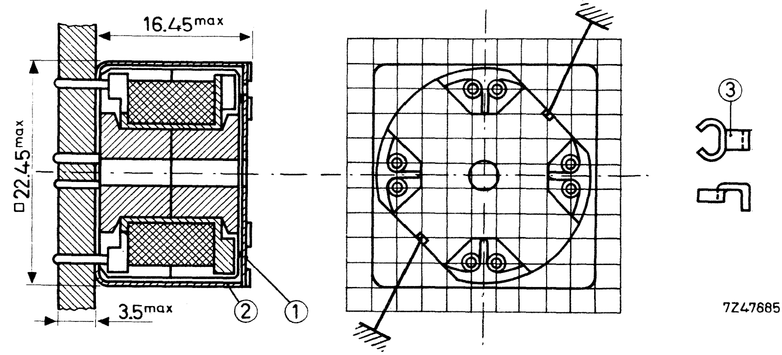

7Z99294
adjustor 4322 021 30730
A_L = 400
ΔL/L (%)
0
2
4
6
8
10
12
14
3H1
0
2
4
6
8
10
12
number of revolutions


7Z99295
adjustor 4322 021 31080
A_L = 400
ΔL/L (%)
0
2
4
6
8
10
12
14
16
18
20
3H1
0
2
4
6
8
10
12
number of revolutions


7Z99293
adjustor 4322 021 31080
A_L = 630
ΔL/L (%)
0
2
4
6
8
10
12
14
3H1
0
2
4
6
8
10
12
number of revolutions


7Z99292
adjustor 4322 021 31080
A_L = 1000
ΔL/L (%)
0
2
4
6
8
10
12
14
3H1
0
2
4
6
8
10
12
number of revolutions

MOUNTING PARTS



(1). Cover 4322 021 30230
(2). Container 4322 021 30040
(3). Soldering spring 4322 021 30700.

The cross core has been developed especially for transformers to be mounted on printed-wiring boards.

An advantage of this construction is that the leading-out wires are soldered to the pins which are directly mounted on the coil former.

The eight soldering pins are positioned according to a grid of 2.52 mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid. The pin length is sufficient for board thicknesses up to 3.5 mm. The printed-wiring board should be provided with holes of 1.3 ± 0.1 mm in diameter.

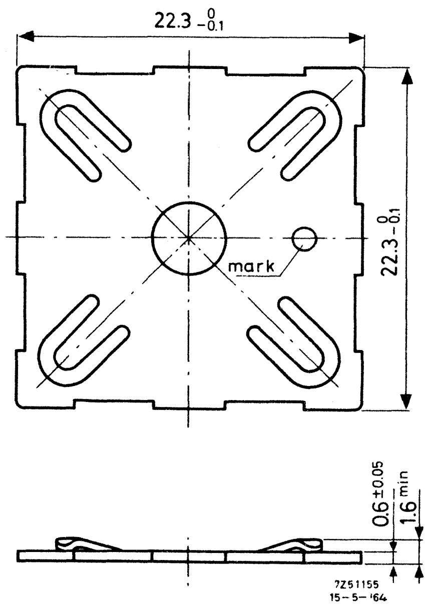
If stranded wire is employed, the use of a soldering spring (pos. 3) is recommended, which facilitates the soldering of the wires to the pins on the coil former. For solid wire the spring is not necessary.

The phosphor-bronze cover has four cut-out lips on the corners, consequently the cover acts as a spring at the same time.

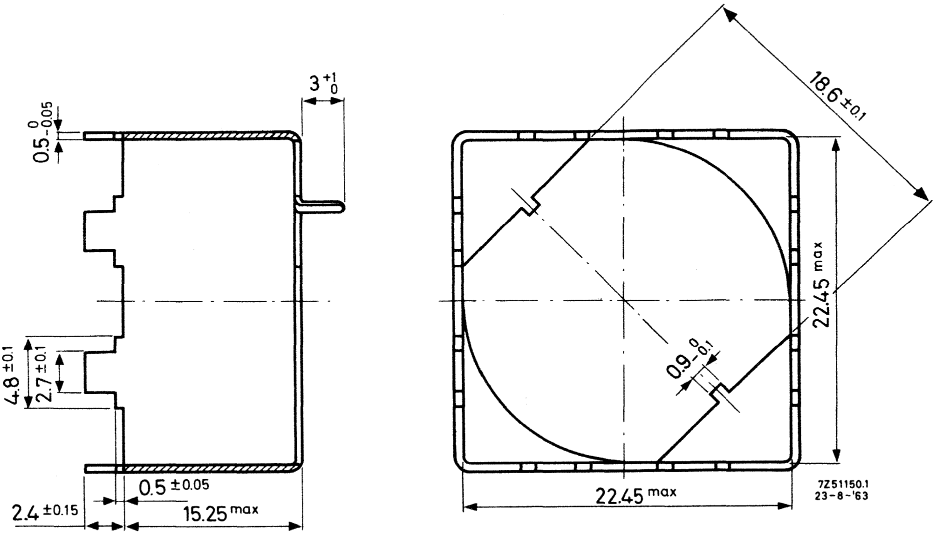
The cover is provided with a marking hole. The mark of the coil former (see the Fig. of coil former) has to be in one line with this hole. These markings facilitate the numbering of the soldering pins and the positioning on the printed-wiring board.

It is recommended to cement the coil former in one of the cross core halves in order to obtain the most possible stable construction.

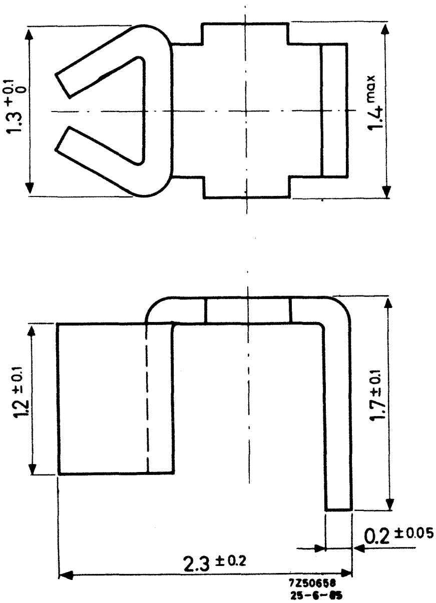
Before bending the lips of the container, pressure should be exercised evenly on the four corners of the cover until the latter meets the container. The required force is approximately 120 Newton. After bending the lips, the core will have the correct tension.



(1) Cover 4322 021 30230
Material: phosphorbronze, nickel plated



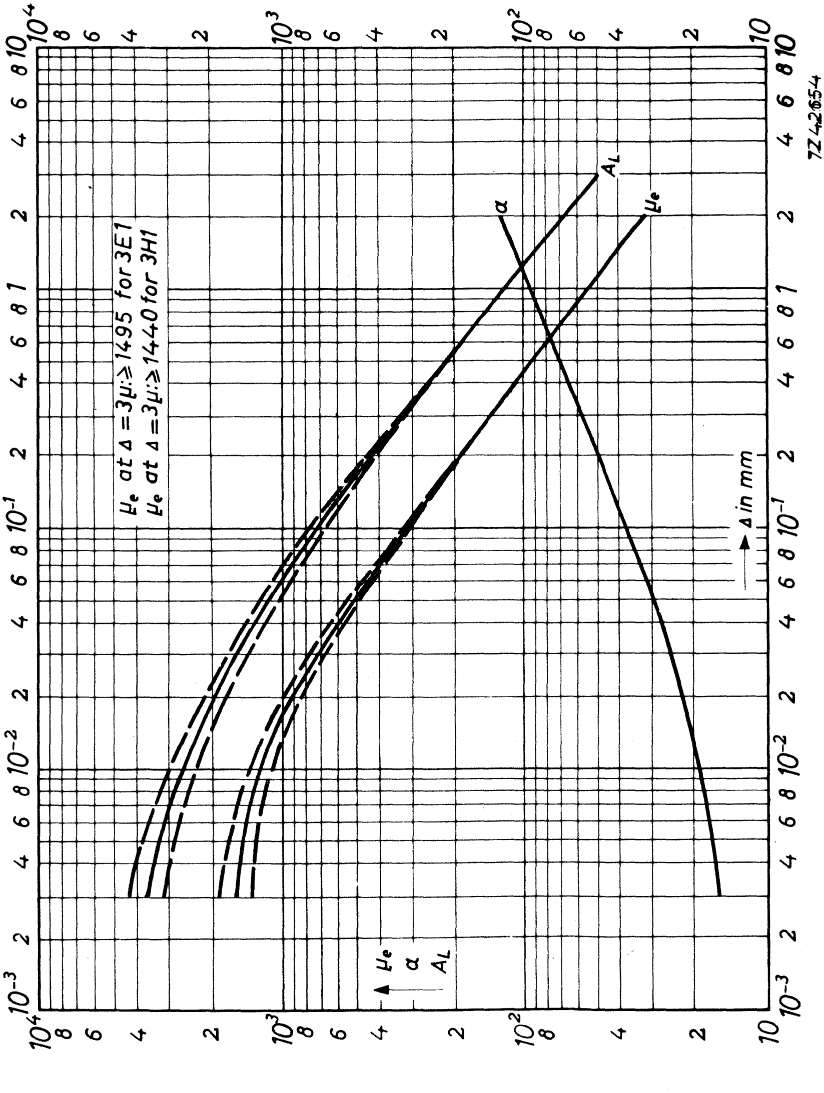
(2) Container 4322 021 30040
Material: brass, nickel plated



(3) Soldering spring 4322 021 30700
Material: brass, dipsoldered

CHARACTERISTIC CURVES

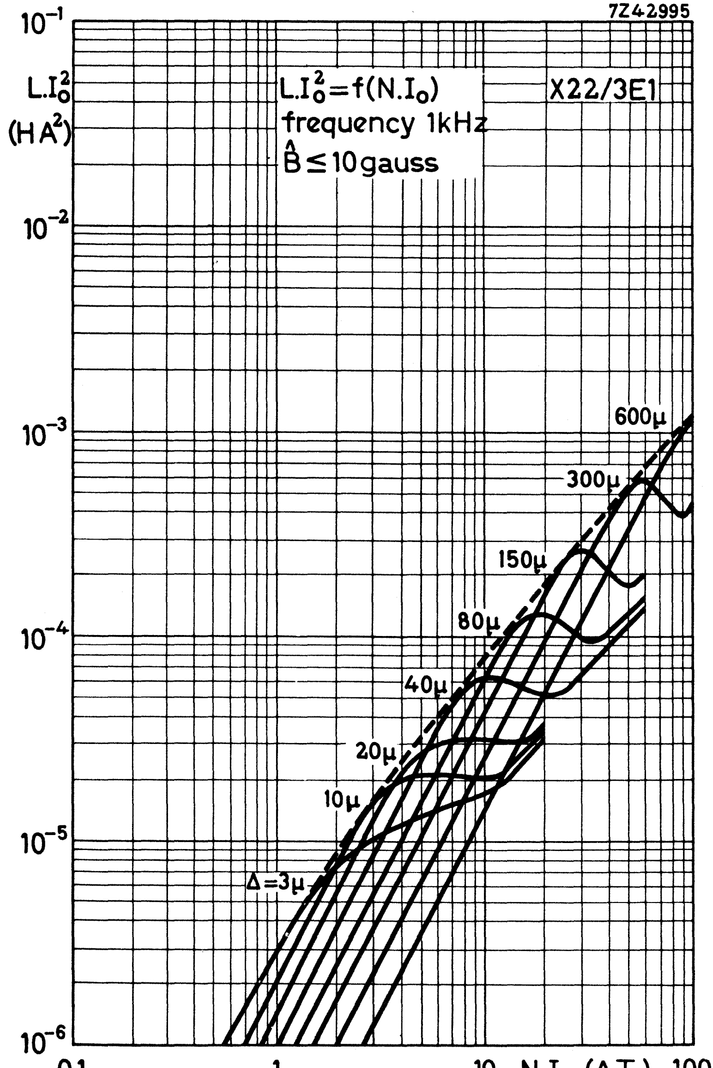
μ_e - α and A_L CURVES.



Effective permeability (μ_e), turn factor for 1 mH (α) and inductance factor in nanohenry (A_L) as a function of the airgap length for grades 3E1 and 3H1.

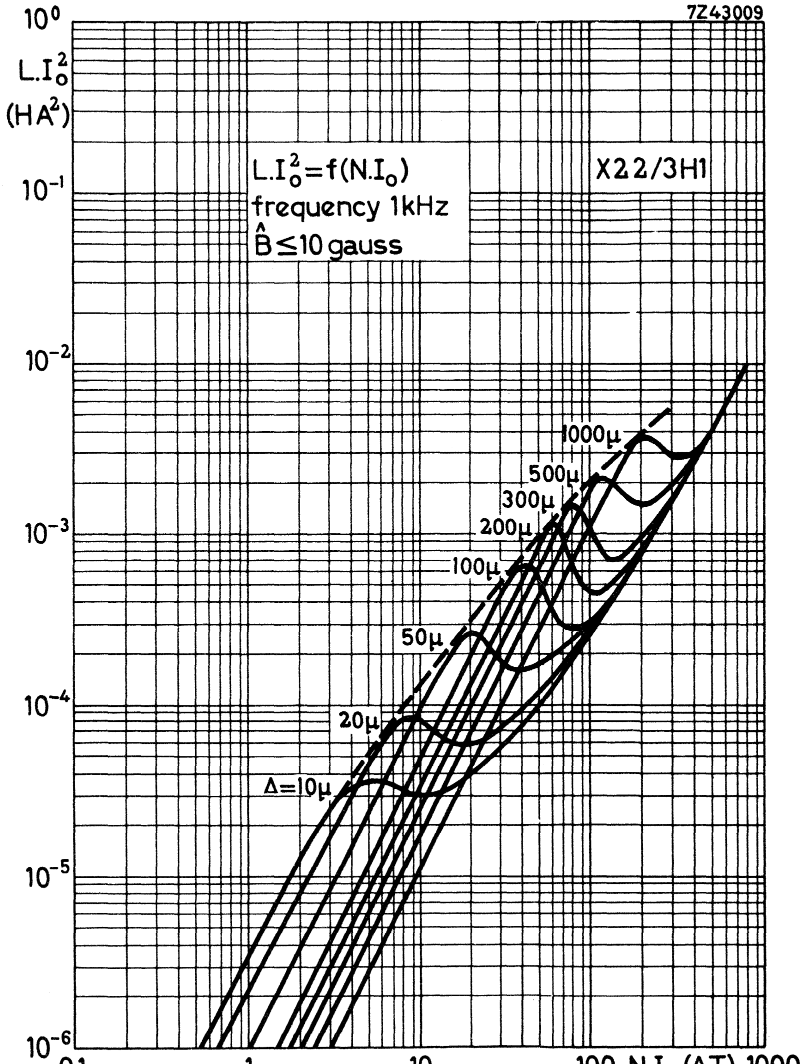
HANNA CURVE

Indicating optimum inductance for a certain airgap and direct current.

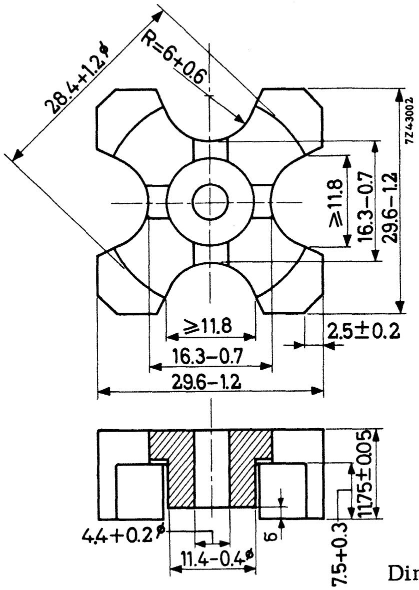


HANNA CURVE

Indicating optimum inductance for a certain airgap and direct current.



CROSS CORES



Dimensions in mm

Two types of core halve can be supplied:

1) without airgap

2) with airgap
   Standardised air-gap lengths in each core half are: 0.02, 0.05, 0.15 and 0.25 mm.

The dimensions of the cross cores meet the following specifications: I.E.C. 226 (international) and C.C.T.U. 06-10 (France).

Cross core halves and associated parts are ordered by their 12-digit catalog number.

CORE HALVES WITHOUT AIRGAP

Versions

ferroxcube grade	catalog number
3H1	4322 020 23750
improved 3E1	4322 020 23760

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I

	at temp. (°C)	grade 3H1	impr. 3E1
T.F. x 10^6	+5 to +23	+0.5 to +1.5	-
	+23 to +55	+0.5 to +1.5	-
	+23 to +70	+0.5 to +1.5 1)	-
D.F. x 10^6	23 ± 1	≤ 4.3	-

For the combination of two cross core halves randomly chosen from a batch and pressed together with a force of 250 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II

	at $\hat{B}$ (Gs)	at freq. (kHz)	grade 3H1	impr. 3E1
μ_e	≤ 1	4	≥ 1525	2200-3675 2)
α	≤ 1	4	≤ 15.9	-
A_L	≤ 1	4	-	5650-9400
$\frac{\tan\delta}{\mu_i} \times 10^6$	≤ 1	4	≤ 1.2	≤ 2.5
	≤ 1	100	≤ 6	≤ 20
q2-24-100	15-30	4	≤ 1.8	≤ 3.0

Weight per half core 19 g approx.

Mean length of lines of force $l_e = 5.58$ cm (two halves)

$A_e = 1.14$ cm^2 (two halves)

$\Sigma \frac{l_e}{A_e} = 4.90$ cm^{-1} (two halves)

$V_e = 6.36$ cm^3 (two halves)

CORE HALVES WITH AIR GAP

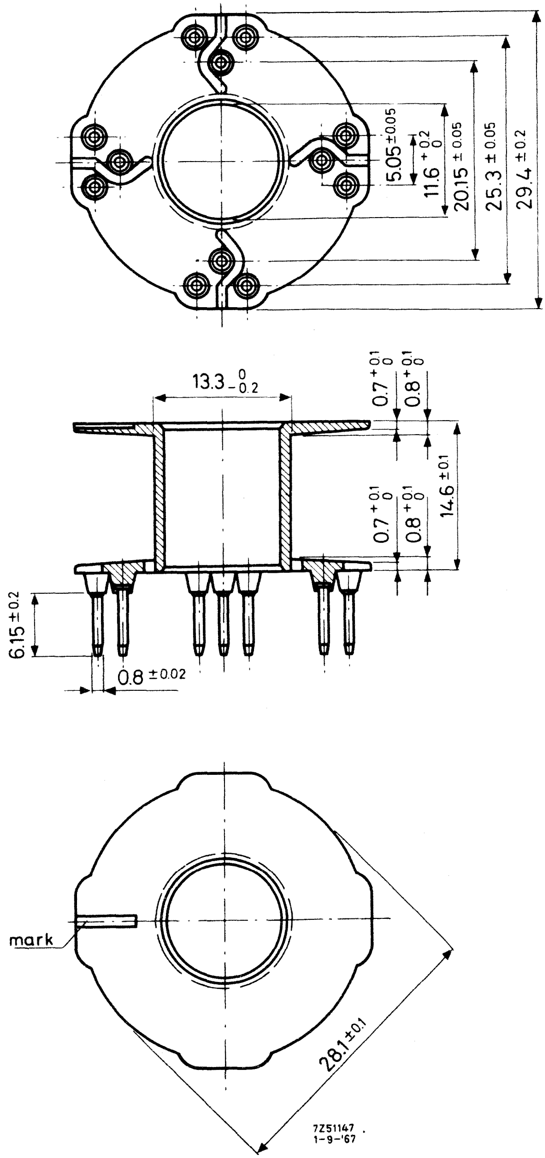
ferroxcube grade	airgap length in mm	catalog number
3H1	0.02 ± 0.01	4322 020 23960
3H1	0.05 ± 0.015	4322 020 23970
3H1	0.15 ± 0.015	4322 020 23980
3H1	0.25 ± 0.015	4322 020 23990

The electrical properties are measured on cores without air gap.

1) Orientation value

2) In the temperature range +23 to +70 °C $\mu_e \geq 2200$

COIL FORMER

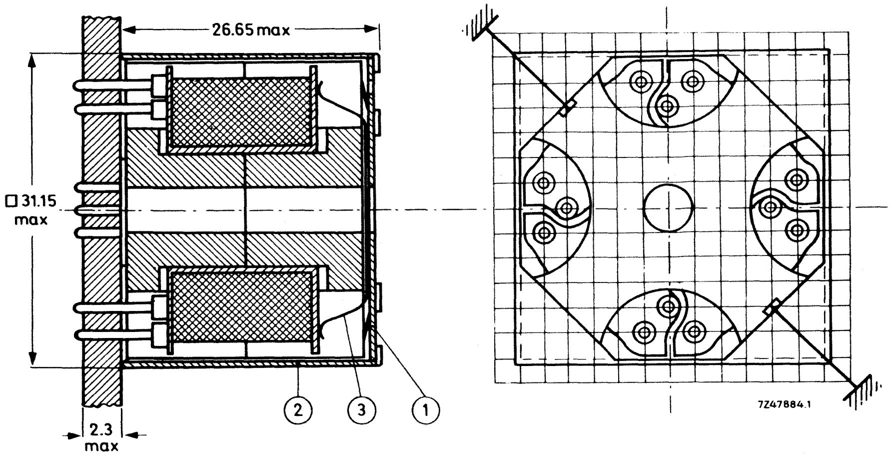


7Z51147
1-9-'67

COIL FORMER

Catalog number	4322 021 31190
Material	reinforced polyester
Window area	97 mm^2
Mean length of turn	6.5 cm
Max. dipsolder temperature (5 to 6 s)	280 ^{o}C
Max. working temperature	130 ^{o}C
Tensile strength of pins (1 minute at 25 ^{o}C)	$\geq$ 20 N
A.C. test voltage between pins (50 Hz, 2 min)	2000 V

MOUNTING PARTS



(1) Cover 4322 021 31150
(2) Container 4322 021 31170
(3) Spring 4322 021 30210
(4) Soldering spring 4322 021 30700 (see below)

The cross core has been developed especially for transformers to be mounted on printed-wiring boards.

An advantage of this construction is that the leading-out wires are soldered to the pins which are directly mounted on the coil former.

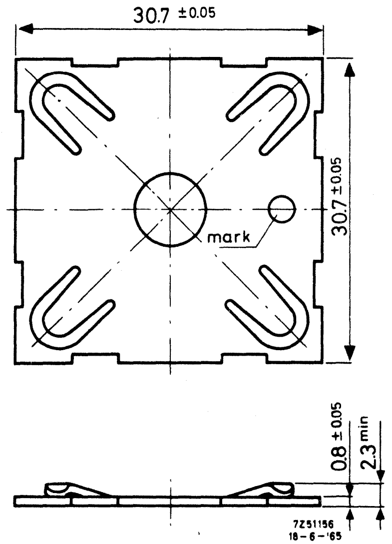
The twelve soldering pins are positioned according to a grid of 2.52 mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50 mm grid. The pin length is sufficient for board thicknesses up to 2.3 mm. The printed-wiring board should be provided with holes of 1.3 ± 0.1 mm in diameter.

The phosphor-bronze cover has four cut-out lips on the corners, consequently the cover acts as a spring at the same time.

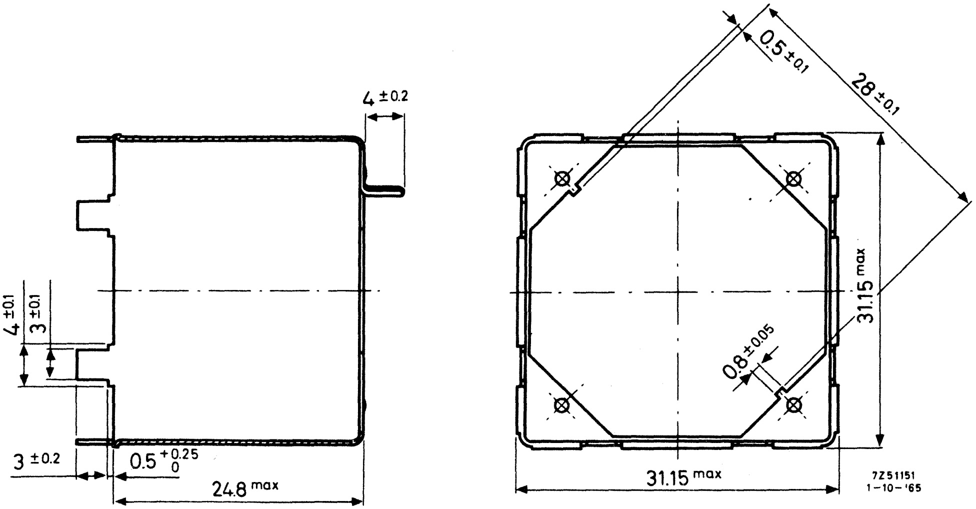
The cover is provided with a marking hole. The mark of the coil former (see the Fig. of coil former) has to be in one line with this hole. These markings facilitate the numbering of the soldering pins and the positioning on the printed-wiring board.

It is recommended to cement the coil former in one of the cross-core halves or to use the spring (pos. 3) in order to obtain the most stable construction.

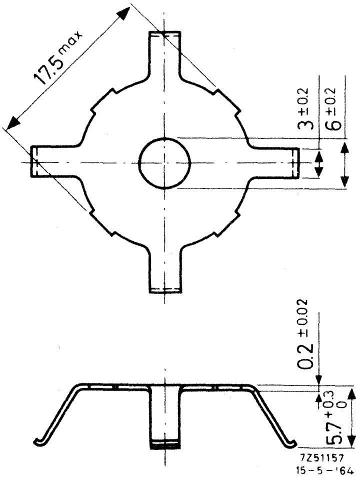
Before bending the lips of the container, pressure should be exercised evenly on the four corners of the cover until the latter meets the container. The required force is approximately 250 Newton. After bending the lips, the core will have the correct tension.



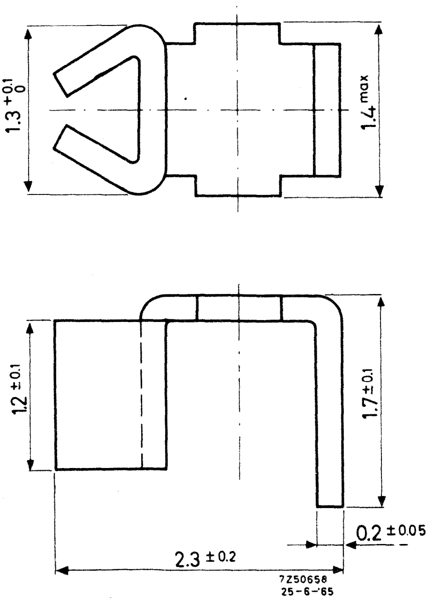
(1) Cover 4322 021 31150
Material: phosphorbronze, nickel plated



(2) Container 4322 021 31170
Material: brass, nickel plated



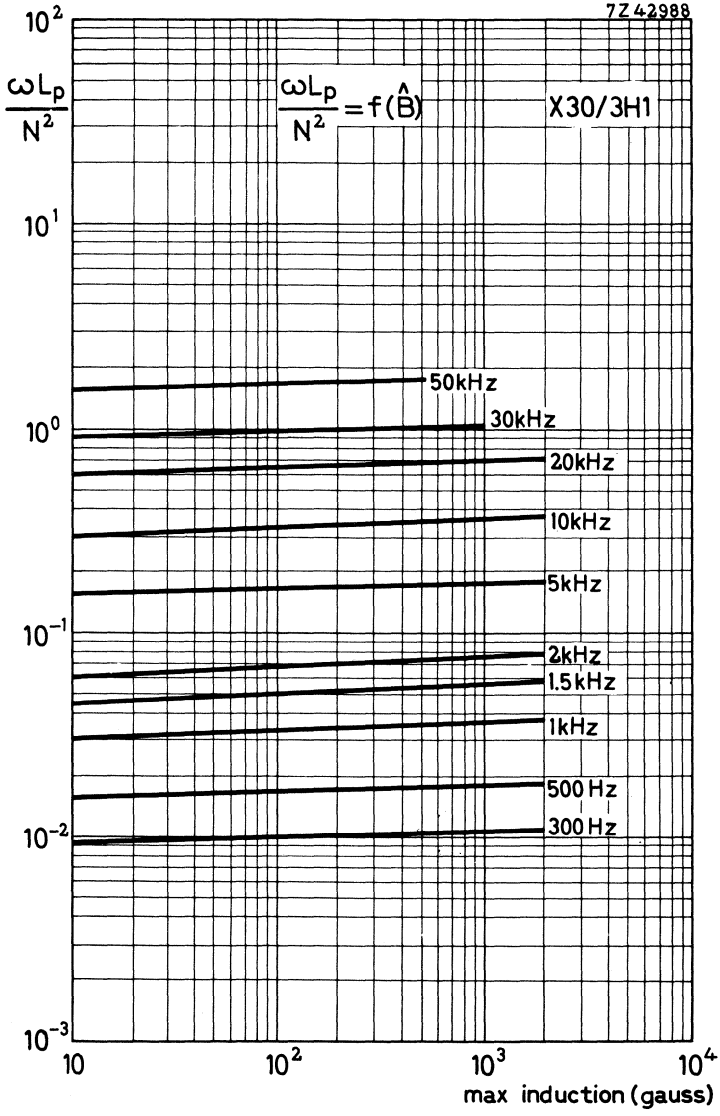
(3) Spring 4322 021 30210
Material: phosphorbronze



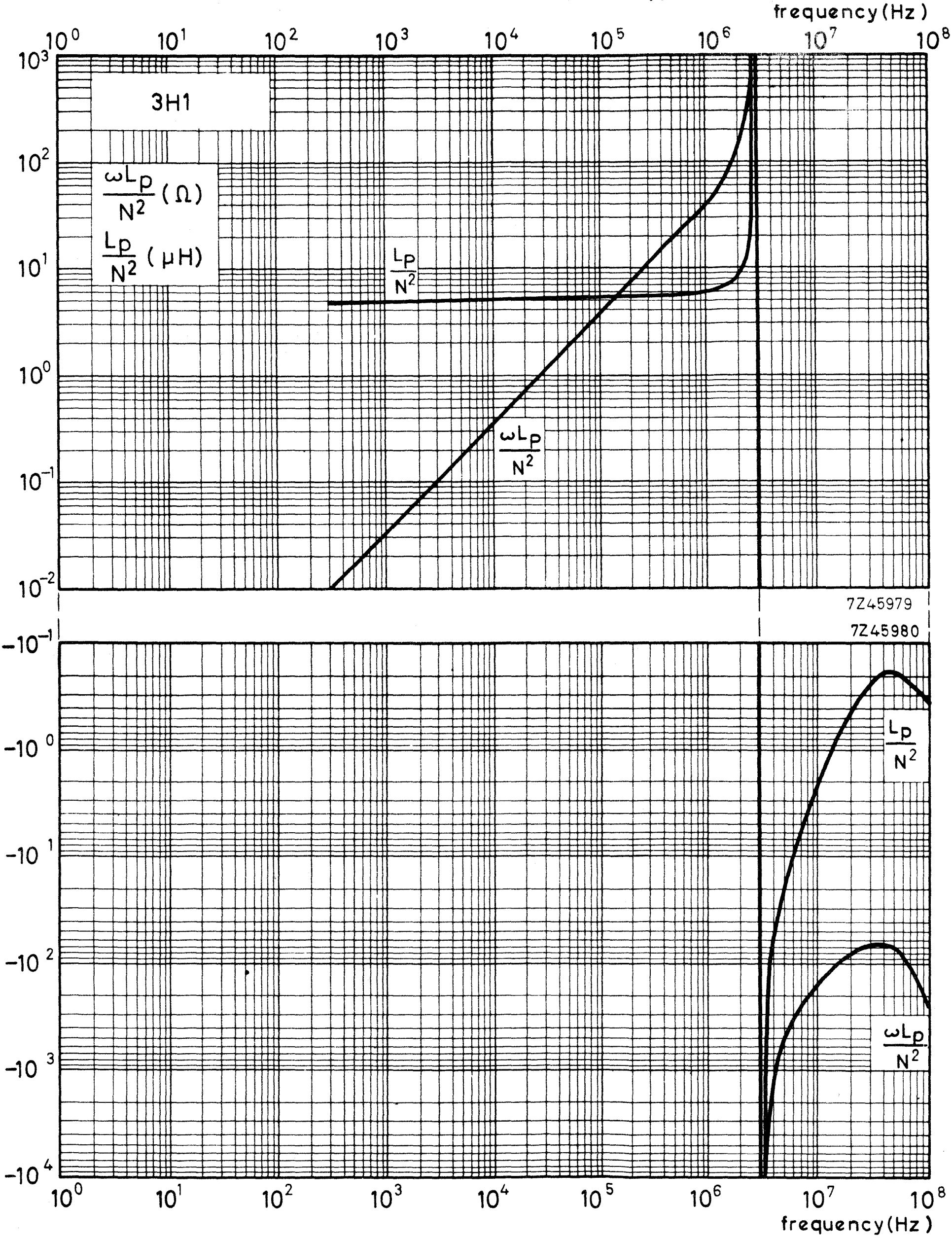
(4) Soldering spring 4322 021 30700
Material: brass, dipsoldered

CHARACTERISTIC CURVES

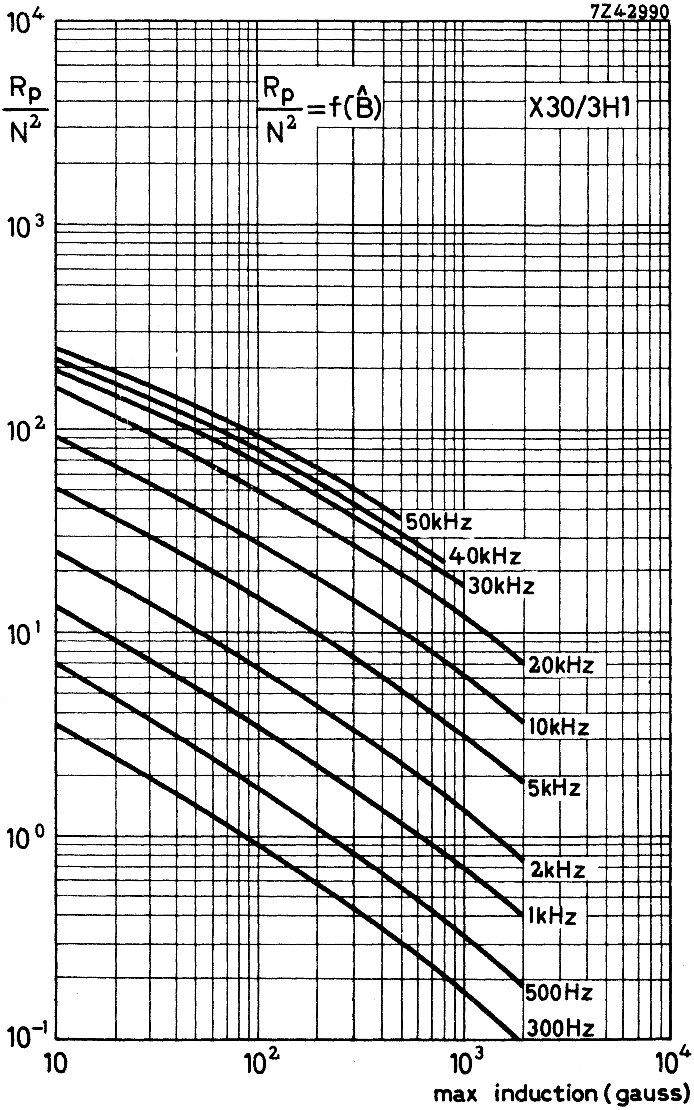
INDUCTANCE AS A FUNCTION OF THE INDUCTION (typical values)



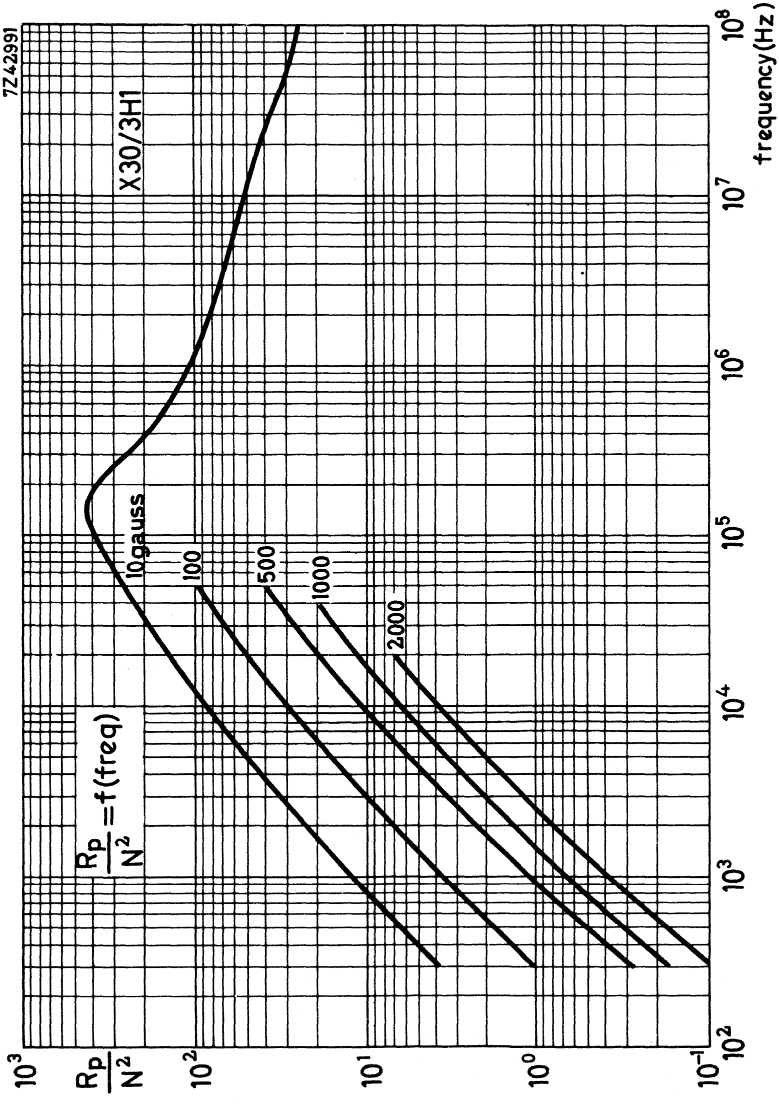
INDUCTANCE AS A FUNCTION OF THE FREQUENCY (typical curves)



CORE LOSSES AS A FUNCTION OF THE INDUCTION (typical values)

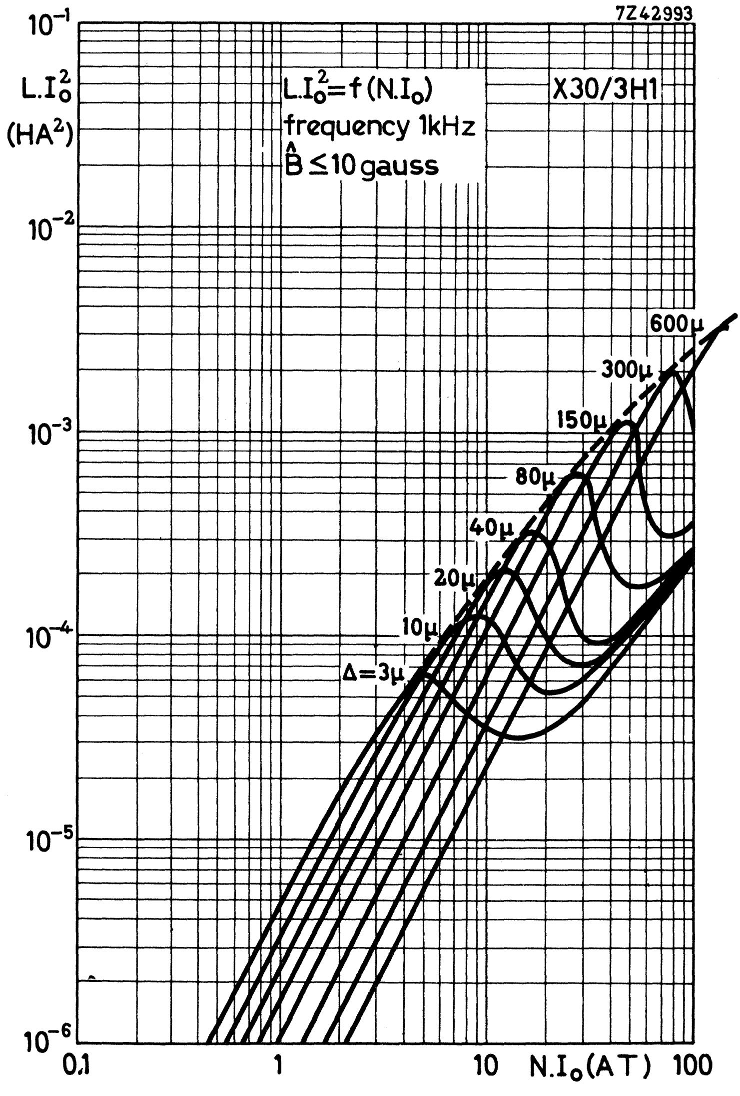


CORE LOSSES AS A FUNCTION OF THE FREQUENCY (typical values)

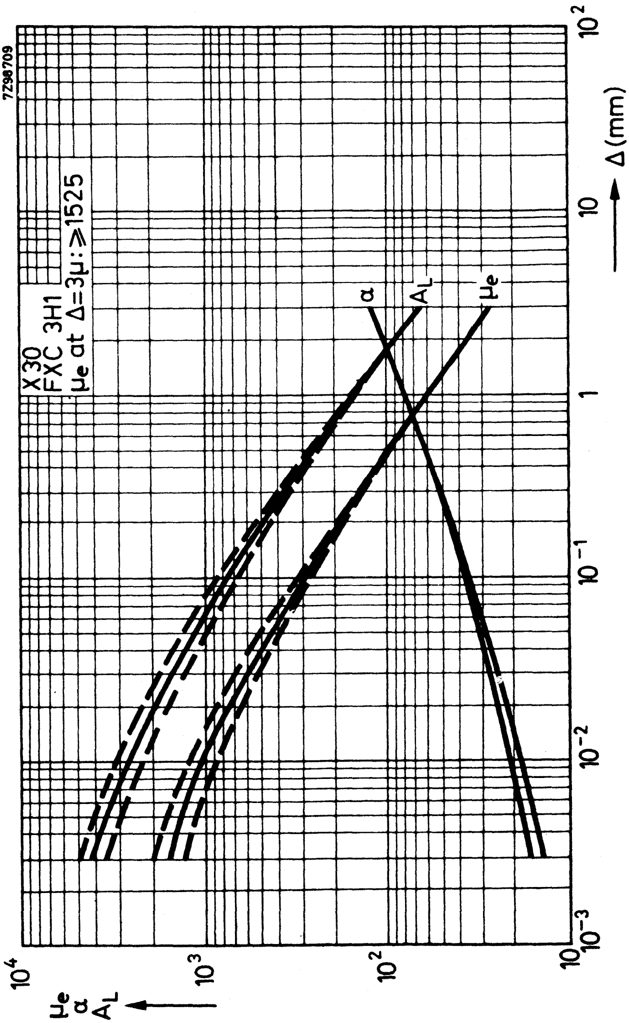


HANNA CURVE (typical values)

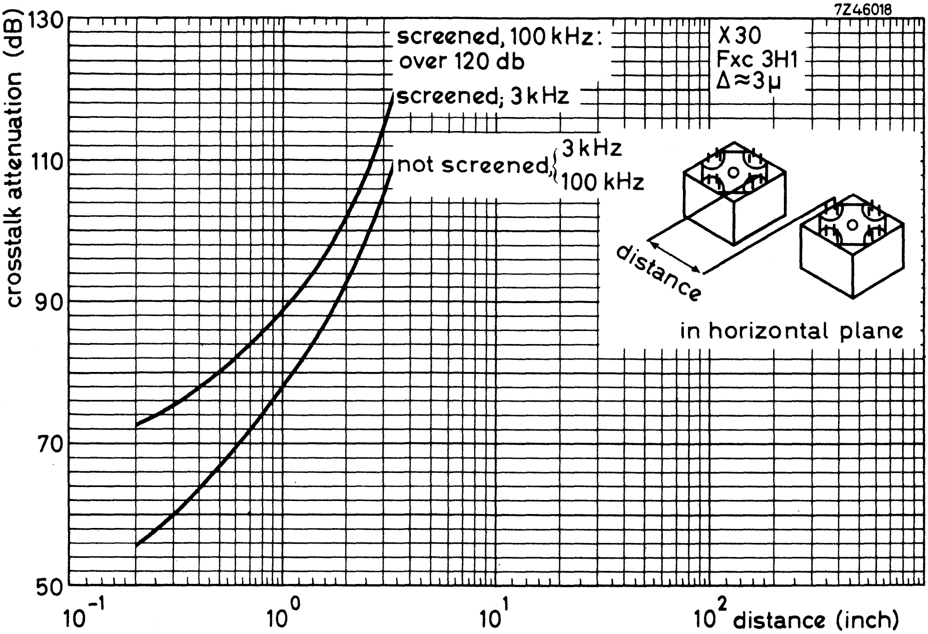
Indicating optimum inductance for a certain airgap and direct current.

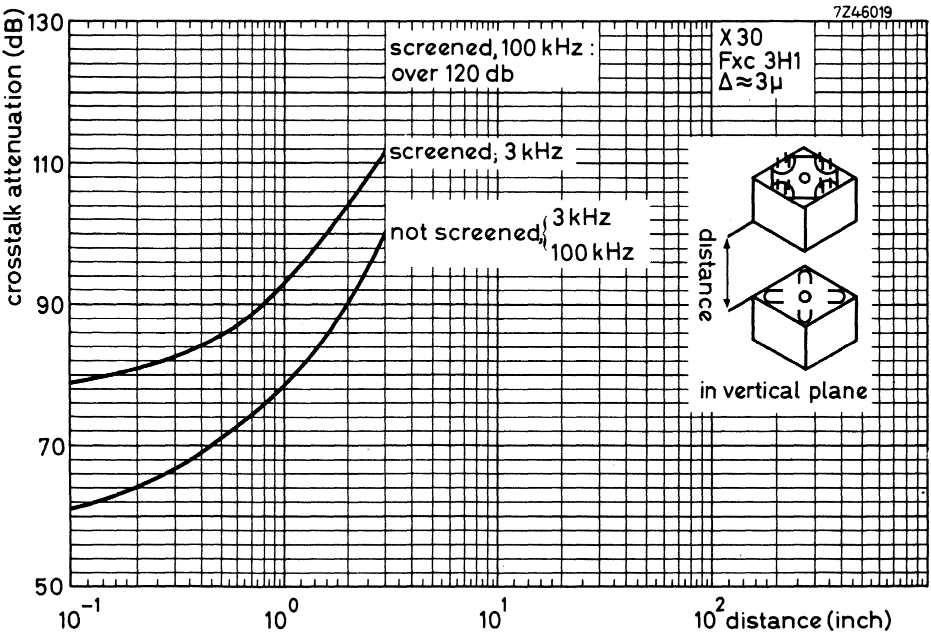


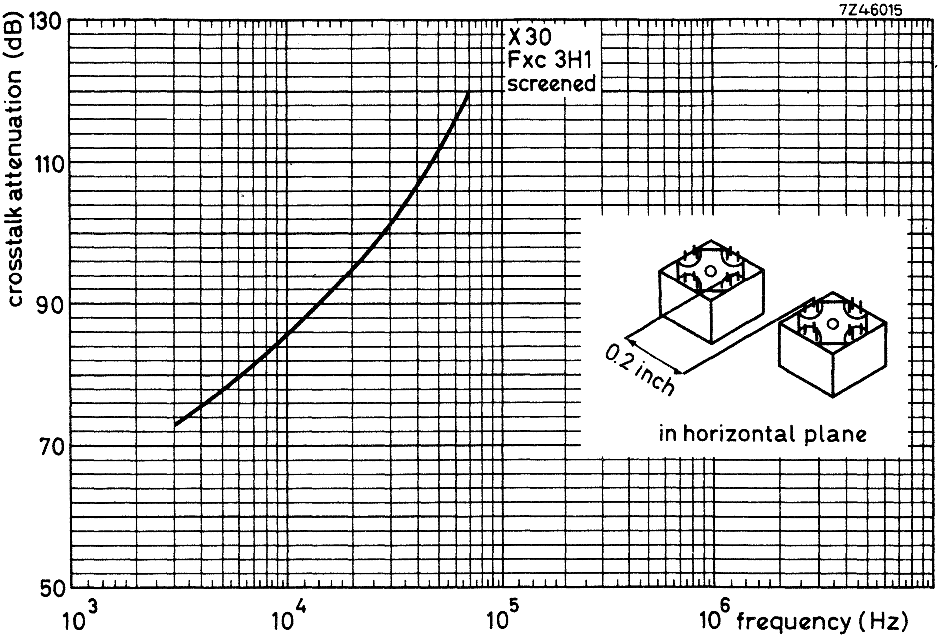
μ_e - α AND A_L CURVES



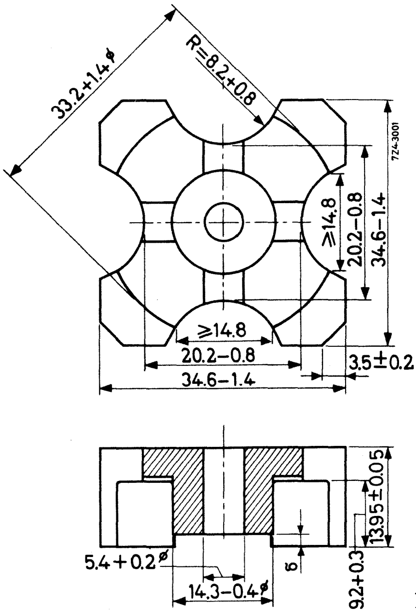
CROSSTALK ATTENUATION






7Z46015
X 30
Fxc 3H1
screened
crosstalk attenuation (dB)
130
110
90
70
50
10^3
10^4
10^5
10^6
frequency (Hz)
0.2 inch
in horizontal plane

CROSS CORES



Dimensions in mm

Two types of core halve can be supplied:

1) without airgap

2) with airgap. Standardised airgap lengths in each core half are: 0.02, 0.05, 0.15 and 0.25 mm.

The dimensions of the cross cores meet the following specifications: I.E.C. 226 (international) and C.C.T.U. 06-10 (France).

Cross core halves and associated parts are ordered by their 12-digit **catalog** number.

CORE HALVES WITHOUT AIR GAP

Version

ferroxcube grade	catalog number
3H1	4322 020 24000

Properties

For toroidally wound core halves the values in Table I are guaranteed.

Table I

	at temp. (°C)	grade 3H1
T.F. x 10^6	+5 to +23 +23 to +55 +23 to +70	+0.5 to +1.5 +0.5 to +1.5 +0.5 to +1.5 *)
D.F. x 10^6	23 ± 1	≤ 4.3

For the combination of two cross core halves randomly chosen from a batch and pressed together with a force of 330 Newton, the values in Table II are guaranteed at 25 ± 10 °C.

Table II

	at $\hat{B}$ (Gs)	at freq. (kHz)	grade 3H1
μ_e	≤ 1	4	≥ 1580
α	≤ 1	4	≤ 14.4
$\frac{\tan\delta}{\mu_i} \times 10^6$	≤ 1 ≤ 1	4 100	≤ 1.2 ≤ 7
$q_{2-24-100}$	15-30	4	≤ 1.8

Weigth per half core — 29 g approx.

Mean length of lines of force — l_e = 6.73 cm (two halves)

A_e = 1.64 cm^2 (two halves)

$\Sigma \frac{l_e}{A_e}$ = 4.10 cm^{-1} (two halves)

V_e = 11.0 cm^3 (two halves)

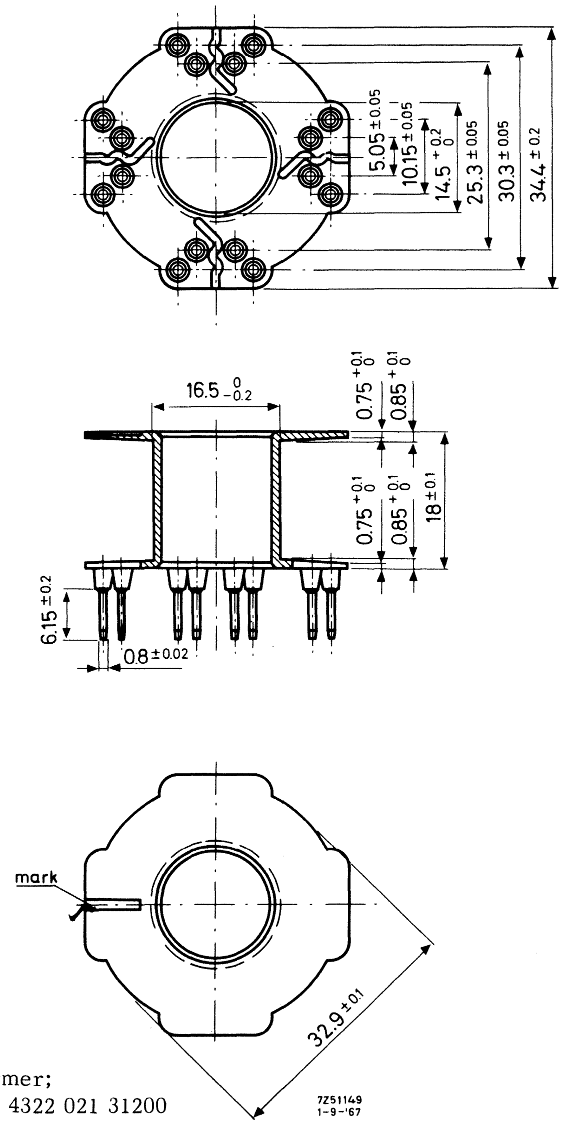
*) Orientation value

CORE HALVES WITH AIR GAP

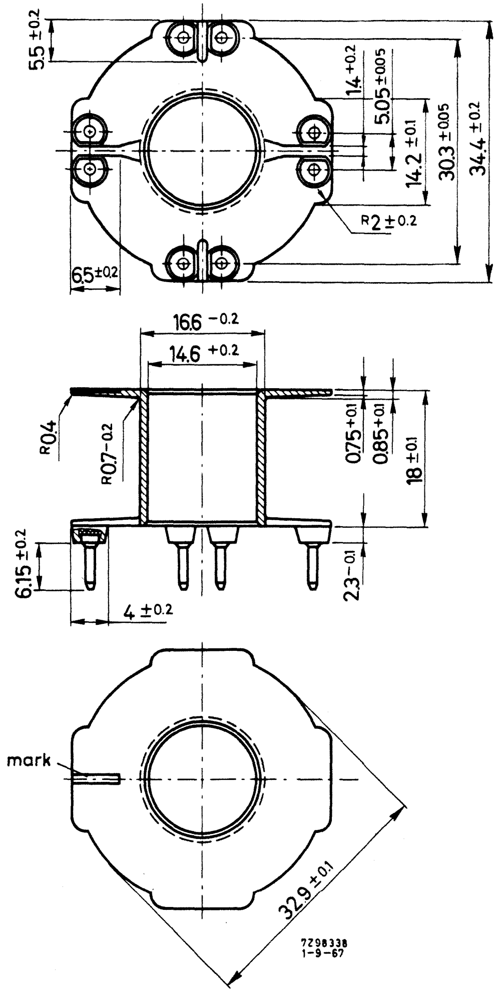
ferroxcube grade	air gap length in mm	catalog number
3H1	0.02 ± 0.01	4322 020 24210
3H1	0.05 ± 0.015	4322 020 24220
3H1	0.15 ± 0.015	4322 020 24230
3H1	0.25 ± 0.015	4322 020 24240

The electrical properties are measured on cores without air gap.

COIL FORMERS



16 pins coil former;
catalog number 4322 021 31200

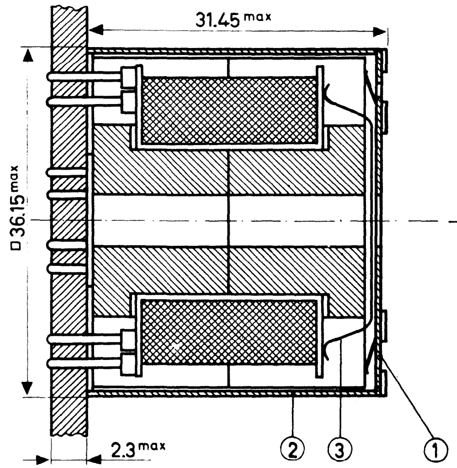


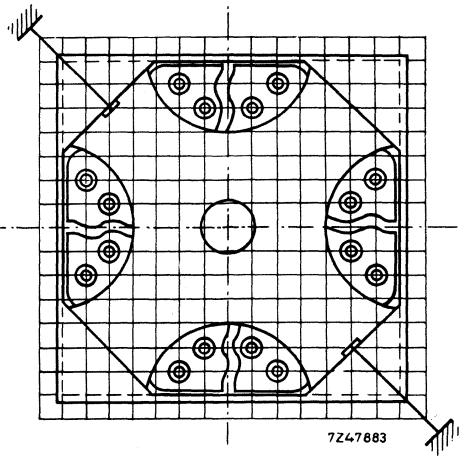
8 pins coil former;
catalog number 4322 021 30190

Properties of the coil formers

Material	reinforced polyester
Window area	134 mm^2
Mean length of turn	7.75 cm
Max. dipsolder temperature (5 to 6 s)	280 ^oC
Max. working temperature	130 ^oC
Tensile strength of pins (1 minute at 25 ^oC)	$\geq$ 20 N
A.C. test voltage between pins (50 Hz, 2 min)	2000 V

MOUNTING PARTS





(1) Cover 4322 021 31160
(2) Container 4322 021 31180
(3) Spring 4322 021 30220
(4) Soldering spring 4322 021 30700 (see below)

The cross core has been developed especially for transformers to be mounted on printed-wiring boards.

An advantage of this construction is that the leading-out wires are soldered to the pins, which are directly mounted on the coil former.

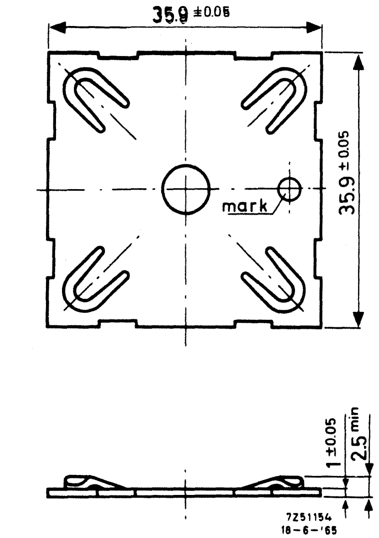
The sixteen soldering pins are positioned according to a grid of 2.52mm. They will fit printed-wiring boards with a 0.1" grid as well as those with a 2.50mm grid. The pin length is sufficient for board thicknesses up to 2.3mm. The printed-wiring board should be provided with holes of 1.3 ± 0.1 mm in diameter.

The phosphor-bronze cover has four cut-out lips on the corners, consequently the cover acts as a spring at the same time.

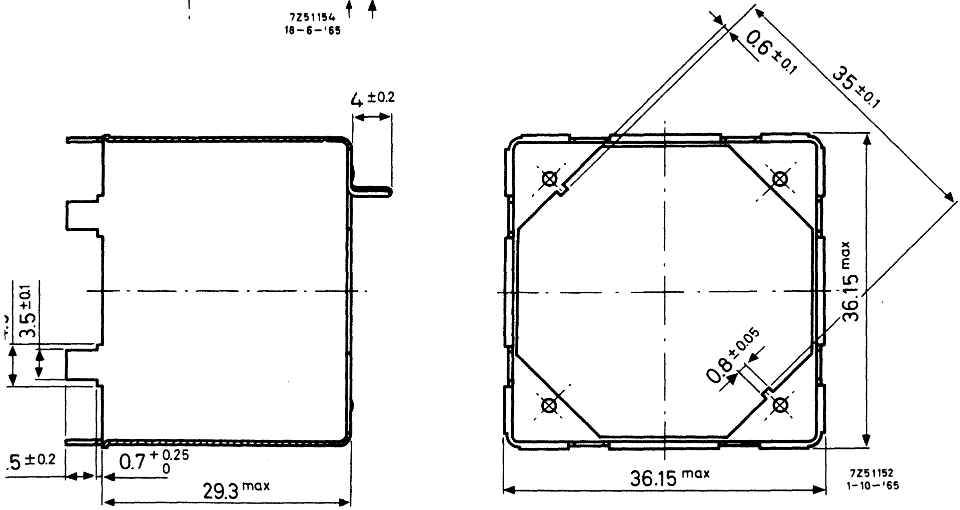
The cover is provided with a marking hole. The mark of the coil former (see the Fig. of coil former) has to be in one line with this hole. These markings facilitate the numbering of the soldering pins and the positioning on the printed-wiring board.

It is recommended to cement the coil former in one of the cross-core halves or to use the spring (pos. 3) in order to obtain the most stable construction.

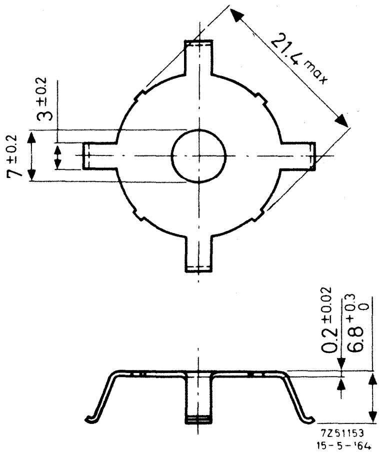
Before bending the lips of the container, pressure should be exercised evenly on the four corners of the cover until the latter meets the container. The required force is approximately 330 Newton. After bending the lips, the core will have the correct tension.



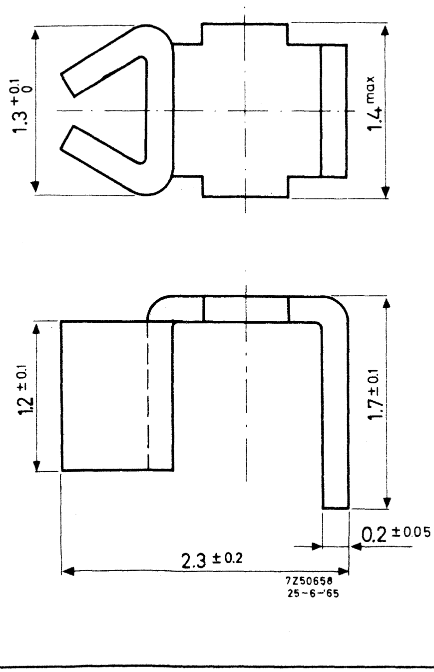
(1) Cover 4322 021 31160
Material: phosphorbronze, nickel plated



(2) Container 4322 021 31180
Material: brass, nickel plated



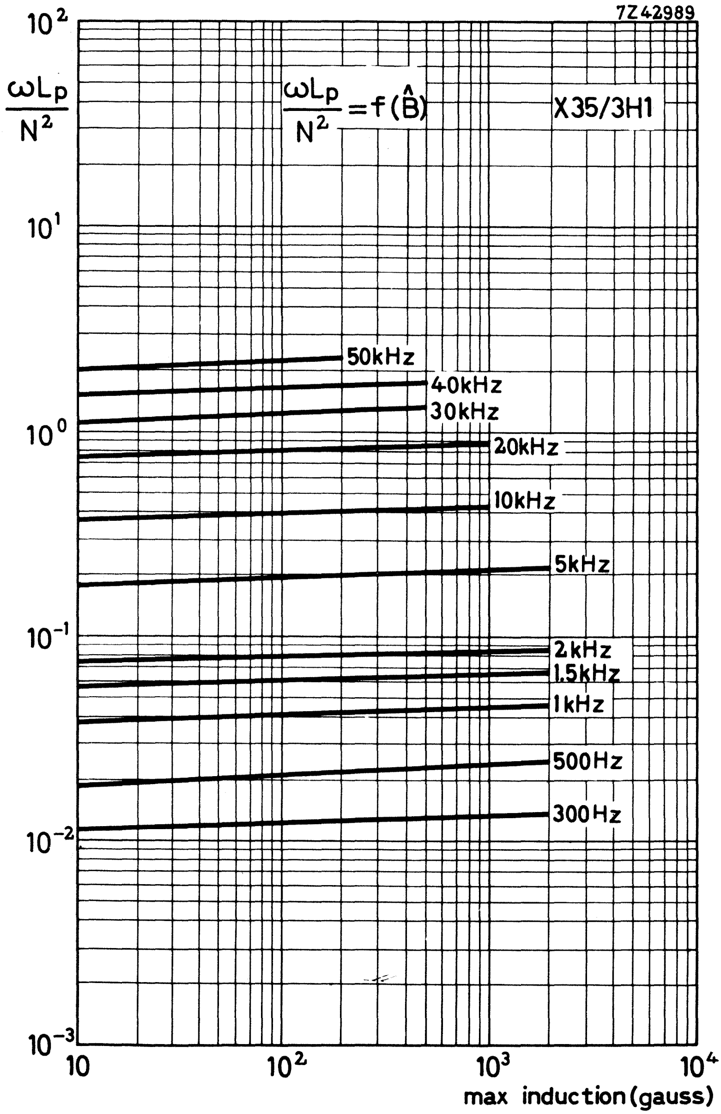
(3) Spring 4322 021 30220
Material: phosphorbronze



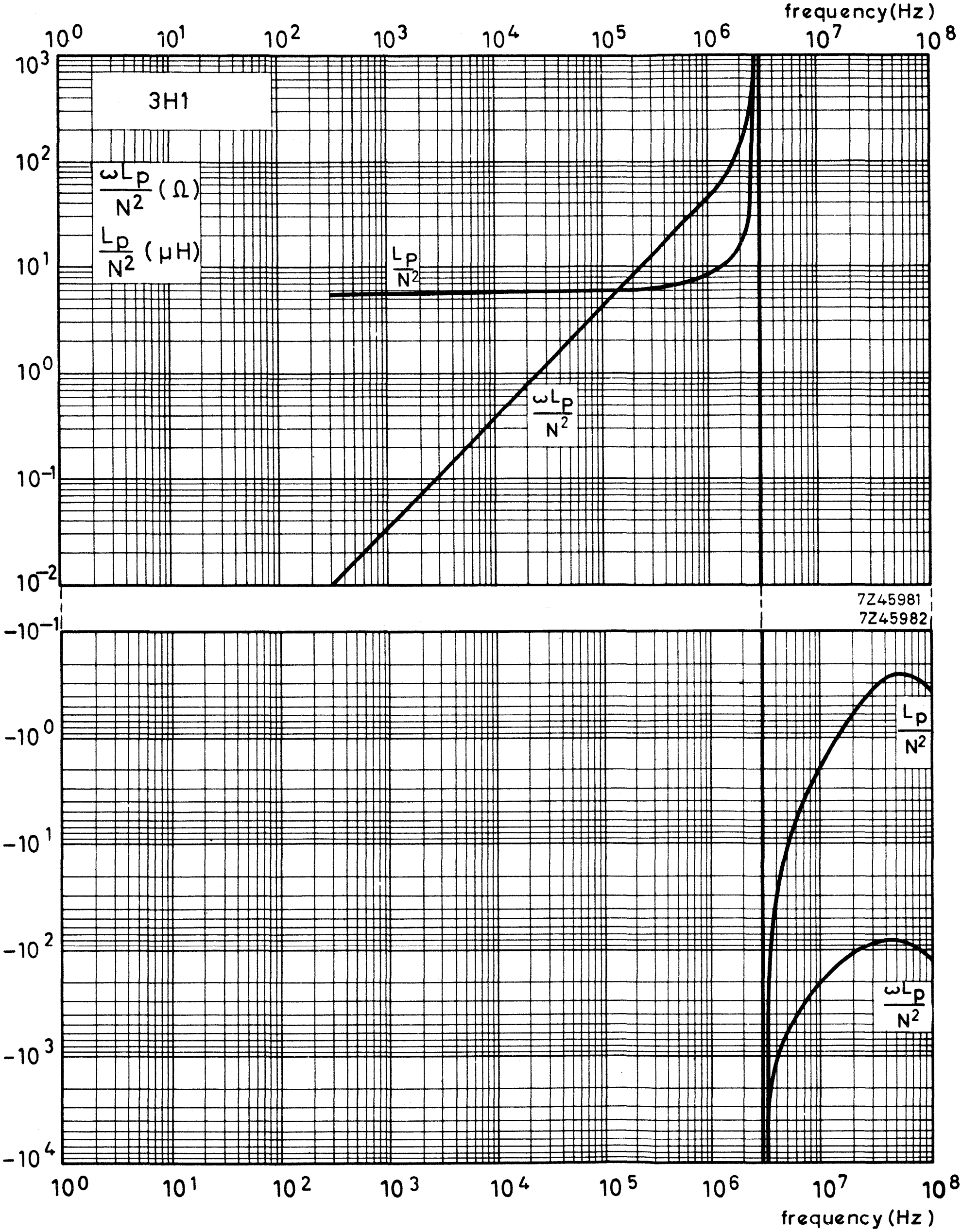
(4) Soldering spring 4322 021 30700
Material: brass, dipsoldered

CHARACTERISTIC CURVES

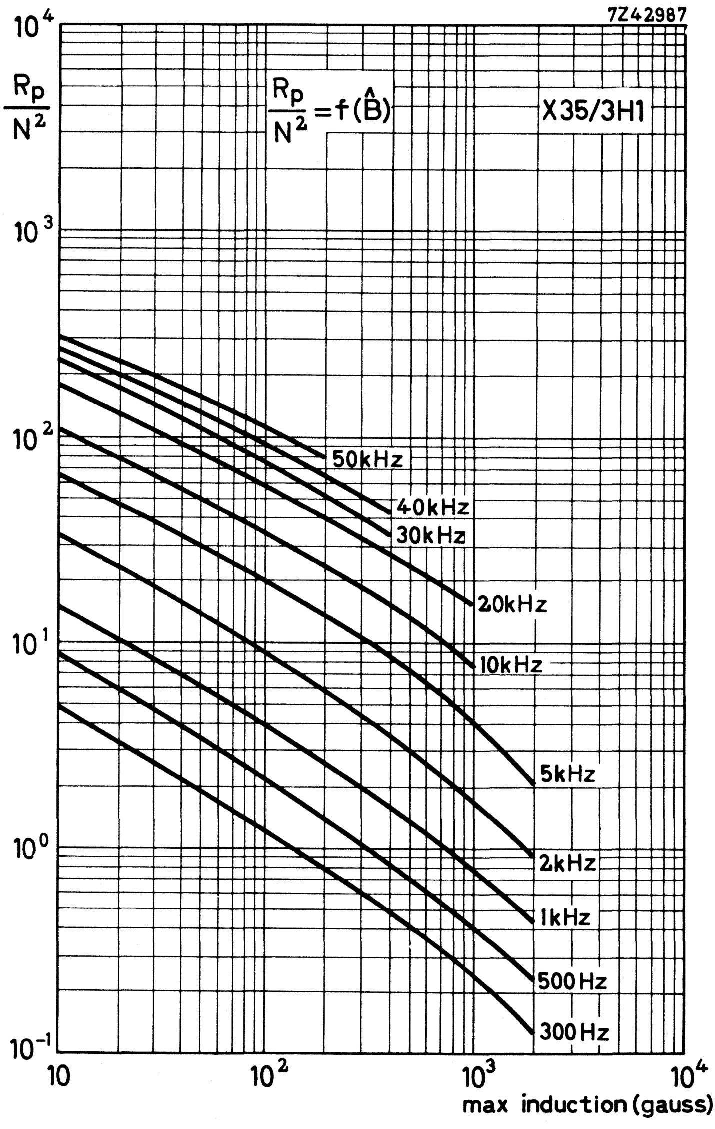
INDUCTANCE AS A FUNCTION OF THE INDUCTION (typical values)



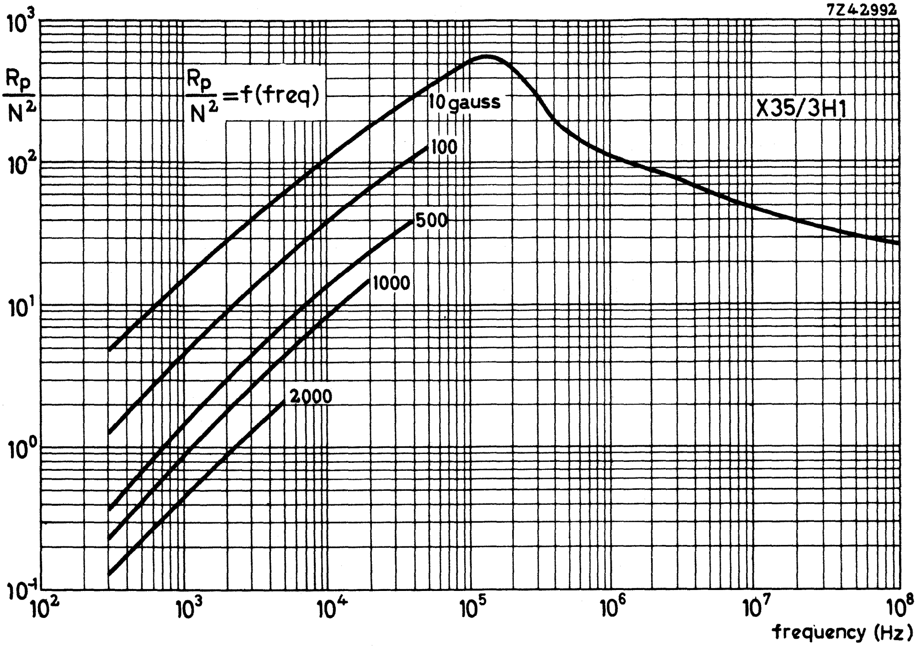
INDUCTANCE AS A FUNCTION OF THE FREQUENCY (typical curves)



CORE LOSSES AS A FUNCTION OF THE INDUCTION (typical values)

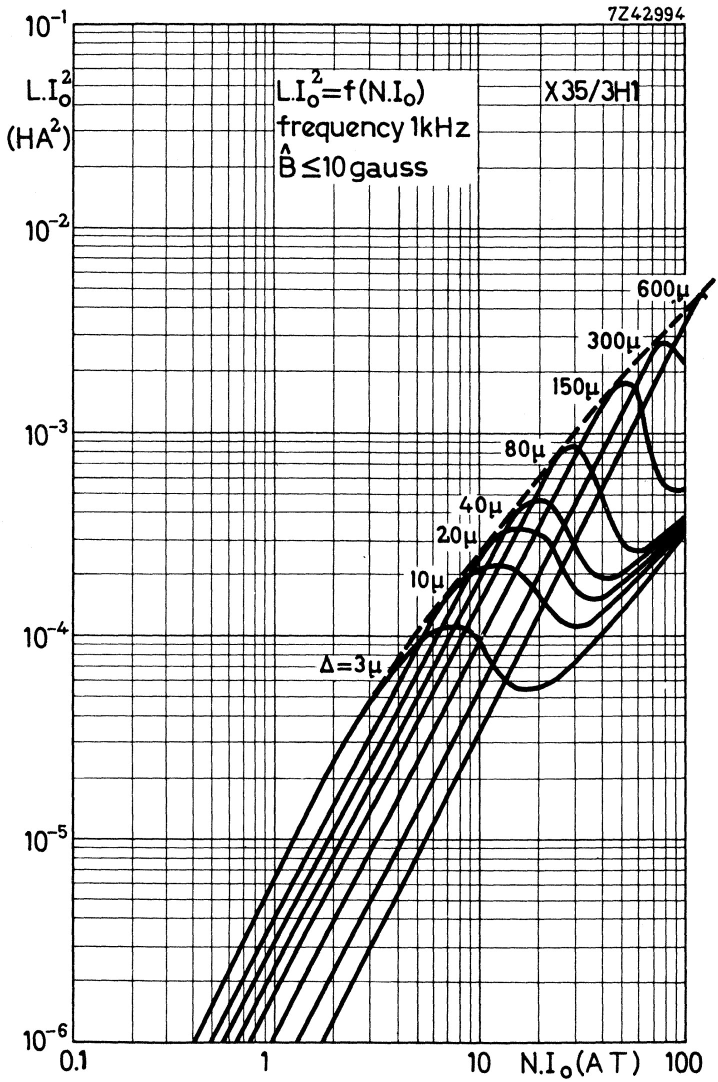


CORE LOSSES AS A FUNCTION OF THE FREQUENCY (typical values)

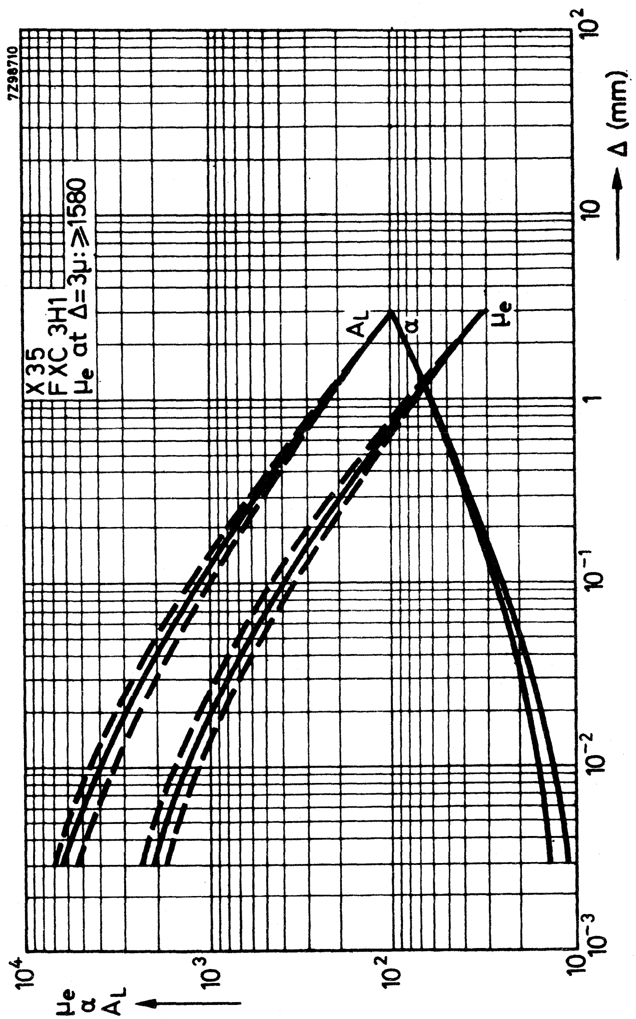


HANNA CURVE (typical values)

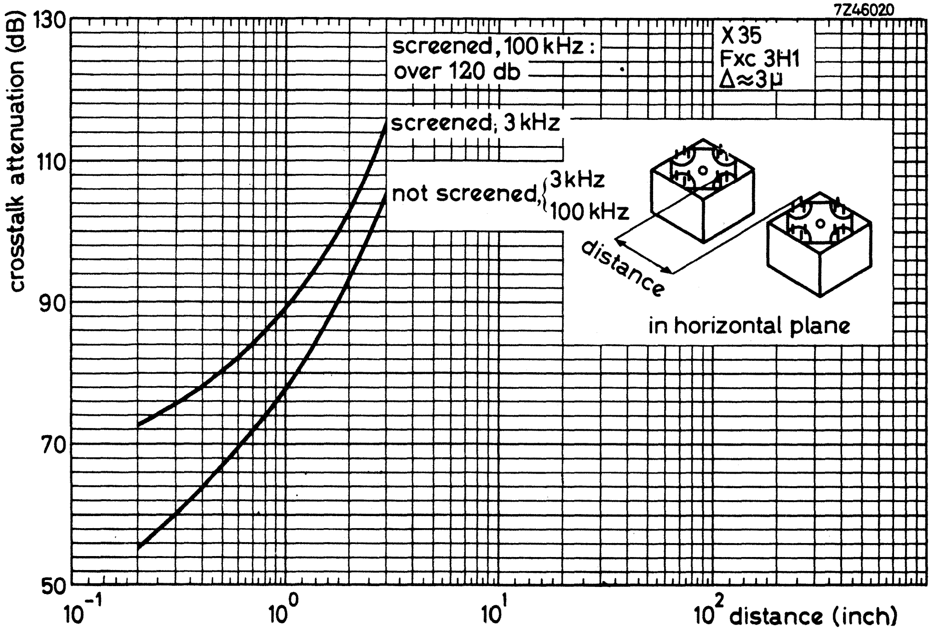
Indicating optimum inductance for a certain airgap and direct current.

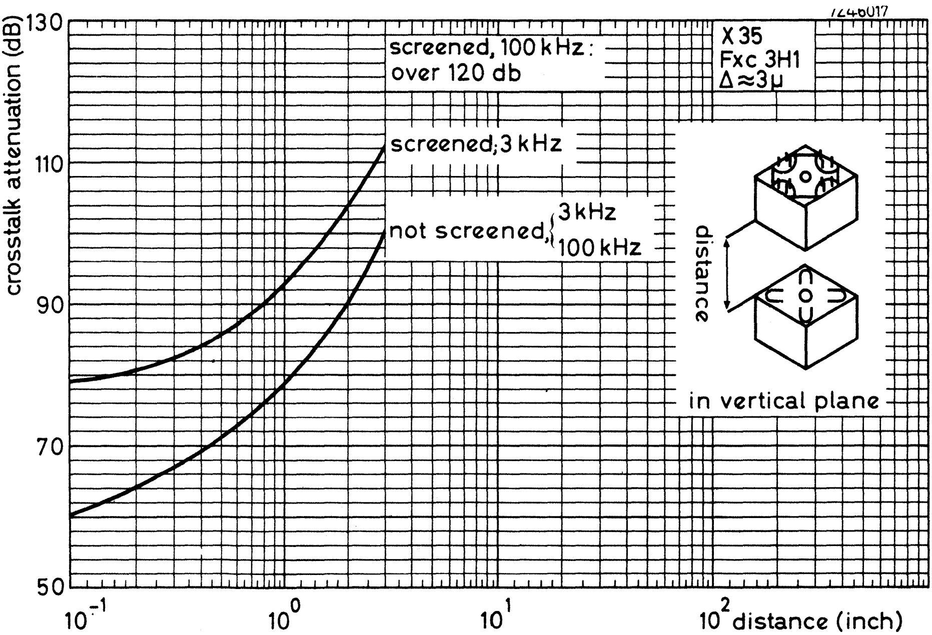


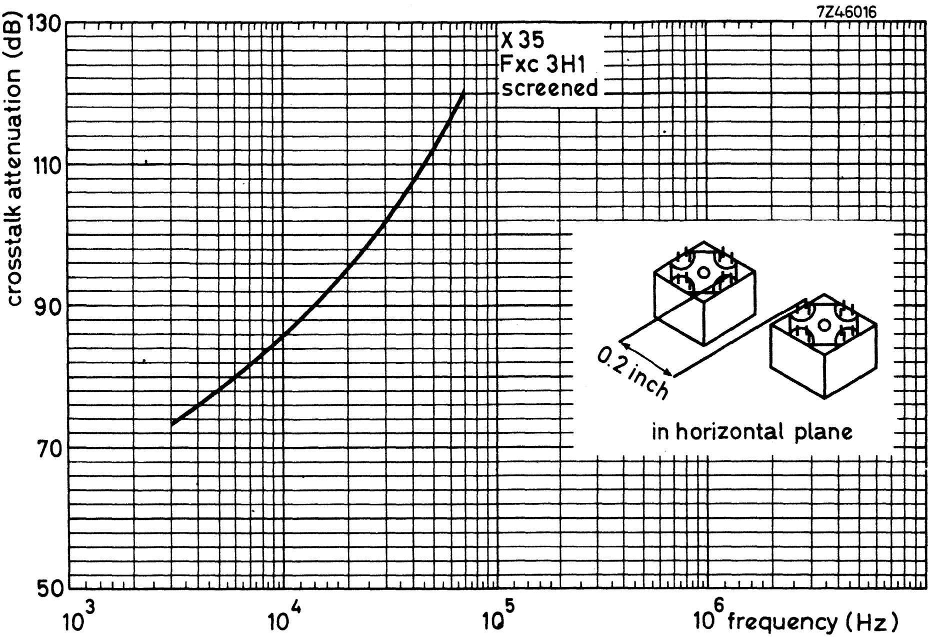
μ_e - α AND A_L CURVES



CROSSTALK ATTENUATION






7Z46016
X 35
Fxc 3H1
screened
crosstalk attenuation (dB)
130
110
90
70
50
0.2 inch
in horizontal plane
10^3
10^4
10^5
10^6
frequency (Hz)

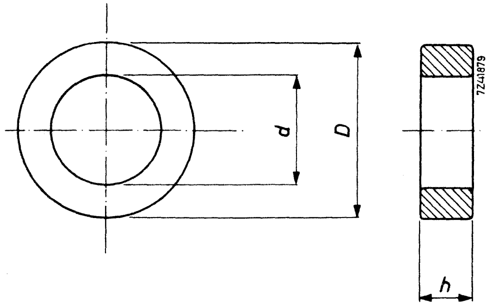
TOROIDS

INTRODUCTION

Toroids, having no air gap, posses a small magnetic stray field and a high permeability.
In spite of the closed magnetic circuit the losses are low due to the favourable properties of ferroxcube.

Toroids are mainly used in small broadband transformers, pulse transformers and chokes. If, however, the direct current through the transformer is relatively large, transformer cores with an air gap are to be preferred.
Toroids are not recommended for tuned circuits.

TOROIDS



Ferroxcube toroids are used in small broadband transformers, pulse transformers, etc.
Toroids are available in various sizes and ferroxcube grades. They are barrel-finished and coated with an insulating lacquer.

DIMENSIONAL QUANTITIES, TOLERANCES AND WEIGHTS (Table I)

D (mm)	d (mm)	h (mm)	l_e (cm)	$\Sigma \frac{l_e}{A_e}$ (cm^{-1})	V_e (cm^3)	weight (g)
2 ±0.1	1.3 ±0.1	0.7 ±0.1	0.511	208	0.00125	0.006
3.93 ±0.13	2.23 ±0.09	1.27 ±0.09	-	87.4	-	-
4 ±0.1	2.2 ±0.1	1.1 ±0.1	0.946	95.6	0.00937	0.045
4.83 ±0.25	2.28 ±0.25	1.27 ±0.25	-	66.3	-	-
5.84 ±0.13	3.05 ±0.2	1.52 ±0.13	-	63.4	-	-
6 ±0.15	4 ±0.15	2 ±0.1	1.55	77.5	0.0310	0.15
9 ±0.2	6 ±0.2	3 ±0.1	2.33	51.7	0.105	0.50
9.53 ±0.25	4.75 ±0.25	3.18 ±0.25	-	28.4	-	-
14 ±0.3	9 ±0.25	5 ±0.15	3.55	28.5	0.445	2.14
23 ±0.5	14 ±0.35	7 ±0.2	5.70	18.1	1.79	8.6
29 ±0.5	19 ±0.4	7.5 ±0.2	7.50	20.1	2.58	13
36 ±0.7	23 ±0.5	10 ±0.2	9.20	14.2	5.60	29
36 ±0.7	23 ±0.5	15 ±0.2	9.20	9.42	8.50	44

Notes

1. All dimensions apply to non-lacquered toroids.
2. All μ-values in the following are determined with the $\Sigma \frac{l_e}{A_e}$ values of Table I at 25 °C.
   The relevant A_L values can be calculated with the formula $A_L = \frac{4\pi\mu}{\Sigma \frac{l_e}{A_e}}$
3. The smaller a toroid, the more its properties deviate from the material properties. Therefore a straight-forward translation of the material figures is not always possible.

GRADES AND SIZES

Toroids of ferroxcube 3E1

μ_{tor} = 2700 ±20% at 23 ± 1 °C
Lacquered green

dimensions (mm)	catalog number
29 x 19 x 7.5	4322 020 36550
36 x 23 x 10	4322 020 36560
36 x 23 x 15	4322 020 36570

Toroids of ferroxcube 3E2

μ_{tor} > 5000 at +23 to +70 °C
Lacquered blue

dimensions (mm)	catalog number
4 x 2.2 x 1.1	4322 020 36650
6 x 4 x 2	4322 020 36660
9 x 6 x 3	4322 020 36670
14 x 9 x 5	4322 020 36680
23 x 14 x 7	4322 020 36690

Toroids of ferroxcube 3E3

μ_{tor} > 10 000 at +10 to +70 °C
Lacquered brown
* Not lacquered

dimensions (mm)	catalog number
*2 x 1.3 x 0.7	8222 293 03230
4 x 2.2 x 1.1	4322 020 36700
6 x 4 x 2	4322 020 36710
9 x 6 x 3	4322 020 36720

Toroids of ferroxcube 3E3

μ_{tor} is between 10 000 and 15 000 at +10 to +60 °C
Not lacquered

dimensions (mm)	catalog number
3.93 x 2.23 x 1.27	4322 020 90780
4.83 x 2.28 x 1.27	4322 020 90790
5.84 x 3.05 x 1.52	4322 020 90800
9.53 x 4.75 x 3.18	4322 020 90810

Toroids of ferroxcube 3H1

Sorted into μ groups.
Lacquered orange
D.F. $\leq 4.3 \times 10^{-6}$ at 23 ± 1 °C

dimensions (mm)	catalog number
4 x 2.2 x 1.1	4322 020 36590
6 x 4 x 2	4322 020 36600
9 x 6 x 3	4322 020 36610
14 x 9 x 5	4322 020 36620
23 x 14 x 7	4322 020 36630

For the convenience of the user the toroids of ferroxcube 3H1 are delivered sorted into groups of approximately equal μ-value. The μ-value is indicated by the colour of the circumference of the toroids, see Table II. Groups are not separately available.

Table II (for toroids of the 3H1 series)

group	colour of circum-ference	μ_{tor} at 23 ± 1 °C	4322 020 36590	36600	36610	36620	36630
			α-factor				
2	red	2140-2360	58.3	52.3	42.8	31.8	25.3
3	orange	2300-2540	56.0	50.3	41.2	30.6	24.4
4	yellow	2480-2740	54.0	48.6	39.8	29.5	23.5
5	green	2680-2960	51.8	46.6	38.2	28.3	22.6
6	blue	2900-3210	49.9	44.8	36.7	27.3	21.7
7	violet	3150-3480	48.0	43.2	35.4	26.2	20.9
8	grey	3420-3780	46.2	41.4	34.0	25.2	20.1
9	white	3720-4110	44.2	39.7	32.5	24.1	19.2

Number of turns for L mH : $N = \alpha\sqrt{L}$

The α factors are mean values, except those of the last group.

Between +23 and +70 °C the min μ_{tor} of the product is higher than the min μ_{tor} of the group.

Toroids of ferroxcube 4C6

$\mu_{tor} > 100$ at +5 to +55 °C
Lacquered violet

dimensions (mm)	catalog number
6 x 4 x 2	4322 020 91000
9 x 6 x 3	4322 020 91010
14 x 9 x 5	4322 020 91020
23 x 14 x 7	4322 020 91070
36 x 23 x 15	4322 020 91090

Toroids of ferroxcube 3B7

Between 0 and +60 °C the deviation in A_L is max. +10/−6% with regard to A_L at the reference temperature +23 °C.
Not lacquered.

dimensions (mm)	A_L ± 20% at 23 ± 1 °C	catalog number
3.93 x 2.23 x 1.27	360	4322 020 90820
4.83 x 2.28 x 1.27	475	4322 020 90830
5.84 x 3.05 x 1.52	495	4322 020 90840
9.53 x 4.75 x 3.18	1100	4322 020 90850

Ferroxcube memory cores

For complete information reference is made to data handbook series "Components and Materials" Part 5.

STANDARD TYPES

core size (mil)	core type	nominal operating conditions						relevant typical output characteristics				
		T (^oC)	I (mA)	C4 [1] (mA/degC)	DR	t_r (μs)	t_d (μs)	uV_1 (mV)	rV_1 (mV)	wV_z (mV)	t_p (μs)	t_s (μs)
150	6E1 [2]	40	346	2.7	0.50	0.8	12	120	115	30	3.5	8
50	6D5 [2]	40	365	2.0	0.50	0.2	1.5	64	60	7	0.54	1.15
50	6D9 [2]	40	450	1.7	0.50	0.2	1.5	60	58	8	0.55	1.20
50	6C1 [2]	40	500	2.0	0.50	0.2	1.1	63	60	8	0.48	0.93
50	6C2 [2]	70	755	1.5	0.50	0.25	1.2	105	103	7	0.45	0.88
30	6F3	70	740	1.3	0.50	0.15	0.6	60	58	5	0.25	0.50
30	6F8	40	655	3.7	0.50	0.1	0.5	55	53	6	0.20	0.39
20	6H2	70	900	1.7	0.50	0.05	0.28	48	45	4	0.110	0.22
20	6H3	40	835	3.0	0.50	0.05	0.45	55	53	5	0.095	0.19
20	6H4	45	665	3.0	0.50	0.05	0.30	54	52	5	0.108	0.22
20	6H5	60	800	1.7	0.50	0.05	0.25	72	69	7.5	0.105	0.195
18	6H6	60	7.78	1.3	0.50	0.05	0.30	56	55	5	0.098	0.175
14	6V2	75	750	1.9	0.50	0.03	0.30	40	38	4	0.062	0.155

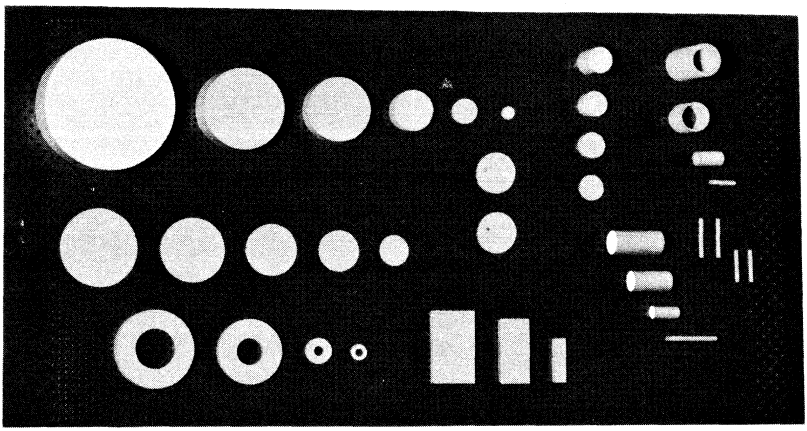
1) Rate of change of full drive current for constant uV_1

2) Maintenance type

Note: Offers for cores differing from those of our range may be made on request.

Piezoxide

INTRODUCTION



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Piezoxide materials are piezoelectric ceramic materials, suitable for almost any electro-mechanical or mechano-electrical energy conversion. Because of their ceramic nature elements in these materials can be preshaped. Their piezoelectric properties are formed during the manufacturing process. This now provides the device designer with a certain freedom of choice for the element shape and its properties for a particular device requirement. A non-polar and unstressed element of these materials has isotropic properties and the crystallographic reference axes may be chosen freely. They exhibit piezoelectricity only when polarised, the direction of polarisation also being chosen freely and made permanent in the process.

MATERIALS AND GRADES

Piezoxide materials are composed of polycrystalline chemical compounds having the general formula ABO_3, where A and B may be cations such as Pb and Zr or Ti; specific examples are the solid solutions of Pb (Ti, Zr) O_3. These materials stem from the family of chemical compounds with perovskite-type structures which have continuous ranges of composition and in which a number of different crystal phases may occur either with ferroelectric or with anti-ferroelectric properties.

Modified forms of these materials are used which may be derived by small atomic disturbances, displacements or substitutions to obtain the permanent ferroelectric phase condition in which the material will be useful for piezoelectric applications.

Physically, piezoxide is a hard non-porous material of a ceramic nature, chemically inert and unaffected by humidity or other atmospheric conditions. It has mechanical properties similar to the more common insulation ceramics, and the manufacturing process resembles the preparation of these although more careful control is exercised in the formation of the electrical properties. Piezoxide is not easily broken but it should be handled with some care.
These materials are, however, extremely "stiff" that is, they are capable of exerting or sustaining very large forces.
Two standard grades are available, having characteristics suitable for almost all applications.

PXE 4: A modified lead zirconate titanate ceramic which has excellent properties for two important fields of application, namely high-power resonance transducers and high-voltage generators for spark ignition of gases.
The high coercive force and the high mechanical Q-factor together with the low amount of dielectric heat dissipation enable PXE 4 to be driven to high strain amplitudes, which are required for e.g. ultrasonic cleaning and sonar. For high-voltage generation it is important that it can withstand easily repetitive loads of very high quasistatic and dynamic forces.

PXE 5: A modified lead zirconate titanate ceramic. It has a low mechanical Q-factor and a very high coupling coefficient and charge sensitivity.
Therefore this is the ideal grade for all kinds of non-resonance mechano-electrical sensing applications, such as pick-up elements, feed-back plates, hydrophones and microphones as well as for low-power electro-mechanical transducer applications. PXE 5 has a better temperature stability than other grades. The resistivity, even at high temperatures, is extremely large.

The following three grades are available on request.

PXE 7: A modified lead zirconate titanate ceramic with a very high shear coupling coefficient, a low dielectric constant and a high voltage sensitivity. Aging of the dielectric constant is extremely low, so that this material is eminently suitable for high-frequency shear resonance applications, e.g. ultrasonic delay-line transducers.

PXE 11: A potassium sodium niobate. It has a very low dielectric constant and a comparatively high frequency constant, both properties rendering PXE 11 the ideal material for very high frequency shear transducers (f_r = 10 - 20 MHz), e.g. in delay lines.

PXE 21: A modified lead zirconate titanate ceramic with excellent properties for high-voltage generation. It has a high dielectric constant and a high voltage sensitivity.
For use in impact-type ignition systems it is important that it can withstand easily repetitive loads of high dynamic forces.

PIEZOELECTRIC RELATIONSHIPS

When a voltage V is applied to a thin polarised element between parallel electroded surfaces a distance l apart, the electric field E is equal to the quotient V/l. If these surfaces are held under a constant stress T, the element will undergo a mechanical strain S. Provided that all mechanical changes are kept within the elastic limit of the material, then the general relationships between the elastic and electrical properties are

$$S = s^E T + dE \qquad (1)$$

$$D = dT + \epsilon^T E \qquad (2)$$

Here D is the dielectric displacement and the constants s^E, d and ϵ^T need to be defined. These may be obtained from a consideration of the boundary conditions of operation for a single element.

If the element is short-circuited, E = 0 and Eq. (2) becomes

$$D = dT \qquad (3)$$

For this condition, the dielectric displacement is equal to the dielectric polarisation P, hence

$$D = P = dT \qquad (4)$$

This gives a definition of the important constant d, which is defined as the charge density developed per unit applied mechanical stress at constant electric field. The dual definition of d is obtained by considering the element operating in a no-load condition (T = 0) so that Eq. (1) becomes:

$$S = dE \qquad (5)$$

Therefore a second definition for the constant d is the mechanical strain produced per unit applied field (piezoelectric strain constant) at constant external stress.

When there is no piezoelectric effect (d = 0) then Eqs. (1) and (2) simplify to the well-known relationships

$$S = s^E T \qquad (6)$$

$$D = \epsilon^T E \qquad (7)$$

Here s^E is the elastic compliance at constant field strength and ϵ^T is the dielectric permittivity at constant (or zero) stress. Both Eqs. (6) and (7) are valid, if either E or T is zero.

From the above analysis, another important constant can be obtained. When D = 0 (open-circuited element) Eq. (2) becomes

$$E = -\frac{d}{\epsilon^T} T \text{ or, if } \frac{d}{\epsilon^T} = g$$

$$E = -g T \tag{8}$$

Thus g, the piezoelectric voltage constant or stress sensitivity constant, is defined as the field developed per unit applied mechanical stress under open circuit conditions.

A second method of defining g is achieved by combining Eqs. (1) and (2) and considering the boundary condition when T = 0. Then

$$S = \frac{d}{\epsilon^T} D = g D \tag{9}$$

which gives an alternative definition for g as the strain obtained per unit applied charge density at constant external stress.

All these relationships are true over the range of linear response for either generator or motor applications, and large values for d and g are required for most electro-mechanical and mechano-electrical applications.

PIEZOELECTRIC CONSTANTS d AND g

constant	definition	units (MKS system)
d	$\frac{\text{charge density developed}}{\text{applied mechanical stress}}$ $\frac{\text{strain developed}}{\text{applied field}}$	$\frac{\text{coulombs/metre}^2}{\text{newtons/metre}^2}$ $\frac{\text{metres/metre}}{\text{volts/metre}}$
g	$\frac{\text{field developed}}{\text{applied mechanical stress}}$ $\frac{\text{strain developed}}{\text{applied charge density}}$	$\frac{\text{volts/metre}}{\text{newtons/metre}^2}$ $\frac{\text{metres/metre}}{\text{coulombs/metre}^2}$

COUPLING COEFFICIENT

By taking the ratio of the cross products of the coefficients in Eqs. (1) and (2) one obtains:

$$\frac{d^2}{s^E \epsilon^T} = k^2$$

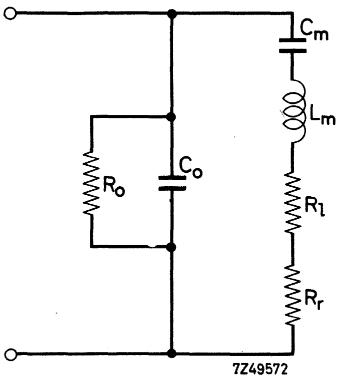
Being introduced like this k can be considered merely as a convenient numerical quantity. It has, however, a basic physical meaning. At frequencies far below the fundamental mechanical resonance frequency k^2 can be expressed as:

$$k^2 = \frac{\text{energy converted}}{\text{input energy}}$$

This formula holds for electro-mechanical and for mechano-electrical energy conversions.

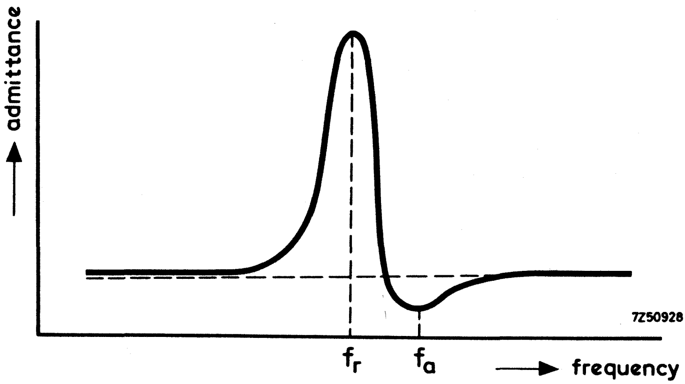
DYNAMIC BEHAVIOUR

A piezoelectric transducer operating near or at the mechanical resonance frequency can be characterised by the following simple equivalent circuit.



C_o = capacitance of the clamped transducer
R_o = dielectric losses of the transducer
R_1 represents the mechanical energy losses
R_r represents the radiated energy
C_m and L_m represent the rigidity and the mass of the material

If the electrical admittance of the vibrating transducer is plotted against the frequency, one obtains the following resonance curve.



The frequency f_r, at which the admittance is maximum, is called the resonance frequency. The minimum value of the admittance is found at the anti-resonance frequency f_a.

FREQUENCY CONSTANT

The frequency constant N is the product of the resonance frequency f_r (where the admittance passes through maximum) with the linear dimension h that governs the mechanical resonance. For half wave length resonators one may write $N = f_r h$ = half the velocity of sound at constant field intensity.

TECHNICAL DATA

	PXE 4	PXE 5	PXE 7	PXE 11*)	PXE 21	
MECHANICAL DATA						
Specific mass	7.45-7.55	7.55-7.65	7.6	4.5	7.7-7.8	$10^3 kg/m^3$
Moduli of elasticity $Y'_{11}{}^E$	0.77	0.65	0.82	1.2	-	$10^{11} N/m^2$
$Y_{33}{}^E$	0.79	0.59	-	-	0.61	$10^{11} N/m^2$
$Y_{55}{}^E$	-	0.26	0.28	0.41	-	$10^{11} N/m^2$
Specific heat	420	420	420	420	420	J/kg.deg C
Heat conductivity	1.2	1.2	1.2	1.2	1.2	W/m.deg C
Compressive strength	> 6	> 6	> 6	> 6	> 6	$10^8 N/m^2$
Tensile strength	approx.0.8	approx.0.8	approx.0.8	approx.0.8	approx.0.8	$10^8 N/m^2$
Flexural strength	approx.1.0	approx.1.0	approx.1.0	approx.1.0	approx.1.0	$10^8 N/m^2$
Poisson constant	approx.0.3	approx.0.3	approx.0.3	approx.0.3	approx.0.3	
ELECTRICAL DATA						
Curie temperature	265	285	320	400	270	^oC
Relative dielectric constants						
$\epsilon_{33}{}^T/\epsilon_o$	1750	1750	680	450	1750	
$\epsilon_{11}{}^T/\epsilon_o$	-	1800	1050	600	-	
Volume resistivity ρ_{el} at 25 ^oC	10^{11}	10^{14}	-	-	-	Ωm
Time constant $\tau = RC = \rho_{el} \cdot \epsilon_{33}{}^T$	> 30	> 300	-	-	-	min
Dielectric dissipation factor tan δ	$0.6x10^{-2}$	$2.0x10^{-2}$	$2.0x10^{-2}$	$2.5x10^{-2}$	$1.6x10^{-2}$	

*) Preliminary data

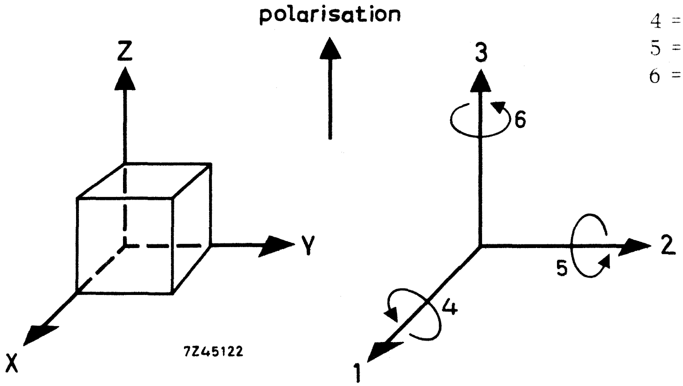
		PXE 4	PXE 5	PXE 7	PXE 11*)	PXE 21	
ELECTRO-MECHANICAL DATA							
Coupling coefficients	k_p	0.55	0.62	0.53	0.43	0.62	
	k_{31}	0.32	0.36	–	0.25	–	
	k_{33}	0.65	0.70	–	–	0.73	
	k_{15}	–	0.66	0.66	0.65	–	
Piezoelectric charge constants							
	d_{31}	-141	-178	-84	-44.5	–	10^{-12}C/N
	d_{33}	305	356	–	–	370	10^{-12}C/N
	d_{15}	–	515	350	235	–	10^{-12}C/N
Piezoelectric voltage constants							
	g_{31}	-9.4	-11.3	-14.0	-11.2	–	10^{-3}Vm/N
	g_{33}	17.5	23.2	–	–	24.0	10^{-3}Vm/N
	g_{15}	–	32.5	44.2	44.0	–	10^{-3}Vm/N
Quality factor	Q_M^E	500	80	approx.80	270	80	
Frequency constants	N_p	2200	2000	2250	3600	2000	Hz.m
	N_1	1620	1460	1640	2650	–	Hz.m
	N_3	1610	1390	–	–	1400	Hz.m
	N_5	–	930	970	1500	–	Hz.m

*) Preliminary data

KEY TO SUBSCRIPTS

For polarised ceramic materials the direction of positive polarisation is usually taken to be that of the Z-axis of a right-hand orthogonal crystallographic axial set X, Y, Z. Since these materials have polar symmetry the senses of X and Y chosen in an element are unimportant and planes parallel to the Z-axis are reflection planes.

If the directions of X, Y and Z are represented as 1, 2 and 3 respectively, and the shear directions to these axes as 4, 5 and 6 respectively then the various related parameters may be written with subscripts referred to these.



4 = shear in 23-plane
5 = shear in 31-plane
6 = shear in 12-plane

Axial notation

Piezoelectric constants: The first subscript refers to the direction of the electric field, the second subscript refers to the direction of the strain. (k_p is the planar coupling coefficient.)

Elasticity constants : The first subscript refers to the direction of the strain, the second subscript refers to the direction of the stress.

Dielectric constants : The first subscript refers to the direction of the dielectric displacement, the second subscript refers to the direction of the electric field.

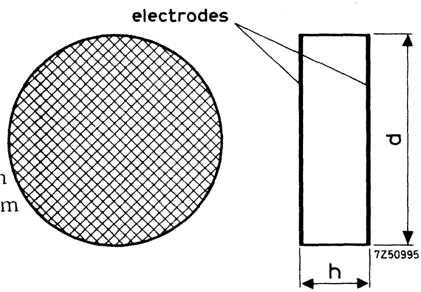
Frequency constants : The subscript refers to the direction of resonance vibration.

TYPE LIST

This survey of types comprises the standard range of shapes and sizes of PXE elements. However, any other shape or size with any tolerance within the technical possibilities can be supplied.
The electrodes normally are silverplated. The electrode, which has been connected to the positive terminal of the polarising apparatus, is marked.
The complete electrical and/or mechanical specification of the types mentioned is delivered on request. For detailed application information, see Application Book "Piezoelectric ceramics".

DISCS AND CYLINDERS

Direction of polarisation : axial
Standard tolerance
on the diameter (d): ±2.5%
Standard tolerance on the height (h)
for $h \geq 0.5$ mm: ±0.1 mm
for $h < 0.5$ mm: ±0.05 mm



dimensions		catalogue number		
d (mm)	h (mm)	PXE 4	PXE 5	PXE 21
3	0.5		8222 293 01100	
3	8		4322 020 05120	
5	0.2		8222 293 01130	
5	0.3		8222 293 01140	
5	0.5	8222 293 10330	8222 293 06060	
5	0.75		8222 293 06070	
5	1	8222 293 08580		
5	2	8222 293 08590	8222 293 08650	
5	8			4322 020 05090
6.35	2			8222 293 13250
6.35	16	4322 020 05060		4322 020 05070

dimensions		catalogue number	
d (mm)	h (mm)	PXE 4	PXE 5
10	0.2		8222 293 01270
10	0.3		8222 293 01280
10	0.5		8222 293 07670
10	1	8222 293 06050	4322 020 02330
10	2	8222 293 08600	8222 293 07680
10	3		8222 293 07740
10	5	8222 293 00890	8222 293 07750
10	10	8222 293 08610	8222 293 07690
10	20	8222 293 06030	8222 293 08660
16	0.2		8222 293 01300
16	0.3		8222 293 01310
16	0.5		8222 293 04300
16	1.1	8222 293 04110	4322 020 02250
16	1.1		8222 293 07780 *)
16	1.1		4322 020 02260 *)
16	1.1		4322 020 02270 *)
16	2		8222 293 06010
16	3	8222 293 08630	4322 020 02300
25.4	0.5		8222 293 01410
25.4	1	8222 293 08640	8222 293 08680
25.4	2	8222 293 07710	8222 293 06020
25.4 (1 in)	6.35 (1/4 in)	4322 020 02440	
38.1 ($1\frac{1}{2}$ in)	6.35 (1/4 in)	4322 020 05000	

Types with special electrode configuration

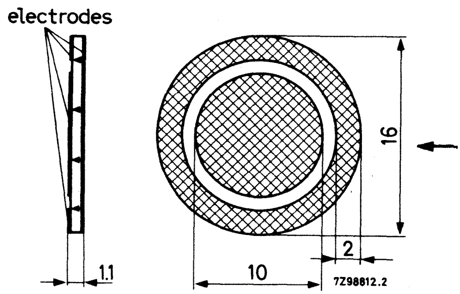
In the table above the catalogue numbers of these types are marked with *).

Three-electrode disc

Direction of polarisation: indicated by arrows, see figure (side of full electrode negative)

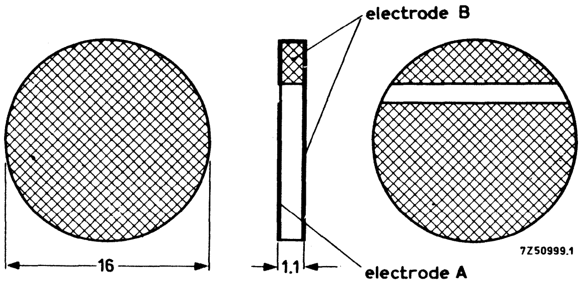
Material : PXE 5

Catalogue number : 8222 293 07780



Feedback plates

Direction of polarisation: axial
Material : PXE 5

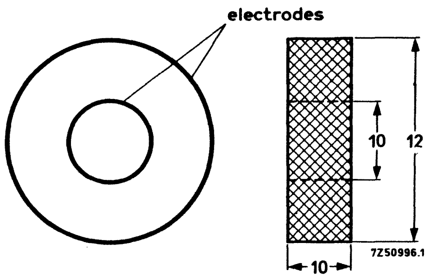


polarity of electrode A	catalogue number
−	4322 020 02260
+	4322 020 02270

RINGS

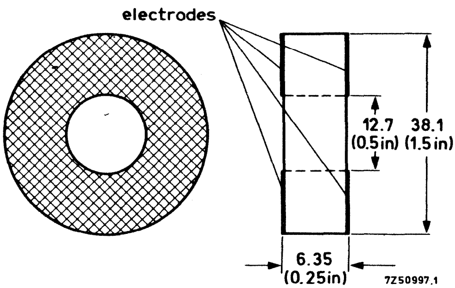
Direction of polarisation: radial (outer electrode negative)
Standard tolerance
- on the outer diameter : ± 2.5%
- on the inner diameter : ± 2.5%
- on the concentricity : 0.1 mm
- on the height : ± 0.1 mm

Material : PXE 5
Catalogue number : 8222 293 01870



Direction of polarisation: axial
Standard tolerance
- on the outer diameter : ± 2.5%
- on the inner diameter : ± 2.5%
- on the concentricity : 0.1 mm
- on the height : ± 0.1 mm

Material : PXE 4
Catalogue number : 4322 020 06000

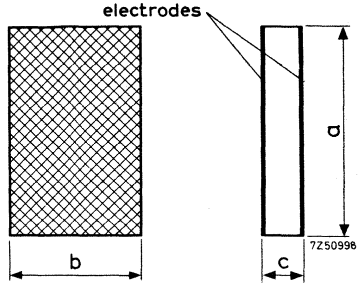


RECTANGULAR PLATES

Direction of polarisation: parallel to dimension c

Standard tolerance
- on the length (a) : ± 0.1 mm
- on the width (b) : ± 0.1 mm
- on the thickness (c)
  - for c ≥ 0.5 mm : ± 0.1 mm
  - for c < 0.5 mm : ± 0.05 mm

Material : PXE 5

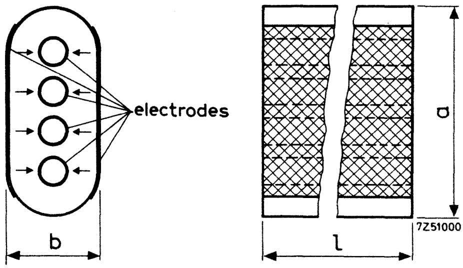


dimensions			catalogue number
a (mm)	b (mm)	c (mm)	
12	6	0.5	8222 293 02760
12	6	1	8222 293 02770
16	12	1	4322 020 02310

MULTIMORPH STRIPS

Direction of polarisation: indicated by arrows, see figure (outer electrodes negative)

Material : PXE 5



dimensions			catalogue number
a (mm)	b (mm)	l (mm)	
1.6	0.67	9.6	4322 020 04760
1.6	0.67	12.7	4322 020 02480
1.6	0.67	15.5	4322 020 02490
1.6	0.67	70	8222 293 02940

Direction of polarisation: opposite to the direction given in the figure above (outer electrodes positive)

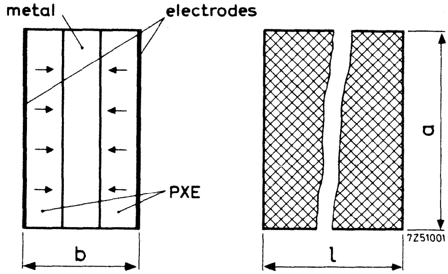
Material: PXE 5

dimensions			catalogue number
a (mm)	b (mm)	l (mm)	
1.6	0.67	9.6	4322 020 04750
1.6	0.67	12.7	4322 020 02460
1.6	0.67	15.5	4322 020 02470

→ BIMORPH STRIPS

Direction of polarisation: indicated by arrows, see figure (outer electrodes negative)

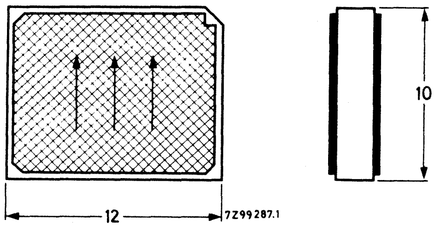
Material : PXE 5



dimensions			catalogue number
a (mm)	b (mm)	l (mm)	
1.60	0.50	12.7	4322 020 04370
1.60	0.60	15.0	8222 293 09510
6.35	0.50	11.6	8222 293 08010
8.0	0.60	8.0	4322 020 04380

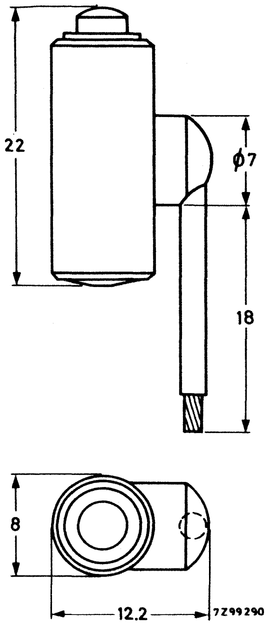
→ DELAY-LINE TRANSDUCER

Direction of polarisation: indicated by arrows, see figure
Material : PXE 7
Frequency of the thickness shear vibration : approx. 4.1 MHz
Catalogue number : 8222 293 13330



IGNITION UNIT

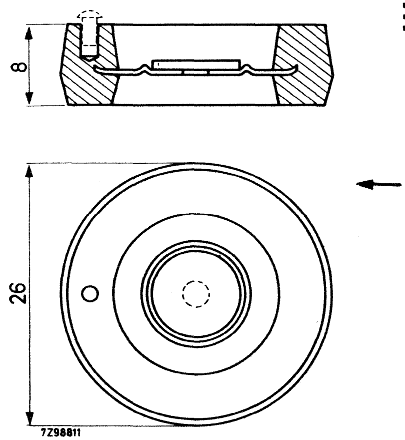
Material : PXE 21
Catalogue number: 4322 020 08010
Application : cigarette lighters



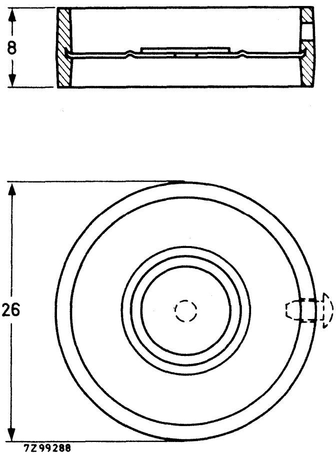
FLEXURE ELEMENTS

Detectors

Material : PXE 5
Resonance frequency : 6 $\pm$ 0.4 kHz
Capacitance at 100 Hz: $\geq$ 4300 pF
Catalogue number : 4322 020 08760



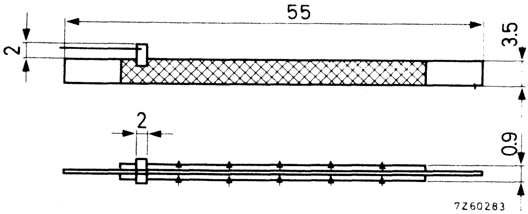
Material : PXE 5
Resonance frequency : 2.85 ± 0.35 kHz
Capacitance at 100 Hz: ≥ 4300 pF
→ Catalogue number : 4322 020 08770



Drive element for low-power synchronous motors

Direction of polarisation: indicated by arrows, see figure
Material : PXE 4
→ Catalogue number : 8222 410 30050

→



APPLICATION POSSIBILITIES

Modern piezoelectric ceramics are of continually increasing importance to device and equipment designers throughout industry.
They may be used where mechanical energy is required to be transformed into electrical energy, or they may be used where electrical energy is available to be transformed into mechanical energy. Such transformations being produced within single solid-state elements offer a wide field of application, which can be divided into five groups.

a. High-voltage generators:
- ignition of pilot lights in gas heaters
- cigarette lighters
- ignition of flash bulbs
- ignition of fuses for explosives

b. High-intensity ultrasound transducers:
- ultrasonic cleaning and degreasing
- ultrasonic plastic and metal welding
- ultrasonic machining, e.g. drilling
- sonar projectors
- ultrasonic medical therapy
- ultrasonic humidifiers

c. Low-intensity ultrasound transducers:
- ultrasonic non-destructive testing
- ultrasonic medical diagnosis
- sonar hydrophones
- geophones for seismic exploration
- acoustic delay-line transducers (shear-wave transducers)

d. Flexure systems:
- gramophone pick-up cartridges
- piezoelectric bell clappers
- ultrasonic sensing in air
- microphones
- telecommanding

e. Miscellaneous:
- ceramic intermediate-frequency bandpass filters
- ultrasonic liquid-level testers
- ultrasonic flow meters
- ultrasonic hardness testers
- feedback plates
- accelerometers
- strain gauges
- fine-movement control

Permanent magnet materials

RECO "TICONAL"	Cast alloys
FERROXDURE	Sintered ceramic materials Plastic-bonded ceramic materials

Contents

FOREWORD

The place of permanent magnets in modern life is so evident that their importance cannot be overlooked. Every home contains at least a few of these devices, and it is hard to imagine present day technology without the aid of the modern permanent magnet. Examples are found in

Communication,
Power distribution,
Timing devices,
Vehicles,
Traffic control etc.

Modern permanet magnets are available in cast alloys ranging in size from large castings to tiny cubes, and available also in ceramic material in any geometric form.

The excellent properties of the modern materials allow permanent magnets to be made with very small dimensions and exceptional stability. They are ideal for use in

electrotechnical and
mechanical equipment and for
applied physics.

In these applications, permanent magnets offer considerable economic advantages over electrically energised systems, not only in initial outlay but also during operation because power supplies - with their attendant costs and complications - are eliminated.

INTRODUCTION

Permanent magnets - either isotropic* or anisotropic* - can be classified as being basically either

metallic alloy
ceramic material or
plastic bonded ceramic material

The table shows the class to which each of our materials belongs.

	metallic alloy	ceramic material	plastic bonded ceramic material
isotropic *	reco	ferroxdure	ferroxdure
anisotropic *	"Ticonal" **	ferroxdure	ferroxdure

The most obvious differences between the groups are that the ferroxdure magnets are characterised by high values of coercivity and resistivity while "Ticonal" magnets possess higher values of remanent magnetism and energy product.

Ferroxdure is therefore most suitable for applications in which demagnetising influences (either from external sources or resulting from the use of short magnets) are large and also in high frequency applications.

"Ticonal" is particularly suitable for applications in which high values of magnetic energy are required from small volumes of magnetic material.

The isotropic materials in general are inferior in magnetic properties to the anisotropic ones but are particularly suitable for applications in which multipolar magnets are to be used or where less expensive magnets are necessary giving a reasonable performance.

The plastic-bonded ferroxdure magnets combine the characteristic magnetic properties of isotropic ferroxdure (however on a lower level) with the mechanical properties of the plastic material used. These magnets open a new field of applications, especially where the price is of prime importance.

Each of the permanent magnet materials is manufactured in a variety of grades possessing different properties that result from differences in composition and treatment.

The grades are distinguished by the addition of letters and numbers to the name of the material. The numbers are approximately relative to the nominal energy product of the grade.

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* Isotropic materials can be magnetised equally well in any direction. Anisotropic materials have optimal magnetic properties in one direction only.

** "Ticonal" is a registered trade name.

SURVEY OF PERMANENT MAGNET MATERIALS

MAIN MAGNETIC PROPERTIES

The survey on the following pages shows data on some of the principal magnetic properties for the complete range of permanent magnet materials.

Demagnetising curves are given after the tables.

The meaning of the survey is to facilitate the selection of the permanent magnet materials for the proper use. The designer can focus his interest on materials yielding:

a. high performance magnets with either
   1) high values of coercivity (H_{cb}) and intrinsic coercivity (H_{ci})
   or
   2) high values of remanence (B_r),

or

b. cheaper magnets.

Typical values

The term typical values ("typ.") concerns a value which frequently occurs. Typical values enable good comparison between the various grades but are not to be treated as average or mean values.

Minimum values

The minimum magnetic values quoted are guaranteed for test pieces or for minimum-flux standard magnets only.

The minimum values of B_r and H_{cb} mostly do not occur simultaneously. Generally the minimum value of B_r will coincide with a H_{cb} well above the quoted typical value, whereas the minimum value of H_{cb} is coupled with a high value of B_r.

Notes

(M) stands for Pb, Sr or Ba etc.
For plastic-bonded ferroxdure grades the letters before the numbers indicate the type of plastic material used for bonding, as follows:

P = flexible thermoplastic material
SP = rigid thermoplastic material
D = rigid thermosetting material

permanent magnet material typical chemical composition	max. energy product $(BH)_{max.}$ (MGs.Oe)		occurs at Bd (Gs)	occurs at Hd (Oe)	remanence B_r (Gs)		coercivity H_{cb} (Oe)		intrinsic coercivity H_{ci} (Oe)	
	min.	typ.	typ.	typ.	min.	typ.	min.	typ.	min.	typ.
ISOTROPIC PLASTIC-BONDED FERROXDURE Ferroxdure P30, P40 and SP50 magnets are extruded, injection moulded and punched, D55 magnets are pressed and cured. Magnetically lower grades can be supplied on request.										
Ferroxdure P30 KPN-K-992 85% ferroxdure powder $(M)Fe_{12}O_{19}$ 15% thermoplastic material	0.3	0.35	700	500	1150	1250	1050	1100	2500	2700
Ferroxdure P40 KPN-K-989 90% ferroxdure powder $(M)Fe_{12}O_{19}$ 10% thermoplastic material	0.4	0.45	800	550	1350	1450	1150	1200	2300	2500
Ferroxdure SP50 KPN-K-7028 93% ferroxdure powder $(M)Fe_{12}O_{19}$ 7% thermoplastic material	0.5	0.55	800	690	1550	1600	1225	1275	2300	2400
Ferroxdure D55 KPN-V-815 95% ferroxdure powder $(M)Fe_{12}O_{19}$ 5% thermosetting material	0.55	0.60	850	700	1650	1700	1300	1400	2500	2750

permanent magnet material / typical chemical composition	max. energy product (BH)max. (MGs.Oe)		occurs at B_d (Gs)	occurs at H_d (Oe)	remanence B_r (Gs)		coercivity H_{cb} (Oe)		intrinsic coercivity H_{ci} (Oe)	
	min.	typ.	typ.	typ.	min.	typ.	min.	typ.	min.	typ.
ISOTROPIC FERROXDURE All magnets are pressed, sintered and can be ground.										
Ferroxdure 100 KPN-K-359 100% ferroxdure powder $(M)Fe_{12}O_{19}$	0.9	0.95	1200	800	2100	2200	1600	1650	2600	2700
ISOTROPIC ALLOYS-RECO All magnets are cast and can be ground only.										
Reco 100 24% Ni, 14% Al, bal. Fe	1.00	1.20	4000	300	5800	6200	460	480	480	530
Reco 120 1% Ti, 4% Co, 26% Ni, 13% Al, 3% Cu, bal. Fe	1.10	1.30	3100	400	5300	5900	500	600	550	650
Reco 140 0.8% Ti, 5% Co, 25% Ni, 10% Al, 7% Cu, bal. Fe	1.30	1.40	3500	400	6200	6500	530	565	550	600
Reco 160 1.9% Ti, 13% Co, 18.5% Ni, 10% Al, 7.5% Cu, bal. Fe	1.50	1.65	4150	400	6000	6600	600	680	650	750
Reco 170 5% Ti, 10% Co, 24% Ni, 9.5% Al, 6% Cu, bal. Fe	1.50	1.65	3300	500	5200	5600	830	890	900	1000
Reco 220 7% Ti, 26% Co, 15% Ni, 7% Al, 5% Cu, bal. Fe	2.00	2.30	3750	600	5600	6300	1100	1200	1200	1300

permanent magnet material typical chemical composition	max. energy product (BH)max. (MGs.Oe)		occurs at Bd (Gs)	occurs at Hd (Oe)	remanence Br (Gs)		coercivity H_{cb} (Oe)		intrinsic coercivity H_{ci} (Oe)	
	min.	typ.	typ.	typ.	min.	typ.	min.	typ.	min.	typ.
ANISOTROPIC PLASTIC-BONDED FERROXDURE All magnets are injection moulded.										
Ferroxdure SP130 KPN-K ·7049 89% ferroxdure powder $(M)Fe_{12}O_{19}$ 11% thermoplastic material	1.3	1.4	1250	1100	2300	2400	2100	2200	2800	3000

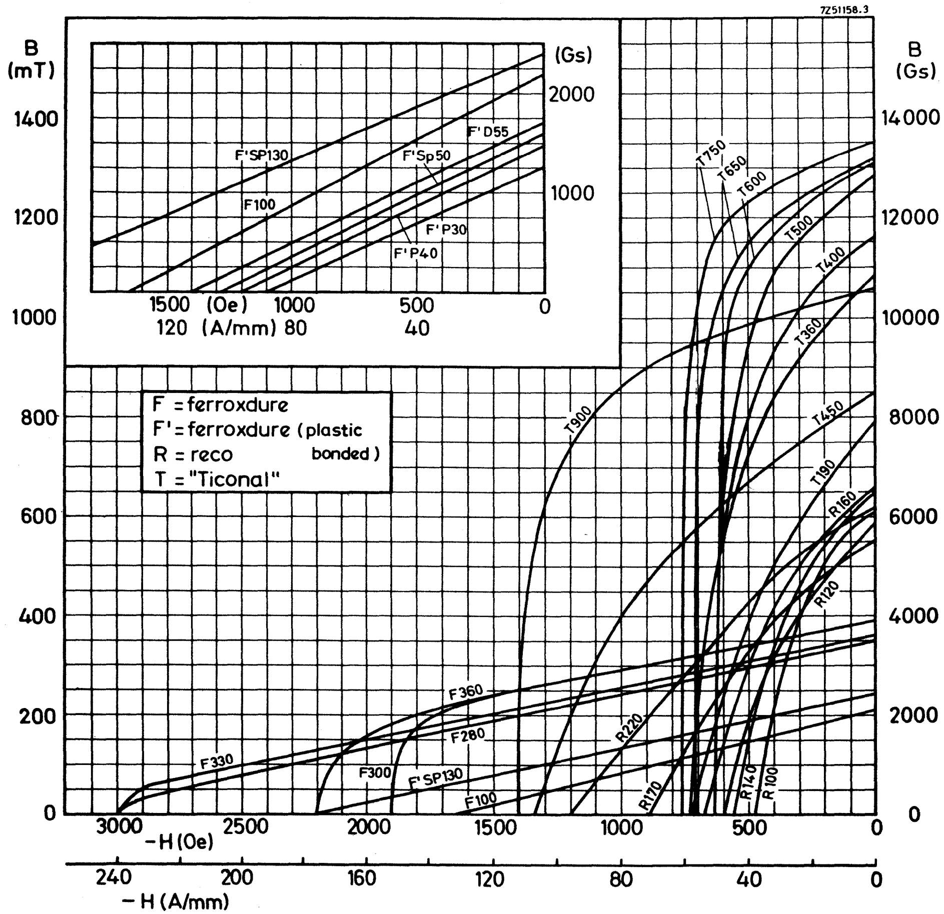
permanent magnet material / typical chemical composition	max. energy product $(BH)_{max.}$ (MGs.Oe)		occurs at B_d (Gs)	occurs at H_d (Oe)	remanence B_r (Gs)		coercivity H_{cb} (Oe)		intrinsic coercivity H_{ci} (Oe)	
	min.	typ.	typ.	typ.	min.	typ.	min.	typ.	min.	typ.
ANISOTROPIC FERROXDURE All magnets are pressed, sintered and can be ground only.										
Ferroxdure 260 1) KBN 100% ferroxdure powder $(M)Fe_{12}O_{19}$	2.4	2.6	1650	1600	3250	3350	2800	2900	3600	3800
Ferroxdure 280 1) KBN-K-1152 100% ferroxdure powder $(M)Fe_{12}O_{19}$	2.6	2.8	1750	1600	3400	3500	2800	3000	3000	3200
Ferroxdure 330 KBN-V-252 100% ferroxdure powder $(M)Fe_{12}O_{19}$	3.0	3.2	1900	1700	3600	3700	2800	3000	2900	3100
Ferroxdure 300 KBN-K-434 100% ferroxdure powder $(M)Fe_{12}O_{19}$	3.2	3.4	2200	1550	3800	3900	1600	1800	1700	1900
Ferroxdure 360 2) KBN-V-254 100% ferroxdure powder $(M)Fe_{12}O_{19}$	3.4	3.5	1950	1800	3800	3900	2000	2200	2100	2300

1) Ferroxdure 260 and 280 are especially suitable for radially orientated segments.
2) Ferroxdure 360 is only for small quantity production.

permanent magnet material / typical chemical composition	max. energy product (BH)max. (MGs.Oe)		occurs at B_d (Gs)	occurs at H_d (Oe)	remanence B_r (Gs)		coercivity H_{cb} (Oe)		intrinsic coercivity H_{ci} (Oe)	
	min.	typ.	typ.	typ.	min.	typ.	min.	typ.	min.	typ.
ANISOTROPIC ALLOYS - TICONAL All magnets are cast and can only be ground.										
Ticonal 190 14% Co, 21% Ni, 12% Al, 3% Cu, balance Fe	1.80	2.10	5000	400	7400	8000	650	730	670	800
Ticonal 360 1.5% Ti, 24% Co, 15% Ni, 8.5% Al, 3% Cu, bal. Fe	320	3.60	7200	500	10500	10700	680	710	700	760
Ticonal 400 0.8% Ti, 24% Co, 14% Ni, 8.5% Al, 3% Cu, bal. Fe	3.80	4,00	8000	500	11200	11600	610	640	620	680
Ticonal 450 5% Ti, 34% Co, 14.5% Ni, 7.5% Al, 4.5% Cu, bal. Fe	4.00	4.25	5300	800	8000	8500	1200	1335	1300	1500
Ticonal 500 24% Co, 14% Ni, 8.5% Al, 3% Cu, balance Fe	4.50	4.80	9600	500	12300	12800	600	630	610	650
Ticonal 600 24% Co, 14% Ni, 8.5% Al, 3% Cu, balance Fe	5.50	5.77	10500	550	13000	13100	630	645	640	680
Ticonal 650 24% Co, 14% Ni, 8.5% Al, 3% Cu, balance Fe	6.20	6.50	11000	565	12800	13000	640	700	650	780
Ticonal 750 1) 24% Co, 14% Ni, 8.5% Al, 3% Cu, balance Fe	7.00	7.50	11500	650	13200	13400	720	760	730	780
Ticonal 900 2) 5% Ti, 34% Co, 14.5% Ni, 7.5% Al, 4.5% Cu, bal. Fe	7.50	9.00	8000	1100	10000	10600	1300	1400	1350	1500

1) Cross-section circular $\geq$ 10 and $\leq$ 25 mm ; rectangular, sides $\geq$ 10 mm and $\leq$ 20 mm. 2) Only for very small rectangular magnets.

Demagnetisation curves



Conversion table for S.I. units (Giorgi units)

1000 Gs	= 100 mT (= 0.1 Wb/m^2)
1 Oe	$= \frac{10^3}{4\pi}$ A/m ≈ 80 A/m = 0.08 A/mm
1 MGs.Oe	= 8 kJ/m^3
1 Mx	= 0.01 μWb
μ_0	= $4\pi \, 10^{-7}$ H/m = 1 Gs/Oe

OTHER MAGNETIC AND PHYSICAL PROPERTIES

Grade	saturation field strength (Oe)	L/D ratio for open circuits	permeance coefficient 1)	recoil permeability μ_{rec}	density (g/cm^3)	specific electrical resistivity ($\Omega\ mm^2/m$)	temperature coefficient of remanence (%/deg C)	Curie temperature (°C)	coefficient of thermal expansion (10^{-6}/deg C)
Ferroxdure P30	12000	0.5	1.4	1.10	3.2	10^{13}	−0.2	–	–
P40	12000	0.5	1.5	1.15	3.6	10^{11}	−0.2	–	–
SP50	12000	0.5	1.2	1.19	4.05	10^{10}	−0.2	–	–
D55	12000	0.5	1.2	1.15	4.10	10^{10}	−0.2	–	–
Ferroxdure 100	12000	0.5	1.5	1.112-1.118	4.9	10^{10}	−0.2	450	8.5
Reco 100	2500	3.0	13	4.0-6.5	6.9	0.7	−0.015	730	12.5
120	2500	3.0	8	4.4-5.0	6.9	–	−0.015	700	12.5
140	2500	3.0	9	5.0-6.0	7.0	0.75	−0.015	770	11.5
160	2500	3.0	11	4.0-5.0	7.0	0.65	−0.015	810	11.5
170	3000	2.2	7	3.4-4.0	7.0	0.60	−0.015	790	11.5
220	5000	2.2	6	3.2-3.8	7.2	–	−0.015	750	11.5
Ferroxdure SP130	12000	0.5	1.14	1.10	3.4	10^{11}	−0.2	–	–
280	10000	0.5	1.1	1.01-1.05	4.6	10^{12}	−0.2	450	–
300	8000	1.0	1.4	1.01-1.05	5.0	10^{12}	−0.2	450	–
330	10000	0.5	1.1	1.01-1.05	4.8	10^{12}	−0.2	450	–
360	8000	1.0	1.1	1.01-1.05	4.9	10^{12}	−0.2	450	–
Ticonal 190	2500	3.0	13	3.8-5.0	7.0	–	−0.015	750	11.5
360	2500	3.5	15	4.0-5.0	7.3	0.50	−0.015	860	10.8
400	2500	4.5	16	4.0-5.0	7.3	0.50	−0.015	800	10.8
450	5000	2.2	7	2.5-3.0	7.3	0.50	−0.015	850	10.8
500	2500	4.5	20	4.0-5.0	7.3	0.45	−0.015	850	10.8
600	2500	5.0	19	3.0-4.0	7.3	0.45	−0.015	850	10.8
650	2500	4.5	20	3.0-4.0	7.3	0.45	−0.015	850	10.8
750	2500	4.3	17	3.0-4.0	7.3	0.45	−0.015	850	10.8
900	5000	2.2	7	1.7-2.5	7.3	0.50	−0.015	850	10.8

Conversion of electrical resistivity: $1\ \Omega\ mm^2/m = 10^{-4}\ \Omega cm = 10^{-6}\ \Omega m$.

1) Permeance coefficient = $-B/\mu_0 H$ at $(BH)_{max}$

MAGNETISING AND DEMAGNETISING RECOMMENDATIONS

PRE-MAGNETISED MAGNETS

Permanent magnets made from materials such as isotropic FXD100 and the anisotropic grades FXD SP130 and FXD 260, 280 and 330 - having a long straight part in their demagnetisation curves - can be demagnetised, in some cases even into the region around B=0, without any appreciable shift of the working point after removal of the demagnetising force.

These magnets can therefore be ordered in the magnetised state.

Permanent magnets not made from these materials are generally magnetised only after being built into the magnetic circuit, since the shorter straight part of their demagnetisation curves may not permit them to be demagnetised to the same extent.

Within the straight part of the demagnetisation curve, magnets of ferroxdure are less sensitive to demagnetising forces than most of the reco and "Ticonal" magnets.

MAGNETISATION

As stated above, efficient magnetic circuit design usually required that a magnet should be magnetised after it has been assembled into its associated magnetic circuit. Failure to do this exposes the magnet to the maximum self-demagnetisation influences. Furthermore, adoption of this procedure also simplifies handling and assembly.

Design equations are usually based on an assumption of magnetisation to saturation, and the magnetising force required to produce this is proportional to the coercivity of the magnetic material. The required values of magnetising field strength are given in the Table (see next page). It is extremely important that the magnetising field strength used is not less than the specified value, otherwise the maximum performance of the materials will not be achieved.

If the magnet is assembled in a circuit which shields the magnet, then the number of ampere-turns of the magnetising equipment should be high enough to saturate also the shielding circuitry. For complicated magnetic circuits, advice should be sought.

The required magnetising current can be obtained from metal rectifiers, ignitron pulse circuits, storage accumulators, charged capacitors or motor generators. To obtain the maximum effect from the magnetising current, the magnetic circuit should be adapted to the magnetising equipment. For instance, for pulse magnetisation a heavy, lamellated iron yoke is required to minimise eddy currents.

Table

Material	Field strength required for saturation (oersted)	Field strength required for saturation (ampere-turns per centimetre length of magnet)
Isotropic ferroxdures	12 000	9 600
Ferroxdure SP130 and 260	12 000	9 600
Ferroxdure 280 and 330	10 000	8 000
Ferroxdure 300 and 360	8 000	6 400
Reco 100 to 160	2 500	2 000
Reco 170	3 000	2 400
Reco 220	5 000	4 000
"Ticonal" 190 to 400 and 500 to 750	2 500	2 000
"Ticonal" 450 to 900	5 000	4 000

DEMAGNETISATION

Partial demagnetisation of permanent magnets may be necessary for stabilisation purposes and, provided that the magnets are relatively small - about 1 kg or less - satisfactory demagnetisation can usually be achieved using the normal 50 Hz power supply. The partial demagnetisation is usually achieved by a controlled alternating field. The magnet is usually placed in an open coil in which the alternating current is controlled by means of a variable transformer.

Complete demagnetisation is often undertaken to facilitate handling and assembly. The complete demagnetisation of ferroxdure is best produced by raising the temperature of the magnet beyond its Curie temperature (about 450 °C). This heating process will not in any way affect the magnetic properties of the ceramic material, but naturally it cannot be applied to plastic-bonded ferroxdure. Demagnetisation can also be effected by alternative current.

Complete demagnetisation of Ticonal is achieved in a similar way to partial demagnetisation, although considerably more power is required. It is generally more convenient to connect the supply directly to the coil and to move the magnet slowly through the coil.

Theoretically, alternating fields of about 2000 oersted are sufficient to demagnetise Ticonal magnets, but the effectiveness of the field is reduced considerably by the screening provided by associated iron circuits. The exact extent of this screening is difficult to calculate, and in practice the quickest method of finding the actual field and current requirements is by experiment.

Under no circumstances should Ticonal be demagnetised by raising the temperature of the magnet above the Curie temperature (about 850 °C). Even raising the temperature above 600 °C will permanently ruin the magnetic performance.

Demagnetisation of very large magnets is a special problem, and advice should be sought in each case.

STANDARD TERMINOLOGY SPECIFYING AXIS AND DIRECTION OF MAGNETISATION

DRAWING SYMBOLS AND TERMINOLOGY

It is recommended that the direction of magnetisation or the magnetic axis be indicated on drawings by means of the following symbols, to avoid misunderstanding.

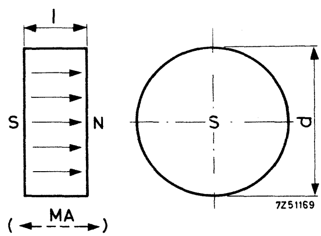
For the direction of magnetisation (ready-magnetised magnets) the symbol →N (or S→) is used.

For the magnetic axis (preferred direction in unmagnetised anisotropic magnets) the symbol <MA> is used.

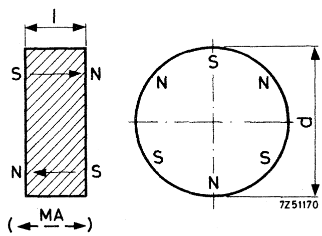
The termology given in the following examples of magnetisation is recommended for correspondence.

ISOTROPIC AND ANISOTROPIC MAGNETS

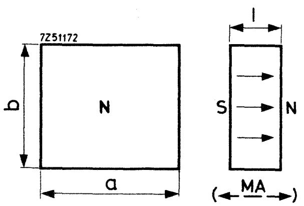
Magnetisation



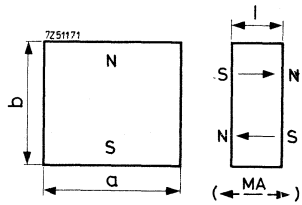
parallel to the length, or axial.



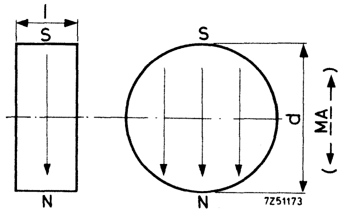
axial (n) poles (in figure n = 6).



parallel to the side l or perpendicular to a x b.

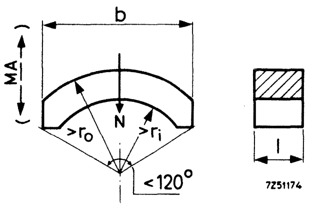


parallel to the side l, n poles. (in figure n = 2).

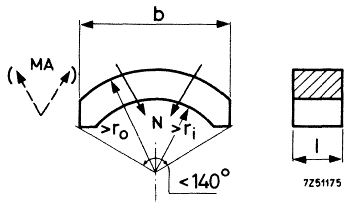


parallel to the diameter
or diametrical.

Magnetisation for segments



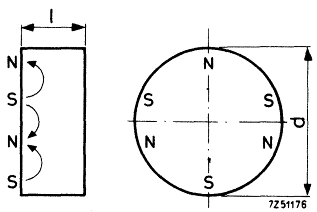
diametrical



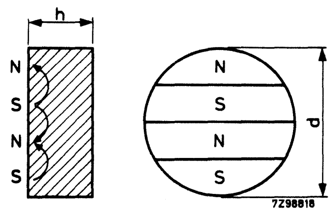
radial

ISOTROPIC MAGNETS ONLY

Magnetisation

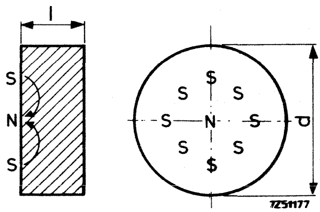


lateral,
n poles on one face only,
neutral zones radial
(in figure n = 6).

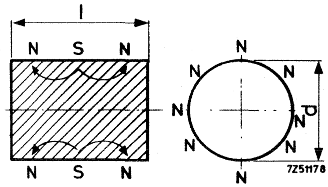


lateral,
n poles on one face only,
neutral zones in parallel
(in figure n = 4)

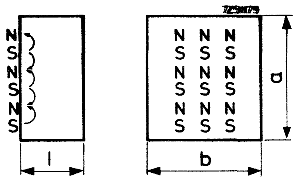
STANDARD TERMINOLOGY SPECIFYING AXIS AND DIRECTION OF MAGNETISATION



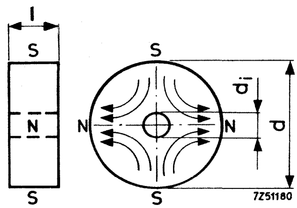
lateral,
2 poles on one face only,
centred north pole with
concentric south pole.



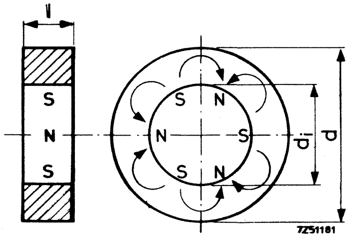
lateral,
n circumferential poles
(in figure n = 3).



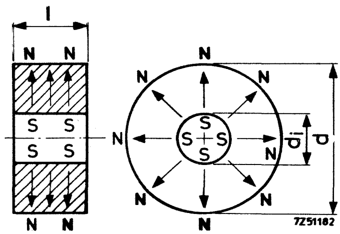
lateral,
n poles on one side a x b,
neutral zones parallel to
side b.
(in figure n = 6).



lateral,
n poles on outer circum-
ference, neutral zones
axial.
(in figure n = 4).



lateral,
n poles on inner circum-
ference.
(in figure n = 6).



radial,
N- or S-pole inside.
(in figure S-pole inside).

MARKING OF PERMANENT MAGNETS

Pole identification

If it is necessary to identify magnetised magnets of the same type but with different ways of magnetisation, a colour code is recommended.

The poles can then be marked by spots of paint or some other identification mark,

either south pole yellow
or north pole red
or neutral side white.

If the accuracy obtainable by spots of paint is not sufficient for the marking of the pole position, it is possible for example to use grooves, which must be indicated on the drawing.

Article identification

If permanent magnets are large enough, a marking by means of the article number can be used.

SHAPE INACCURACIES AND TOLERANCES

In the interests of rational and economical manufacture there should be as little restriction placed on the tolerances as possible in order to avoid additional processing operations.

FERROXDURE

Sintered ferroxdure

Ferroxdure magnets are shaped during manufacture. The raw material is pressed under high pressure in dies or extruded through jets prior to sintering.

Preference should be given to simple designs, because changes in shape due to shrinkage after sintering are then less troublesome.

For the wet manufacturing process linear shrinkage is larger than for the dry process and thus somewhat greater tolerances are required.

Linear tolerances for "as sintered" products are approximately:

dimension	tolerance
5 mm	±0.3
5 - 10 mm	±0.4
10 - 25 mm	±0.5
above 25 mm	±2.5 %

Grinding will be necessary if closer tolerances are required. This is often the case with parallel pole faces.

Ceramic parts in general may not only exhibit departures from linear dimensions but also slightly bent or warped surfaces.
Furthermore ellipticity, eccentricity and conicity lead to deviations in diameter and wall thickness.

Apart from the inaccuracies inherent in unmachined parts, errors may also occur during machining. For instance, rings ground on the outer periphery will run out-of-true if the ring is incorrectly clamped.

Plastic-bonded ferroxdure

Plastic-bonded ferroxdure magnets are not sintered after shaping. Shape inaccuracies and tolerances therefore can be kept small. They depend mainly on the mechanical tolerances (including wear-off) of the tools and dies used for shaping.

For flexible magnets of P-grade ferroxdure, naturally, special rules have to be set up, because ready-shaped piece parts can easily be deformed by external forces.

The tolerances for rigid magnets of SP- and D-grade ferroxdure generally can be kept smaller compared to flexible magnets.

Without any machining operation after shaping, which should be avoided for economical reasons, the tolerances are approximately:

dimension	tolerance	
	ferroxdure SP and D	ferroxdure P
below 10 mm	±0.05 to ±0.1 mm	±0.2 to ±0.3 mm
10-30 mm	±0.1 to ±0.2 mm	±0.3 to ±0.4 mm
30-50 mm	±0.2 to ±0.3 mm	±0.4 to ±0.5 mm
above 50 mm	±0.3 mm or ±0.5%, whichever is greater	±0.5 mm or ±1%, whichever is greater

RECO AND "TICONAL"

Reco and "Ticonal" magnets may be sand cast, shell moulded or cast to the required shape by any other modern technique.

These permanent magnets being hard and brittle cannot be machined economically by conventional methods. Holes are cored with sand or graphite and the magnets are finished by grinding.

For smaller holes inserts can be used which can subsequently be drilled out.

For the high energy product materials, holes and inserts have to be avoided as they spoil the crystal orientation.

Linear tolerances for "as cast" products are approximately:

dimension	tolerance
< 50 mm	± 0.5 mm
50 - 100 mm	± 0.8 mm
> 100 mm	± 1.0 mm

It is recommended to apply "as cast" tolerances in all dimensions and to restrict grinding to the pole faces only.

Tolerance between two ground parallel surfaces is ± 0.05 mm

Tolerance perpendicularity

between one ground and one cast surface is ± 1.5 degrees

between two ground surfaces is ± 0.5 degree.

Tolerance parallelity

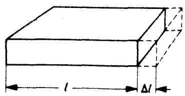
between two ground parallel surfaces, measured at opposite ends is 0.05 mm.

Magnets cut from bars have a diameter tolerance of

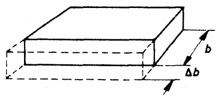
dimension	tolerance
Ø10 - 18 mm	± 0.05 mm
Ø > 18 mm	± 0.15 mm

DIMENSIONAL DEVIATIONS

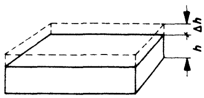
In the following table are given a few deviations of shape and dimensions consequent on the manufacturing techniques used.



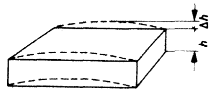
Δl length tolerance



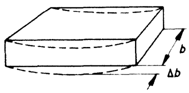
Δb width tolerance



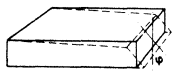
Δh height tolerance



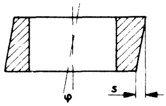
Δh curvature



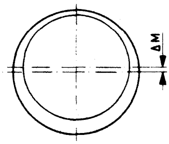
Δb curvature



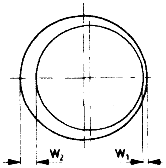
φ twisting with long rods



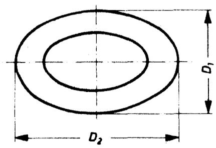
out of true running because of angular deviation in the case of grinding of outer circumference



ΔM eccentricity in the case of grinding outer circumference

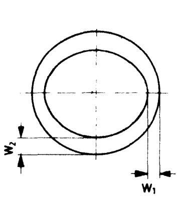


ΔW = W2 - W1 difference in wall thickness on account of eccentricity with ground outer circumference

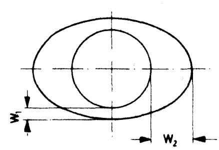


$$\Delta D = \frac{D2 - D1}{2}$$

deviation in diameter on account of ovality



ΔW = W2 - W1 difference in wall thickness in the case of inner ovality, with outer circumference ground



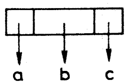
ΔW = W2 - W1 difference in wall thickness in the case of outer ovality, with inner circumference ground

SYMBOLS FOR DIMENSIONAL DEVIATIONS

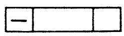
In general, shape inaccuracies are kept within the dimensional tolerances.
If it is desired for functional reasons, that shape tolerances are indicated on article drawings, the following symbols are recommended.

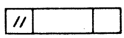
- ↗ Tolerance of eccentricity
- — Tolerance of straightness
- ▱ Tolerance of plainness
- ○ Tolerance of roundness (circularity)
- ⌭ Tolerance of cylindricity
- ⌒ Tolerance of accuracy to shape
- ⌓ Tolerance of surface uniformity
- // Tolerance of parallelism
- ⊥ Tolerance of perpendicularity
- < Tolerance of angularity
- ⌖ Tolerance of position
- ◎ Tolerance of concentricity
- ⌯ Tolerance of symmetry
- 80√ Surface roughness in ru (1 ru = 1/40 μm)

The necessary indications on drawings can be written in a rectangular frame which is divided into two, sometimes three, compartments. From left to right the sections show the tolerance symbol, the total tolerance value and the datum feature.

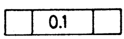


The symbol in section a represents the type of characteristic to be controlled by the tolerance, for instance:

 = Straightness tolerance

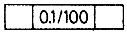
 = Parallelism tolerance

The symbol in section b represents the total tolerance value e.g.



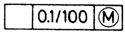
The unit of the tolerance value shall be the same as that used for dimensioning.

If the tolerance zone is circular or cylindrical, the sign Ø is placed before the tolerance value in the symbol frame, unless it is evident that the zone can only be circular or cylindrical.
If the tolerance is applied to a limited length or limited part of the surface, this length or part is inserted after the tolerance value, a stroke separating the two expressions e.g.



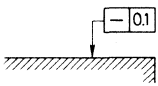
The letter in section c represents the datum feature, e.g.

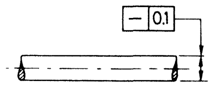
The "maximum material condition" is indicated by symbol M placed after the tolerance value and/or datum letter, e.g.



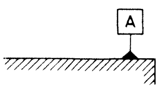
Symbol M indicates that the tolerance with which it is associated, has been specified in relation to the maximum material limit of the feature concerned.
For instance: a rod of 10+0.7 mm diameter and a straightness tolerance of 0.5 mm. If the actual diameter is 10.5 mm, the straightness tolerance may be increased by the difference between the max. material limit (10.7) and the actual diameter (10.5), which is 0.5 + (10.7-10.5) = 0.7 mm.

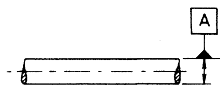
The tolerance frame is connected by a leader line to the feature to be toleranced or to the dimension line if the tolerance applies to a median plane (e.g. an axis).





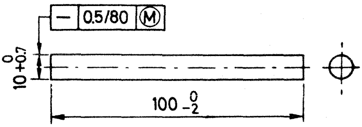
The datum plane is indicated by a capital letter in a square connected to the datum feature by a leader line terminated by ▲, or, if the datum is a median plane, to an extension of the line dimensioning this feature.





In the following examples of shape tolerances the dimensions have been chosen arbitrarily.

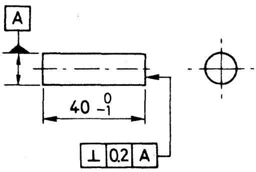
Example of straightness tolerance



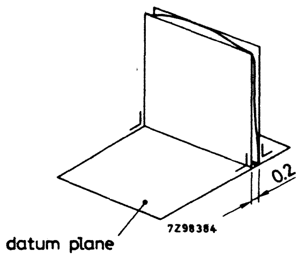
For a rod with a diameter of 10.7 mm, the deviation from straight in a length of 80 mm must not exceed 0.5 mm.

For a rod with a diameter smaller than 10.7, the straightness tolerance may be increased by the difference between the actual diameter and the max. allowable diameter.

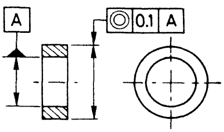
Example of perpendicularity tolerance



The considered surface must be contained between two imaginary parallel planes which are 0.2 mm apart, perpendicular to the datum feature and contained within the limits of 39 and 40 mm.

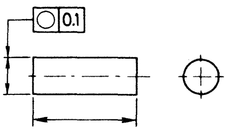


Example of concentricity tolerance



The centre of the outside circumference must be contained in a circle with a radius of 0.1 mm and of which the centre coincides with the centre of the reference circle "A".

Example of circularity tolerance



The outside circumference must be contained between two imaginary concentric circles which are at 0.1 mm radial distance from each other and contained within the limit of size.

STANDARDS FOR TESTING

TESTING

The best method of testing magnets is to measure their performance under actual working conditions. For this reason the test requirements for any type of magnet should be laid down in concert with the customer.

Often a simplified model of the magnetic circuit will suffice for measuring flux, voltage or force of attraction etc. according to the application.

VISUAL STANDARDS FOR FERROXDURE MAGNETS

Visual requirements are laid down by means of limit samples of which photographs have been made.

For each visual characteristic two limit samples should be determined one of which one is to be marked X and the other O.

In all cases it is to be understood that X means bad and is to be rejected
O means good and is acceptable.

MAGNETIC STANDARDS FOR PERMANENT MAGNETS

For series and mass production of permanent magnets the testing of the material specifications on each magnet is impracticable. It has become common practice to test each magnet in comparison with a magnet of minimum guaranteed flux. Copies of these "minimum flux standard magnets" are available on request.

The minimum guaranteed flux magnet standards are laid down in the following way:

A standard magnet is made out of a material having either

min. B_r value (min. flux standard) or
min. H_c value (min. coercivity standard)

and has the following dimensions:

Ring magnets: minimum dimensions perpendicular to pressing direction and nominal dimensions parallel to pressing direction.

Block and disk shaped magnets: ditto
Segmentary magnets : ditto

Ring magnets with diametrical magnetisation:
minimum wall thickness,
minimum length or height.

Cylinders and disk shaped magnets with diametrical magnetisation:
minimum cross section, minimum diameter.

AQL SYSTEM

The quality of our permanent magnets is guaranteed in conformity with the military standard MIL-STD-105D. The AQL values are laid down as follows:

Guaranteed properties	AQL	Inspection level
Visual	0.65%	II
Dimensional	0.65%	II
Magnetic	0.65%	II

For the guaranteed properties reference is made to the article drawing concerned.

"TICONAL" AND RECO

INTRODUCTION

One of the most important groups of industrial permanent magnet materials are the anisotropic alloys known by the trade name "Ticonal". They consist mainly of Iron, Cobalt, Nickel and Aluminium; some have additions of Copper and Titanium.

The earliest group of permanent magnet materials of this composition and known as the isotropic reco alloys, are used today mainly in older designs.

"Ticonal" and reco are alloys which base their magnetic properties on the phenomenon of precipitation; they are made by modern foundry techniques and specialised heat treatment. The available range of these high efficiency metallic permanent magnet materials gives a wide coverage of performance and characteristics.
The correct choice from this range enables magnetic circuits to be designed having efficiencies hitherto unattainable. The reduction in the size of magnets and the associated circuits usually results in a significant reduction in costs.

"Ticonal" and reco permanent magnets are manufactured from pure materials, and every stage in their production is subject to close control to ensure that the high standards of performance of these magnets are maintained.
These materials are melted in an induction furnace, which is essential for the close control of the composition required in the production of "Ticonal" and reco.

There have been marked advantages in the manufacturing of these alloys since the first reco grades became available, and the few original grades have been expanded to today's standard range with grades having

- a coercivity up to 2000 oersted,
- a remanence up to 1400 gauss and
- maximum energy products over 9×10^6 gauss - oersted.

"Ticonal"
190
360
400
450
500

These earlier "Ticonal" grades were achieved by only applying a magnetic field during cooling. The elongated precipitates formed are more or less aligned in the direction of the applied field, resulting in anisotropic magnetic properties.

"Ticonal"
600

The later "Ticonal" grades were achieved by orienting the crystals in combination with a heat treatment in a magnetic field. The orientation is accomplished by casting the molten metal against steel plates, which chill the metal and cause rapid cooling and growth of long crystals in the desired preferred direction, resulting in a higher value of the energy product. This technique can only be followed for straight sections and solid magnets.

"Ticonal"
650 750 The newest "Ticonal" grades show a further improvement in the magnetic properties which were achieved by a more perfect directional crystal growth. This type of structure is achieved by special casting techniques.

"Ticonal"
900 The "Ticonal" grade combining a high coercivity with a high magnetic energy product - one of the most recent grades - opens new fields for permanent magnets because larger demagnetising influences can be withstood.

Due to the heat treatment the "Ticonal" and reco grades have a structure which is very stable, so that there are practically no irreversible changes of the magnetic properties in the course of time, if the magnet is used at a not too high temperature.

MECHANICAL PROPERTIES

The "Ticonal" and reco permanent magnets are very hard and brittle and cannot be machined other than by grinding.

The tolerances "as cast" can generally be kept within such narrow limits that only the surfaces through which the magnetic flux is passing need further processing. This applies particulary to magnets of "Ticonal" 750, which are manufactured with a highly automated casting technique. Holes may be cored during the original casting, or alternatively, mild-steel inserts may be cast in. These inserts can then be drilled and tapped to give accurately located fixing holes.

For the "Ticonal" grades with crystal orientation, holes have to be avoided and inserts cannot be used.

The "Ticonal" and reco permanent magnets can be fixed by means of non-magnetic screws (if the magnet can be manufactured with a hole or insert), adhesive or soft soldering. Hard soldering may lead to deterioration of the magnetic properties.

The "Ticonal" and reco permanent magnets should as far as possible, only be exposed to compressive loading.

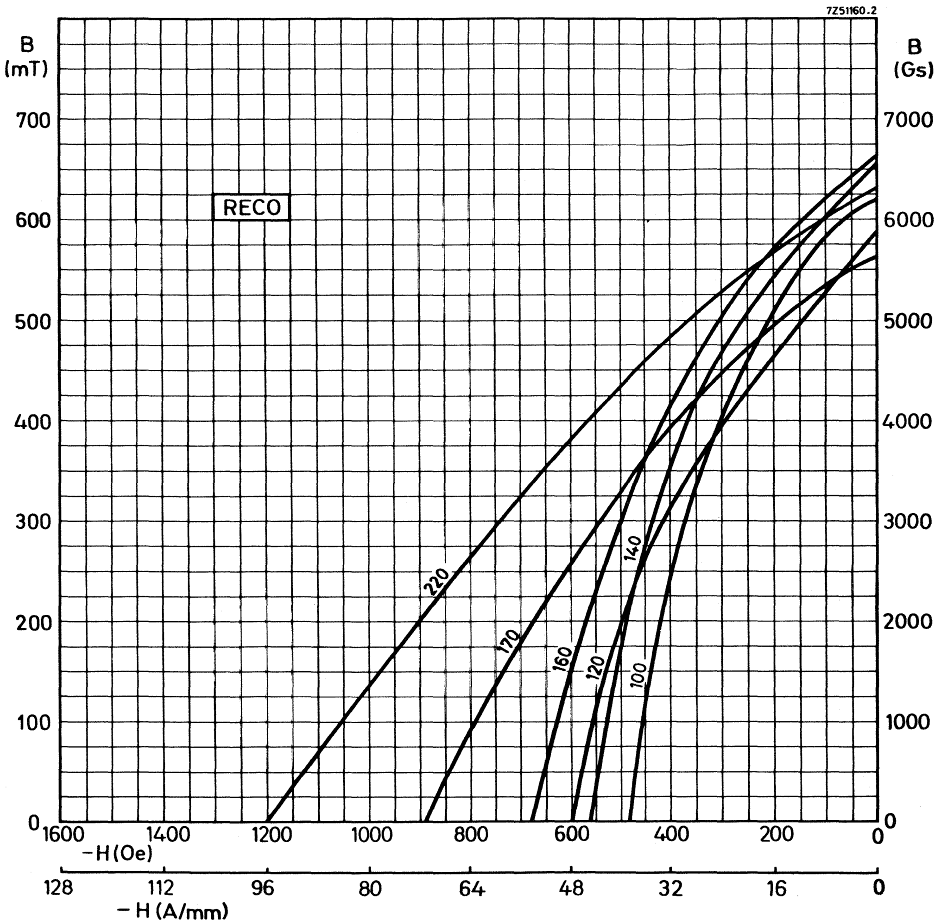
"Ticonal" and reco magnets have a great resistance against corrosion and attack by acids.

RECO

The reco permanent magnet materials are isotropic which means they have the same magnetic properties regardless of the direction of magnetisation.

The various grades show different energy products as a result of different compositions.

Demagnetisation curves at 20 °C



The types reco 170 and reco 220 are characterised by their higher values of coercivity.

Chemical composition in wt%

Material	Ni	Al	Co	Cu	Ti	Fe
Reco 100	24	14	-	-	-	bal.
Reco 120	26	13	4	3	1	bal.
Reco 140	24	10	5	7	0.8	bal.
Reco 160	18.5	10	13	7.5	1.9	bal.
Reco 170	24	9.5	10	6	5	bal.
Reco 220	15	7	26	5	7	bal.

Design data

See Survey of permanent magnet materials.

"TICONAL"

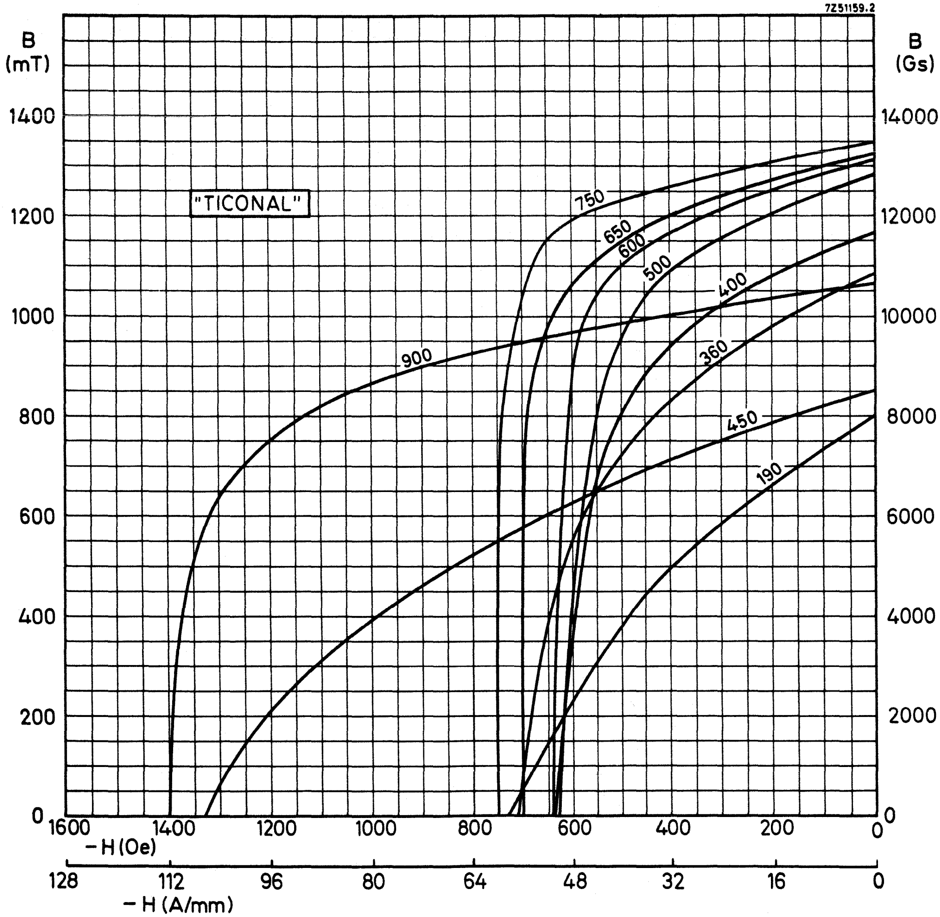
The "Ticonal" permanent magnet materials are anisotropic, which means that the optimum magnetic properties are achieved only if the magnets are magnetised in the preferred direction.

With the technique of heat treatment in a magnetic field an axial preferred direction is most easily obtained. For optimum magnetic properties therefore, the magnets to be produced should have a straight axis coincident with the preferred direction.

This means that the only practical cross sections are circular, rectangular or polygonal. The manufacture of magnets with a complicated shape or with more than two poles is generally laborious and expensive.

The methods of production of the grades "Ticonal" 190 - 360 - 400 - 450 and 500 are similar. For "Ticonal" 600 chilling by means of steel plates is introduced to achieve crystal orientation.
"Ticonal" 750 compared with these types has a high degree of crystal orientation due to the continuous casting technique. "Ticonal" 650 is somewhat lower in energy product and is manufactured for instance by multi-cavity hot moulding.

Demagnetisation curves at 20 °C



Grades of "Ticonal

"Ticonal"

190 360 400 500 are the first anisotropic grades cast by normal foundry practice, which provide less restrictions to shape and magnetisation than the production methods for the crystal oriented "Ticonal" grades.

The external energy products may be considered good, having values up to 5×10^6 gauss-oersteds.

"Ticonal"
600 is a crystal oriented permanent magnet material with excellent magnetic properties. It is advantageous when the magnets are relatively short in the preferred direction as otherwise the crystal orientation might be incomplete.

"Ticonal"
750 is a permanent magnet material with nearly ideal crystal orientation. The high energy product of this grade is the result of the continuous casting technique forming long circular rods and rectangular bars from which magnets of any length can be cut.
Diameter of circular cross-section preferably between 10 and 25 mm.
Sides of rectangular cross-section preferably between 10 and 20 mm.

Note: It should be remembered that the demagnetisation curve has a rather sharp knee at the value (BH)max. Therefore the working line of a statically used magnetic circuit - without an external demagnetising field - should intersect the BH-curve in the (BH)max point. Otherwise the optimum performance will not be achieved, and the use of "Ticonal" 750 would not lead to a higher performance or to a smaller system than obtainable with "Ticonal" 600 or even "Ticonal" 500.

"Ticonal"
650 is a crystal oriented anisotropic permanent magnet material with lower magnetic properties than "Ticonal" 750. The various manufacturing techniques, of which multi-cavity hot moulding is the most common, have the advantage that magnet shapes are less restricted than with "Ticonal" 750. Nevertheless holes should be avoided, because they degrade the magnetic values as a result of incomplete crystal orientation.

Note: The knee in the demagnetisation curve is less sharp than with the 750 grade.
For diameters smaller than 15 mm it is recommended that the diameter/length ratio be greater than unity.

"Ticonal"
450 has a very high coercivity due to the combination of high cobalt and titanium content and an isothermal heat treatment in a magnetic field.

"Ticonal"

900 (previously Ticonal XX) has the highest energy product of permanent magnet materials combined with a high coercivity.

It is economically attractive for tiny rectangular magnets. Owing to the great coercivity the optimum length of the magnet will usually be small.

The material is often used with success where previously platinum-cobalt was the only solution.

Chemical composition in wt%

Material	Ti	Co	Ni	Al	Cu	Fe
Ticonal 190	–	14	21	12	3	bal.
Ticonal 360	1.5	24	15	8.5	3	bal.
Ticonal 400	0.8	24	14	8.5	3	bal.
Ticonal 450	5	34	14.5	7.5	4.5	bal.
Ticonal 500, Ticonal 600, Ticonal 650, Ticonal 750	–	24	14	8.5	3	bal.
Ticonal 900	5	34	14.5	7.5	4.5	bal.

Design data

See "Survey of permanent magnet materials".

APPLICATIONS FOR RECO AND "TICONAL" PERMANENT MAGNETS

Reco magnets are used today mainly in older designs which would not benefit from a replacement by stronger magnetic materials.

"Ticonal" magnets having the highest energy product are used in all those applications requiring superior performance.

Also the need for small dimensions (watches),
high acoustic quality (loudspeakers),
sensitivity (microphones and telephones),
accuracy (meters),
ease of starting (magnetos),
high torque (motors),
cold stability

requires the use of "Ticonal" permanent magnets.

The crystal oriented "Ticonal" permanent magnets therefore find wide use in

- Pick-ups
- Microphones
- Loudspeakers
- Meters
- Magnetos
- Magnetrons
- Instrumentation such as
  - Watt-hour meters
  - Magnetic detectors
  - Ampere-, volt-, and lumen meters
  - Tachometers/Speedometers
  - Temperature control
  - Circuit breakers
- Timing devices in clocks and watches.

See also the general list of applications of permanent magnet materials.

FERROXDURE

INTRODUCTION

Another important group of industrial permanent magnet materials are the ferromagnetic oxides, one of which is a ceramic material known as ferroxdure.

Ferroxdure is a major development in permanent magnet materials and represents a complete departure from the conventional permanent magnet.

Ferroxdure, a ceramic material containing only non-critical raw materials, is distinguished by its high coercivity - up to more than 4000 oersteds - and such high electrical resistivity that it may be considered to be an insulator.

The high coercivity means that magnets with very short lengths can be used without excessive self-demagnetisation. The high electrical resistivity - some 10^{10} times that of iron - minimises eddy current losses and thus makes ferroxdure an ideal material for high frequency applications.
The relative low induction values require larger cross sections than for conventional permanent magnets.

These properties have led to new applications and new designs for existing applications.

Ferroxdure corresponds approximately to the chemical formula $(M)Fe_{12}O_{19}$ where M stands for Ba, Sr, Pb etc.

Ferroxdure being a true ceramic material is brittle, and close dimensional tolerances can only be achieved by grinding.

Ferroxdure has a low specific gravity which introduces a weight advantage over other permanent magnet materials.

Ferroxdure isotropic permanent magnets are manufactured from carefully selected raw materials which are milled to give an intimate mixture of powder. The powder - in some cases after pre-firing - is granulated and formed to the required shape in dies by high pressure pressing or extrusion. The fragile, compacted piece then undergoes an accurately controlled firing process in a special furnace from which it emerges with a ceramic structure and a black colour.

Ferroxdure anisotropic permanent magnets are produced by an extension of the above manufacturing process.
The isotropic ferroxdure material is remilled after firing to a very fine powder. The powder or slurry is then formed to the required shape by high pressure pressing in dies with simultaneous application of an intense homogenous magnetic field. The pieces are now magnetically orientated.

After this magnetic treatment the orientated compacted pieces are again fired in the furnace in which atmosphere and temperature are accurately controlled, and from which the pieces emerge with a ceramic structure and a black colour.

Compared with isotropic ferroxdure, the orientated or anisotropic ferroxdure permanent magnets possess a very much improved performance in the direction of the magnetic field used during pressing.

Note: During sintering the compacts shrink to about 85% of the dimensions of the pressed form.

Specific gravity is about 4.8.
The higher the coercivity, the lower the specific gravity.

Ferroxdure plastic-bonded, isotropic and anisotropic permanent magnets are manufactured starting from a mixture of isotropic ferroxdure powder with either thermoplastic or thermosetting materials as bonding agents. Familiar plastics-manufacturing techniques such as extrusion, injection moulding and pressing are used for the shaping of the magnets.

The plastic-bonded ferroxdure materials combine the magnetic properties of ferroxdure (but at a lower level) with the mechanical advantages of plastics. They can be used to make magnets which

- can be bent and even cut with a knife or scissors (P-grades)
- meet narrow size tolerances without being machined (SP- and D-grades)
- have complicated shapes (all grades)
- can be machined with conventional tools (all grades)
- can possess inserted metal parts, such as shafts, plates and bushes (SP- and D-grades)

Thus plastic-bonded ferroxdure magnets can be useful where permanent magnets have been unsuitable till now for either technical or economical reasons.

ISOTROPIC PLASTIC-BONDED FERROXDURE

Ferroxdure P30 (KPN - K - 292)

A soft, flexible and resilient permanent magnet material with 85 wt% ferroxdure powder (M)$Fe_{12}O_{19}$ and 15 wt% thermoplastic material, shaped by extrusion or injection moulding.

Ferroxdure P40 (KPN - K - 989)

A flexible permanent magnet material with 90 wt% ferroxdure powder (M)$Fe_{12}O_{19}$ and 10 wt% thermoplastic material, shaped by extrusion or injection moulding in bars, strips, rods and suchlike.

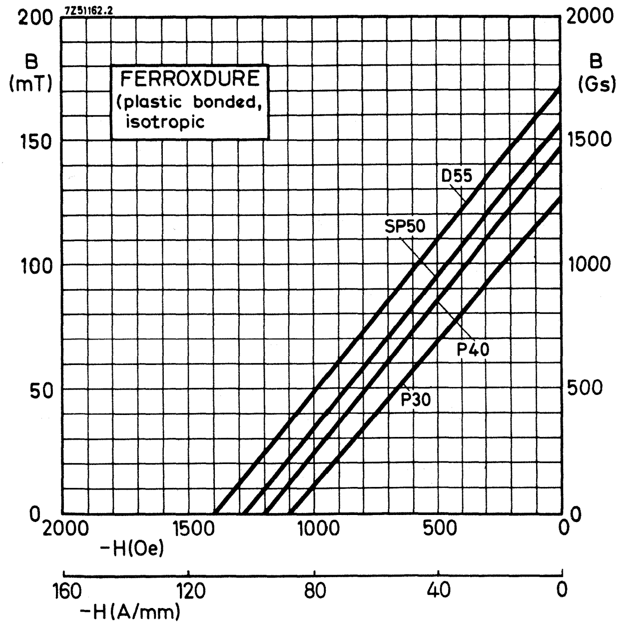
Ferroxdure SP50 (KPN - K - 7028)

A relatively rigid permanent magnet material with 93 wt% ferroxdure powder (M)$Fe_{12}O_{19}$ and 7 wt% thermoplastic material, shaped by injection moulding to the required shapes.

Ferroxdure D55

A hard and rigid permanent magnet material with 95 wt% ferroxdure powder (M)$Fe_{12}O_{19}$ and 5 wt% of thermosetting material, shaped by pressing.

Demagnetisation curves

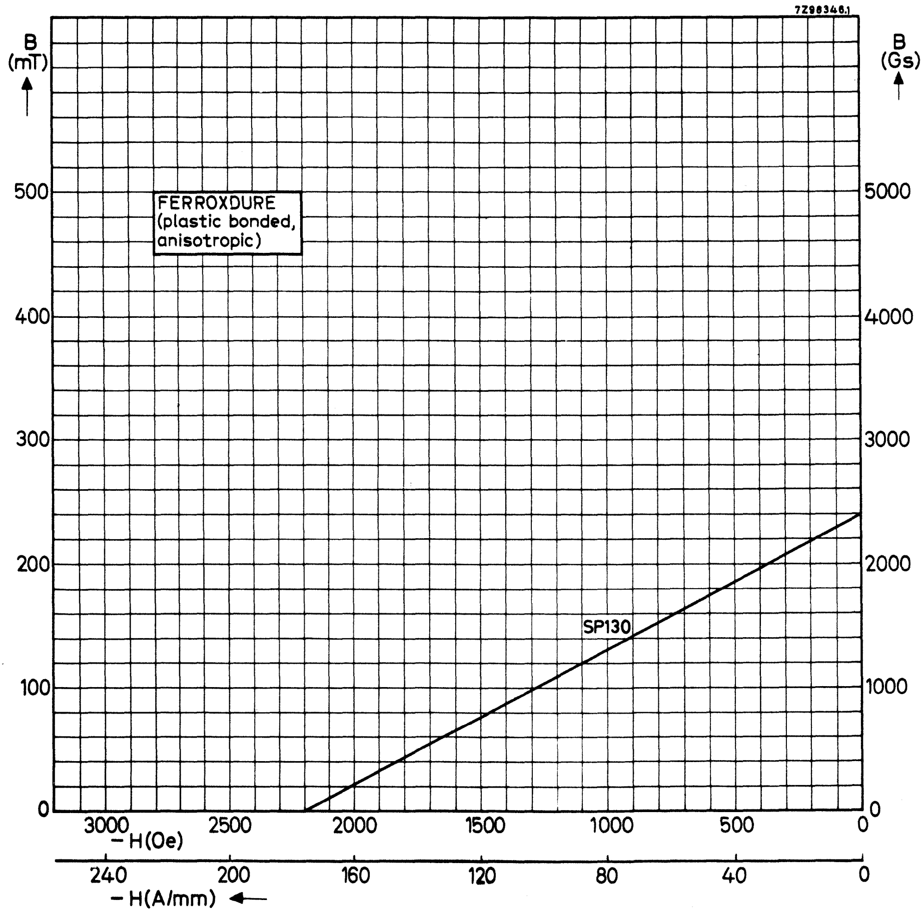


ANISOTROPIC PLASTIC-BONDED FERROXDURE

Ferroxdure SP130 (KPN - K - 7049)

A relatively rigid permanent magnet material with 89 wt% ferroxdure powder (M)$Fe_{12}O_{19}$ and 11 wt% thermoplastic material, shaped by injection moulding to the required shapes.

Demagnetisation curve at 20 °C

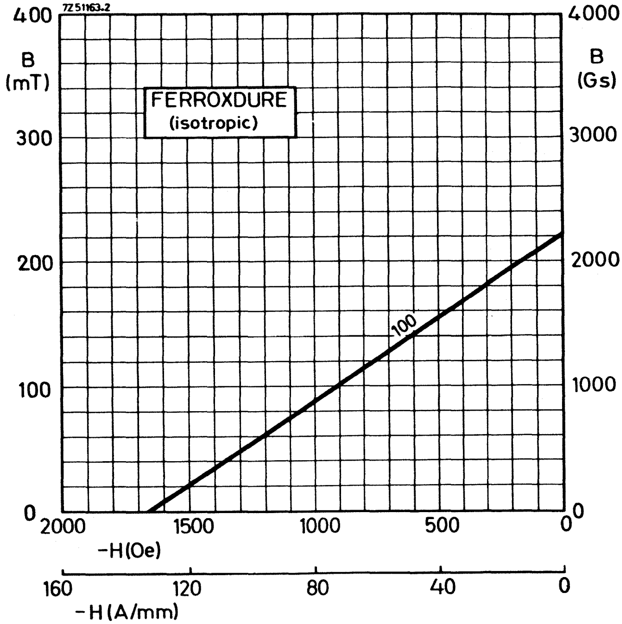


ISOTROPIC FERROXDURE

Ferroxdure 100 (KPN - K - 359)

The individual crystals have a random orientation and poles can therefore be induced wherever the application demands. The material is best suited either for applications where high magnetic values are not essential or else where the isotropic properties are required.

Demagnetisation curve at 20 °C



ANISOTROPIC FERROXDURE

Ferroxdure 280 and 330 (KBN - K - 435-252) and ferroxdure 260

The materials have high values of coercivity and are therefore ideal for applications where strong demagnetising influences are encountered.
Ferroxdure 260 and 280 are especially suitable for the manufacture of radially orientated segments for use in d.c. motors.

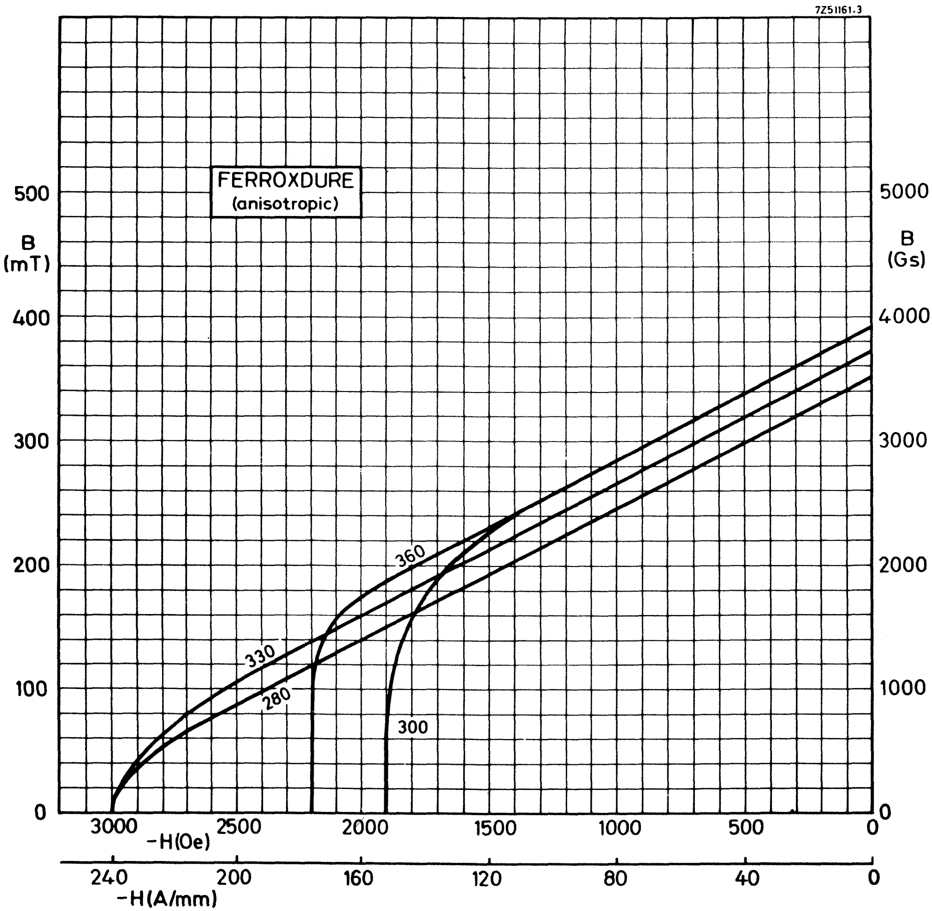
Ferroxdure 300 and 360 (KBN - K434 - V-254)

The materials have the same high values of flux density but ferroxdure 360 has a higher coercivity (and a greater distance of the point (BH)max from the knee in the demagnetisation curve), which permits designs to operate at the maximum energy product of the material.

Both materials are particularly suitable for applications demanding high values of energy product.

If dismounting requirements and/or highest flux requirements are imposed, it is recommended that the magnet be magnetised in its system.

Demagnetisation curves at 20 ^{o}C



DESIGN DATA

See "Survey of permanent magnet materials".

CHEMICAL COMPOSITION

The sintered ceramic ferroxdure permanent magnet materials contain 100 wt% $(M)Fe_{12}O_{19}$, where M stands for Ba, Sr, Pb etc.

CHEMICAL PROPERTIES

Ferroxdure (sintered)

Ferroxdure is chemically rather inert. Its chemical resistance is characterised as follows:

Ferroxdure is not attacked by: sodium chloride in a 30% solution;
a mixture of benzol-trichlorine ethylene in a 50% solution;
petrol;
nitric acid;
nitric acid in a 50% solution;
acetic acid;
cresol;
phenolic solutions;
sodium sulphate solution.

Ferroxdure is lightly attacked by: dilute sulphuric acid;
hydrochloric acid in a 50% solution.

Ferroxdure is subject to attack by: concentrated hydrochloric acid.

Plastic-bonded ferroxdure

Ferroxdure P- and SP-grades (being bonded with thermoplastic material) are attacked by a great number of organic solvents and by concentrated mineral acids, whereas ferroxdure D-grades (bonded with thermosetting material) are not attacked by organic solvents.
All grades are resistant to water, dilute acids, dilute caustics and ethylic alcohol.

TEMPERATURE COEFFICIENT AND THE EFFECT IN MAGNETIC PERFORMANCE

All ceramic ferroxdure grades have a temperature coefficient of remanence of -0.2 %/deg C and a temperature coefficient of coercivity of $+0.5$ %/deg C.
With the isotropic ferroxdure grades the effect of variations in temperature on the induction is practically reversible. In other words, after temporarily heating or cooling, the starting point on the BH curve is regained within some percent without remagnetisation being necessary. Only after heating above the Curie point does permanent demagnetisation occur.

With the anisotropic ferroxdure grades care should be taken that when cooling below room temperature occurs (which gives an increase of B and a decrease of H), the working point of the magnets does not pass the knee of the demagnetisation curve. Otherwise a lower working point will be obtained after reheating to the original temperature. This is explained as follows:

The published demagnetisation curves are true for ambient temperature conditions (20 °C). For any other temperature, the curves will be displaced. In fact, we can derive a family of curves for various operating temperatures. Such a family of curves is shown in Fig.1.

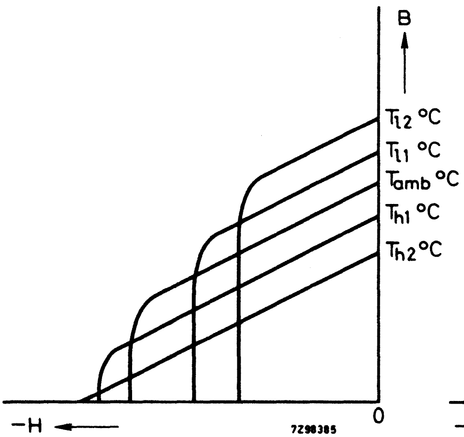


Fig.1

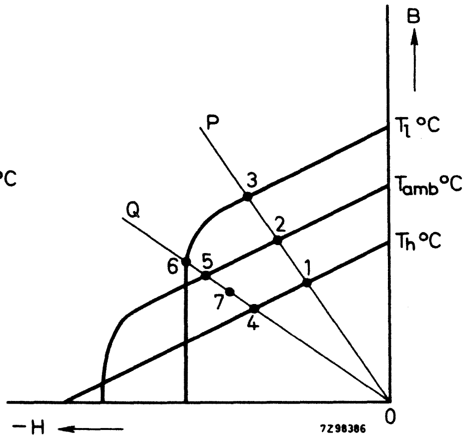


Fig.2

As shown in the section Theory of Permanent Magnets, for any magnetic circuit a "working line" can be calculated, and this dictates the point in its demagnetisation curve at which the magnet will operate.

Referring now to Fig.2 we see that if the working line is 0P, then the working point will be at 2 for ambient temperature, 1 for high temperature and 3 for low temperature. As all three points are on the initial straight line portions of the respective characteristics, the flux will revert to its original value 2 after cycling to $+T_h$°C or $-T_\ell$°C.

If, however, the working line is 0Q, then the working point will be at 5 for ambient temperature, but at low temperature the working point will be at 6. It will be noted that this point is below the "knee" of the demagnetisation curve for low temperature. On re-heating to room temperature, the magnet will be working on a recoil curve at point 7.

It is possible to formulate an expression, which will hold for all cases of low temperature cycling, to enable the value of flux after re-heating to ambient to be determined. This is:

$$B_{amb} = \frac{B_{\ell}}{1.038 - 0.0019\, T_{\ell}}$$

Where B_{amb} = Flux density at ambient after re-heating
B_{ℓ} = Flux density at T_{ℓ} °C
T_{ℓ} = Low temperature in °C

To use this expression, we have to know T_{ℓ} °C, usually determined by working conditions, and B_{ℓ}. To find B_{ℓ}, the demagnetisation curve for T_{ℓ} °C must be plotted and the working line drawn in.

It may be noted that if the working line cuts the ambient demagnetisation curve above the "knee", it will also cut any demagnetisation curves for temperatures higher than ambient above the knee, and any flux losses due to high temperature cycling will therefore be reversible. The limit for high temperature operation is set by the Curie point of the material, i.e. 450 °C.

In the sequence

ferroxdure 300
360
280
330
260

the materials have a decreasing sensitivity for temperature cycling, due to the higher coercivity values, resulting in a favourable shift of the knee.

GLUING OF FERROXDURE MAGNETS

For making very large magnets it is possible to glue individual ferroxdure parts to each other. Ferroxdure parts can also be glued to metal fittings. Here it should be noted that ceramic materials have a considerably smaller coefficient of thermal expansion than most metals.

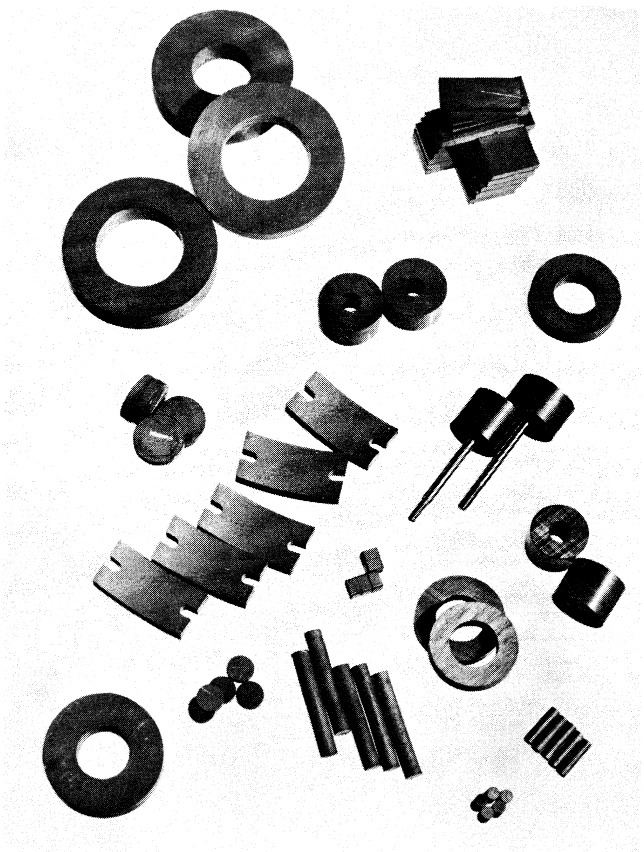
The coefficient of expansion is for

ferroxdure	8 to 15 x 10^{-6}/deg C
steel	11 to 20 x 10^{-6}/deg C
brass	18 x 10^{-6}/deg C

With a very rigid connection the inevitably occurring thermal stresses may easily lead to damaging of the ferroxdure crystal structure and may even cause fracture.
With some epoxy resins particularly, the formation of cracks has been observed.

Generally a less rigid, reasonably strong but elastic adhesive joint is adequate. Frequently it is reinforced by the magnetic clamping force. Experience with adhesives on a neoprene base has been good.

In the design stage it should be noted specially that ferroxdure permanent magnets can resist large pressure more readily than tension.



Magnets of sintered ferroxdure

APPLICATIONS

Some applications in which ferroxdure permanent magnets are commonly used today are

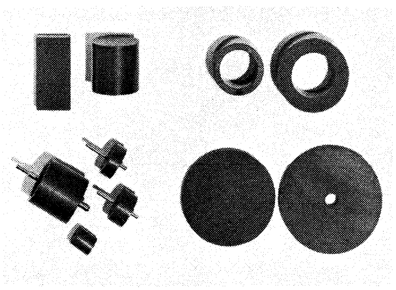
- Loudspeakers
- Bicycle dynamos
- Generators and magnetos
- Synchronous and d.c.-motors
- Separators, filters and chucks
- Couplings and sticking devices
- Deflection units and biasing magnets in soft magnetic circuits
- Travelling wave tubes
- Clocks and watches.

The radially orientated ferroxdure 260 and 280 will no doubt further stimulate the use of segments in fractional horse power motors

a) for the automotive industry such as starter motors, screen wiper motors, ventilator motors, screen washer motors and all those motor-equipped devices which make car driving more comfortable.

b) for the household appliances such as mixers, coffee mills, knives, small vacuum cleaners, polishers, electric tooth brushes, etc.

All the grades with nearly straight demagnetisation curves will expand the applications for permanent magnets in sandwich type devices and the more professional applications such as travelling wave tubes, watches, magnetos, alternators, generators, synchronous motors, filters and separators.



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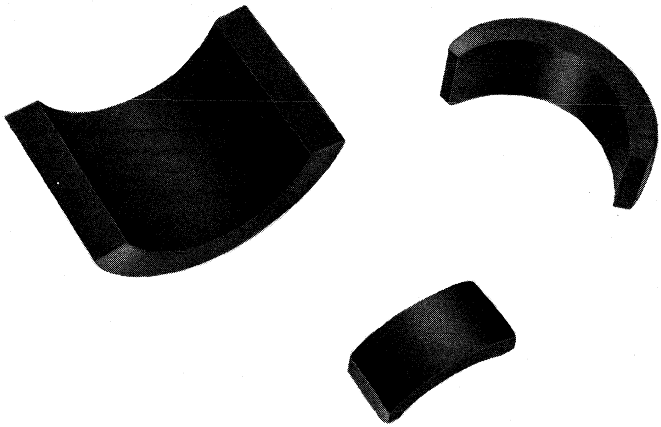
Magnets of plastic-bonded ferroxdure (grade D55)

ANISOTROPIC FERROXDURE SEGMENTS



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Besides the already well known ferroxdure magnets in the form of rings, disks, cylinders, rods and blocks, a new and rather important form has been introduced: the ferroxdure magnet in the form of a segment with either diametrical or radial orientation.

Material for diametrical magnetisation: ferroxdure 330
for radial magnetisation : ferroxdure 260 and 280

Segmentary permanent magnets are used in the magnetic circuit of e.g.

D.C. motors and
Fly-wheel magnetos.

These circuits are composed of a soft iron armature (with coils) and a soft iron ring with segmentary magnets.

The following data are of major consequence for both the circuit engineer and the manufacturer of the magnets.

A. The internal radius of the ring.
B. The external radius of the armature.
C. The min. acceptable air gap between rotor and magnet.
D. The angle of the segment: $< 120^{o}$ for diametrically orientated magnets;
120^{o}-140^{o} for radially orientated magnets.
E. The required flux from which the length of the segment is derived.
F. The max. demagnetising field strength at the min. temperature of the segment.

On enquiry, please give at least these data complete with tolerances. A check list is also available on request.

The radii of the segments should slightly exceed the radii of the ring and of the armature + min. acceptable air gap. In this way, the segments will touch the ring at their edges and so the risk of breakage during mounting is reduced. Also, the varying air gap occurring between segments and armature will favourably influence the silent running of the device, without adversely affecting the magnetic performance.

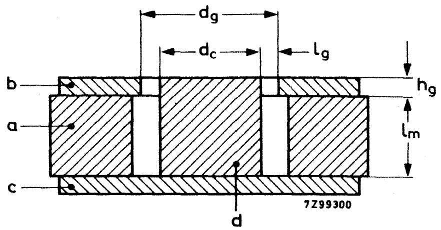
Apart from checking the width and length of the magnet, the segment height and thickness are checked by means of a test jig as approved by customer.
Normally, the magnetic flux is checked in a static system where a segment is enclosed by a soft iron ring and surrounds a soft iron cylinder which carries a longitudinal measuring coil. The diameter of the cylinder is slightly larger than the diameter of the armature. The larger diameter allows for some eccentricity. The flux measured with a production segment is compared with the flux measured with the standard segment. This procedure may be varied in accordance with customer's wishes.

Attention is drawn to the fact that the material for radially orientated segments has a high intrinsic coercivity which enables them to withstand high demagnetising influences.

Special requirements for the values of intrinsic coercivity should be stated.

FERROXDURE MAGNETS FOR LOUDSPEAKERS

A loudspeaker magnet system equipped with a ring magnet of ferroxdure is illustrated in Fig.1.



The system consists of:

(a) Axially magnetized ferroxdure ring
(b) Soft-iron ring serving as pole piece
(c) Soft-iron disc serving as second pole piece (bottom plate)
(d) Soft-iron cylindrical core
The soft iron is of the type free-cutting steel.

Loudspeaker magnet systems can be characterized by a combination of the numbers:

$$d_c/h_g/B_g - l_g$$

where: d_c = core diameter in mm
h_g = height of air gap in mm
B_g = flux density (induction) in the air gap in Gs
l_g = width of air gap = $(d_g - d_c)/2$, in mm

SYSTEM DESIGN

For the calculation of the flux density in a given loudspeaker magnet system, and for the determination of the dimensions of the ferroxdure ring to produce a given flux density in the air gap, we refer to

Philips Technical Review, Vol.24, 1962/63, No.4/5, p. 150-156.

The article gives a design method which introduces an internal magnetic resistance (internal magnetic reluctance) R_m lying in series with the magnetomotive force F_m, see equivalent magnetic circuit Fig. 2.
The design is also based on a straight demagnetization line extrapolated to the point H_c' on the $-H$-axis, see Fig. 3, so that $F_m = H_c' l_m$. The tangent of the angle α is $1.1\mu_0$, so that $H_c' = B_r/1.1\mu_0$.

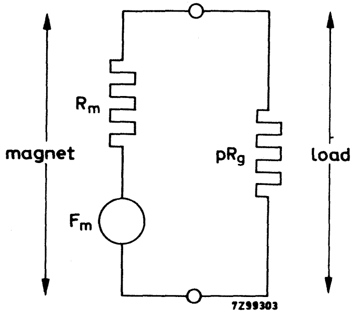


Fig. 2 Equivalent magnetic circuit

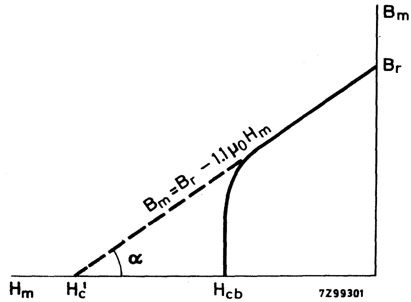


Fig. 3. Demagnetization curve of ferroxdure

The flux in the air gap, usually calculated from $\phi_g = B_g A_g$, is now calculated from an equation derived from Fig. 2:

$$\phi_g = \frac{F_m}{pR_g + R_m} = \frac{H_c' l_m}{pR_g + R_m}$$

R_m = internal magnetic resistance (reluctance) of magnet $= \dfrac{l_m}{1.1\,\mu_0 A_m}$

R_g = magnetic resistance (reluctance) of air gap $= \dfrac{l_g}{\mu_0 A_g}$

A_m = cross-sectional area of magnet

A_g = area of air gap $= \pi(d_c + l_g)h_g = \frac{1}{2}\pi(d_c + d_g)h_g$

μ_0 = permeability of vacuum $= 4\pi.10^{-7}$ H/m or 1 Gs/Oe

The term pR_g represents the load of the magnet including the leakage losses of the whole magnet system. The leakage factor p has been empirically found to be dependent on the system's dimensions:

$$p = 14.2\,\mu_0 l_m R_m + 1.86 = \frac{14.2}{1.1}\frac{l_m^2}{A_m} + 1.86.$$

The above equations have been used for a number of standardized rings of ferroxdure 300. As a result graphs I and II give the flux in the air gap as a function of its "relative" permeance (λ') with the magnets as parameter.

$$\lambda_g' = \frac{\lambda_g}{\mu_0} = \frac{1}{\mu_0 R_g} = \frac{A_g}{l_g}$$

(In the c.g.s. system of units λ_g is identical to λ_g').

Example: A magnet system 16/4 - 0.8, which means: core diameter d_c = 16 mm,
gap height h_g = 4 mm,
gap width l_g = 0.8 mm,

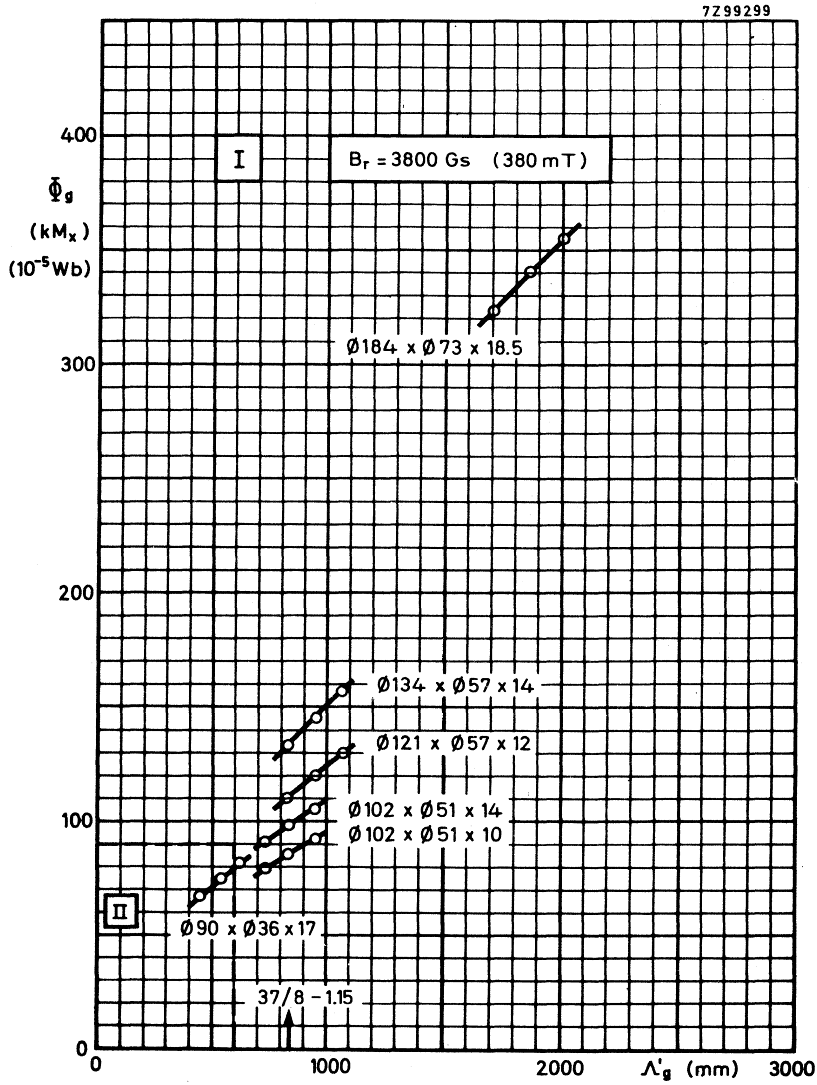
has a λ_g' of 265 mm.
A ring magnet of Fxd 300 having the following dimensions:
external diameter d_o = 45 mm,
internal diameter d_i = 22 mm,
height $h = l_m$ = 9 mm.

can produce in the above air gap a flux Φ_g of 17 700 Mx (177 μWb); this means a flux density B_g of 8 400 Gs (840 mT)

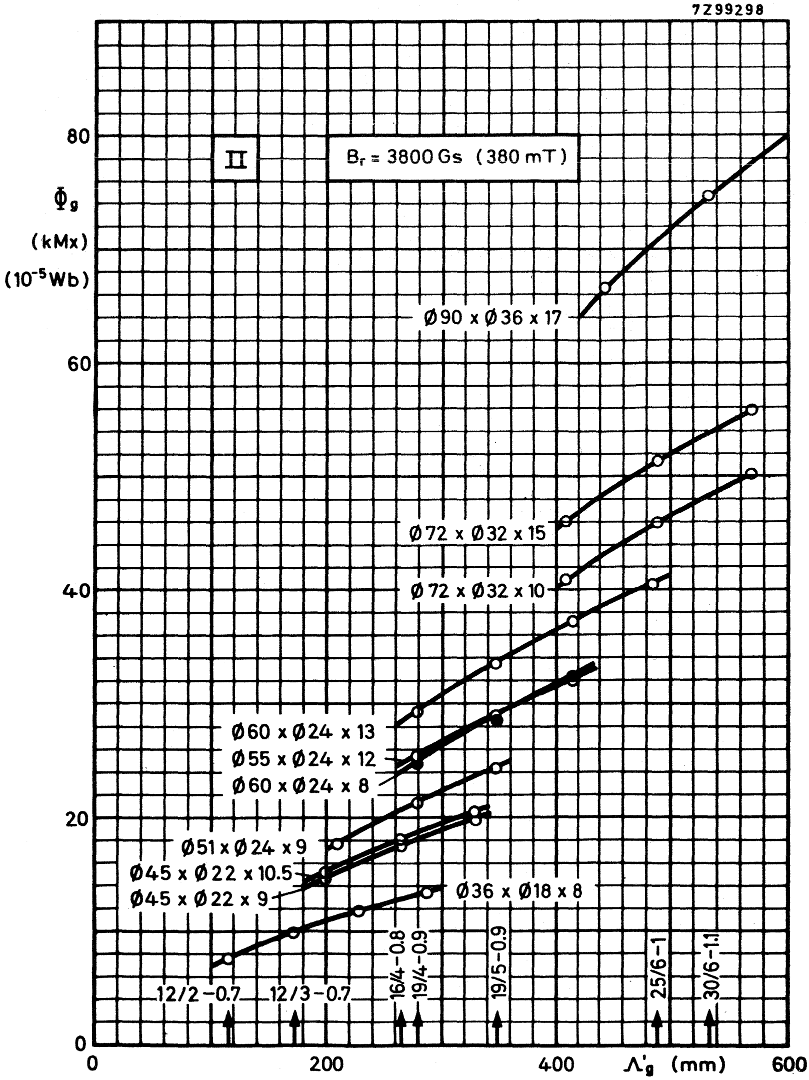
Another quantity which is often used in the design of loudspeaker magnet systems is the magnetic energy in the air gap:

$$W_g = \frac{\Phi_g^2}{2\,\mu_0 \lambda_g'} = \frac{B_g^2 A_g l_g}{2\,\mu_0} = \frac{B_g^2 V}{2\,\mu_0}$$

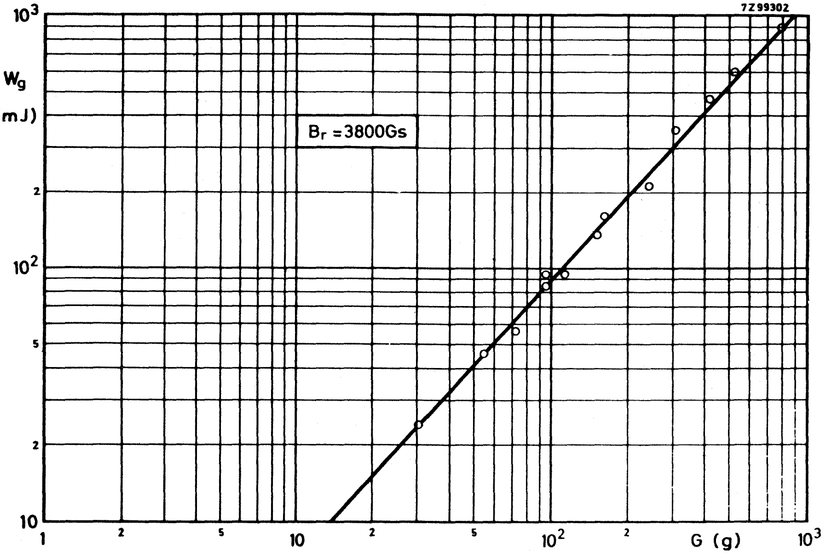
The unit of energy J (joule) is mostly to great and, therefore, W_g is expressed in mJ (mWs).
When 0_g is expressed in Mx and λ_g in cm, then W_g follows in ergs; 1 erg = 10^{-4} mJ.
Graph III shows the energy as a function of magnet weight.
Note: For all calculations it has been assumed that Fxd 300 has a remanence of 3 800 Gs and a density of 5 g/cm^3.



Graph I. Air gap flux as a function of the "relative" permeance of the air gap, calculated for a number of rings of Fxd 300.



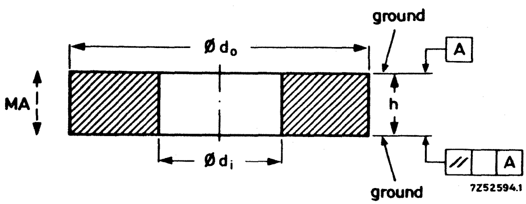
Graph II. Air gap flux as a function of the "relative" permeance of the air gap, calculated for a number of rings of Fxd 300.



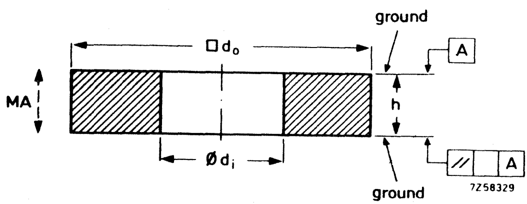
Graph III. Magnetic energy in a typical appropriate air gap as a function of the weight of the magnet

PREFERRED TYPES OF MAGNET

Material: Fxd 300
Direction of magnetic axis: axial
Supplied: unmagnetized



Ring magnet



Square magnet (rounded angles)

ring magnet						
d_o (mm)	d_i (mm)	h (mm)	//..A 1) (mm)	weight (g)	catalogue number	system 2)
36 ± 0.8	18 ± 0.5	8 ± 0.1	0.1	30	4322 020 60070	12/3/ 8330 - 0.7
45 ± 1	22 ± 0.6	9 ± 0.1	0.1	54	60110	16/4/ 8400 - 0.8
45 ± 1	22 ± 0.6	10.5 ± 0.1	0.1	63	60120	16/4/ 8580 - 0.8
51 ± 1.2	24 ± 0.6	9 ± 0.1	0.1	71	60150	19/5/ 7800 - 0.9
53 ± 1.2	24 ± 0.5	11 ± 0.1	-	96	4304 071 80260	19/5/ 8650 - 0.9
55 ± 1.2	24 ± 0.6	12 ± 0.1	0.1	115	4322 020 60170	19/5/ 9250 - 0.9
60 ± 1.5	24 ± 0.6	8 ± 0.1	-	95	60180	19/5/ 9250 - 0.9
60 ± 1.5	24 ± 0.6	13 ± 0.1	-	154	60200	19/5/10 750 - 0.9
72 ± 1.5	32 ± 0.7	10 ± 0.1	-	163	60620	25/6/ 9360 - 1
72 ± 1.5	32 ± 0.7	15 ± 0.1	-	245	60240	25/6/10 450 - 1
90 ± 1.8	36 ± 0.9	17 ± 0.15	-	454	60280	30/6/12 700 - 1.1
102 ± 3	51 ± 1.5	10 ± 0.15	-	306	60300	37/8/ 9050 - 1.15
102 ± 3	51 ± 1.5	14 ± 0.15	-	427	60310	37/8/10 300 - 1.15
121 ± 3.6	57 ± 1.7	12 ± 0.2	-	535	60320	44/8/10 550 - 1.2
134 ± 4	57 ± 1.7	14 ± 0.2	-	805	60330	44/8/12 750 - 1.2
184 ± 5.5	73 ± 2.2	18.5 ± 0.2	-	2070	60350	63/12/14 000-1.3
square magnet						
30.6±0.8	12.9±0.4	5 ± 0.1	-	20.7	4322 020 63010	10/3/ 8500 - 0.6

Appearance: The appearance of the magnets must be better than that of stereophotes X.8.1, X.8.7 and X.8.8.

1) Tolerance of parallelism.

2) System which for example can be realized with this ring.

FERROXDURE MAGNETS FOR HOLDING PURPOSES

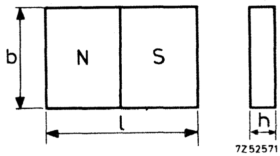
The magnetic force of attraction can be used to hold ferrous or non-ferrous objects in position.
In magnetic door latches this is done by means of a holding system consisting of an axially magnetized block with a hole and two soft iron plates.
For clamping purposes there are laterally magnetized discs, blocks and strips.
The guaranteed holding force of the magnets is often stated for a small air gap (instead of zero gap) because there may be a non-magnetic layer - lacquer, paper, dust, etc. - between magnet and soft-iron pole plate or base and because at near-zero air gap the holding force changes very much with distance. The holding force has been stated in newtons; 1 N = 100 gram-force.

RECOMMENDED TYPES

Blocks and Strips

Material: Fxd100

Magnetization: lateral on largest face

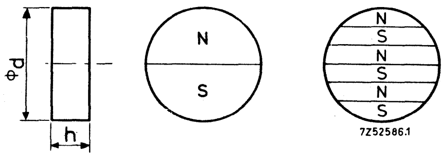


l (mm)	b (mm)	h (mm)	number of poles	air gap (mm)	holding force (N)	catalogue number
10 ± 0.5	5 ± 0.5	3 −0.1	2	—	—	4312 020 66470
20 ± 0.35	10 ± 0.25	4 ± 0.25	2	0.5	> 1.35	4312 020 66740
36 ± 1.2	15 ± 0.3	4.5 ± 0.4	4	2	> 0.95	4312 020 66720
50 ± 0.7	15 ± 0.4	6 ± 0.4	4	0	> 6.50	4312 020 66990

Discs

Material: Fxd100

Magnetization lateral

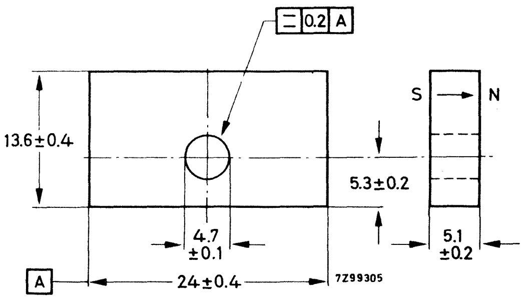


d (mm)	h (mm)	number of poles	air gap (mm)	holding force (N)	catalogue number
14 ± 0.5	4 ± 0.3	2	0.5	> 1	4312 020 65660
20 ± 0.5	3 ± 0.3	6	0	> 3.6	4312 020 65790
20 ± 0.35	5 ± 0.3	2	–	–	3122 104 90620
25 ± 0.5	5 ± 0.4	6	0	> 8.5	4312 020 65780
30 +0.2 −0.7	5 ± 0.3	6	0.5	> 6	4312 020 65740
30 +0.2 −0.7	3 ± 0.5	6	–	–	4312 020 65630

Block with hole (for door latches)

Magnetization: axial

Catalogue number: 4312 020 66530



FERROXDURE MAGNETS FOR SYNCHRONOUS COUPLINGS

Magnetic synchronous couplings are used for magnetically coupling two in-line axes which cannot be connected mechanically; they can transfer a torque through a wall without a hole in it. The main parts of the couplings, whether they are axial or radial couplings, are laterally magnetized rings of isotropic ferroxdure; see Figs 1 and 2. With Fxd100 it is possible to arrange many lateral poles on a surface without danger of irreversible demagnetization.

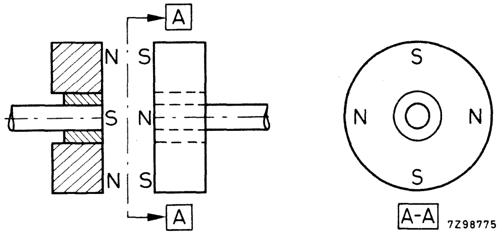


Fig.1. Principle of axial magnetic coupling. Lateral magnetization on the opposing faces.

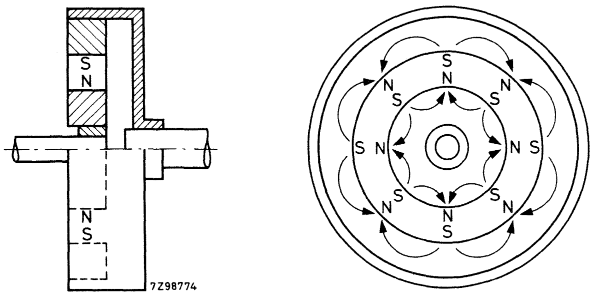


Fig.2. Principle of radial magnetic coupling. Lateral magnetization on the opposing cylindrical surfaces.

The operation of these magnetic couplings is based on the force of attraction between opposite poles, which means that the spindles can only rotate synchronously. However, there may occur an angular shift between the spindles, dependent on the load and the number of poles. The magnets can be coupled to each other only if the difference in spindle speeds is zero, i.e. in stand-still position or at equal speeds. Any material in the gap between the magnets should be non-conducting to avoid eddy currents, and, of course, be non-ferromagnetic.

Note: 1 Nm = 0.1 kgf.m approx.

Pairs of rings for radial couplings (preferred types)

Material: Fxd100

Magnetization: lateral, poles on appropriate cylindrical surface, neutral zones longitudinal (see Fig.2).

ext. diam. (mm)	int. diam. (mm)	height (mm)	number of poles	static torque (Nm)	catalogue number
48 ± 0.05 72 ± 0.05	30 ± 0.05 52 ± 0.05	12 ± 0.1 12 ± 0.1	14 14	0.2	4312 020 62750 4312 020 62790
55 ± 0.05 78 ± 1.5	15 ± 0.5 58 ± 0.05	13 ± 0.1 13 ± 0.1	12 12	0.4	4312 020 62430 4312 020 62420
86 ± 0.2 120 ± 0.5	32 ± 0.5 96 − 0.2	23 ± 0.1 23 ± 0.1	8 8	1	4312 020 62440 4312 020 62450

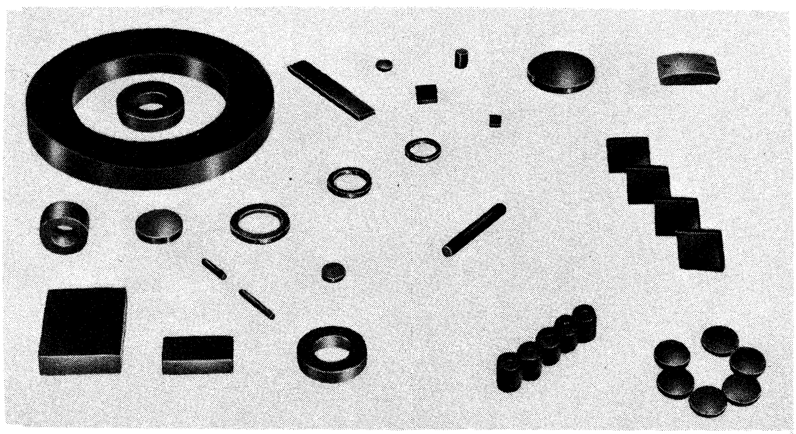
LIST OF PREFERRED PERMANENT MAGNETS

Permanent magnets may be

a. Ordered to your own design (within the limits of the materials and manufacturing techniques).

b. Selected from the list of preferred types. The list contains data on types for which the dies and moulding plates already exist. In a lot of cases stock is available for immediate dispatch to enable trials and small series production in short time.
   Choice of a preferred type eliminates the need for additional tools and development work at the factory.

Our technical assistance on the design and application of permanent magnets is always at your disposal - see the section "Design advisory service".



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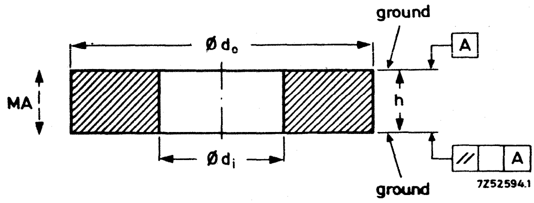
ANISOTROPIC FERROXDURE

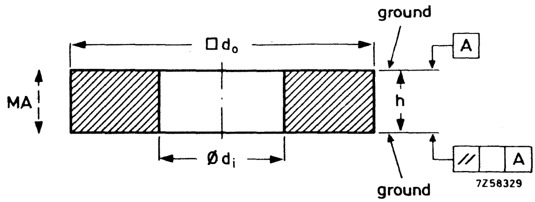
MAGNETS FOR LOUDSPEAKERS

Material: Fxd 300
Direction magnetic axis: axial
Supplied: unmagnetized

Ring magnet

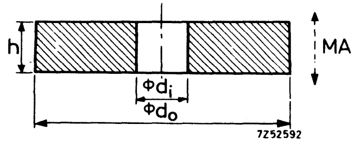


Square magnet (rounded angles)



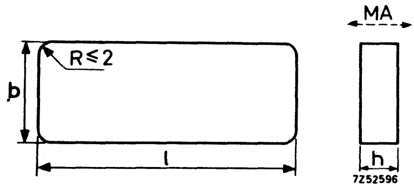
d_o (mm)	d_i (mm)	h (mm)	//..A 1) (mm)	weight (g)	catalogue number
ring magnet					
36 ± 0.8	18 ± 0.5	8 ± 0.1	0.1	30	4322 020 60070
45 ± 1	22 ± 0.6	9 ± 0.1	0.1	54	4322 020 60110
45 ± 1	22 ± 0.6	10.5 ± 0.1	0.1	63	4322 020 60120
51 ± 1.2	24 ± 0.6	9 ± 0.1	0.1	71	4322 020 60150
53 ± 1.2	24 ± 0.5	11 ± 0.1	-	96	4304 071 80260
55 ± 1.2	24 ± 0.6	12 ± 0.1	0.1	115	4322 020 60170
60 ± 1.5	24 ± 0.6	8 ± 0.1	-	95	4322 020 60180
60 ± 1.5	24 ± 0.6	13 ± 0.1	-	154	4322 020 60200
72 ± 1.5	32 ± 0.7	10 ± 0.1	-	163	4322 020 60620
72 ± 1.5	32 ± 0.7	15 ± 0.1	-	245	4322 020 60240
90 ± 1.8	36 ± 0.9	17 ± 0.15	-	454	4322 020 60280
102 ± 3	51 ± 1.5	10 ± 0.15	-	306	4322 020 60300
102 ± 3	51 ± 1.5	14 ± 0.15	-	427	4322 020 60310
121 ± 3.6	57 ± 1.7	12 ± 0.2	-	535	4322 020 60320
134 ± 4	57 ± 1.7	14 ± 0.2	-	805	4322 020 60330
184 ± 5.5	73 ± 2.2	18.5 ± 0.2	-	2070	4322 020 60350
square magnet					
30.6 ± 0.8	12.9 ± 0.4	5 ± 0.1	-	207	4322 020 63010

RINGS (other than for loudspeakers)
Material: see table
Direction of magnetic axis: axial
Supplied: unmagnetized



dimensions			material	catalogue number
ext. diam. d_o (mm)	int. diam. d_i (mm)	height h (mm)		
24 + 0.08	10.2 ± 0.3	4.05 ± 0.1	280	4322 020 60050
30 ± 0.6	12.7 ± 0.5	6.35 ± 0.05	280	4322 020 60060

BLOCKS
Material: see table
Direction of magnetic axis: ⊥ l x b
Supplied: magnetized if not specified otherwise

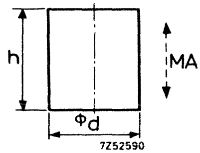


dimensions			material	catalogue number
l (mm)	b (mm)	h (mm)		
5 ± 0.2	5 ± 0.2	4 - 0.2	300	4322 020 62020
7 ± 0.3	7 ± 0.3	4.2 ± 0.05	280	4322 020 62000
15 ± 0.3	9 ± 0.5	5 ± 0.25	280	3122 104 92700
28 − 0.5	13 − 0.5	3.5 + 0.5	330	4322 020 62240 [1])
40 ± 1	25 ± 0.75	10 ± 0.1	330	4322 020 62180
50 ± 1.3	19 ± 0.5	4.9 − 0.25	280	4322 020 62100
50 ± 1.3	19 ± 0.5	4.9 − 0.25	330	4322 020 62230
50 ± 1.3	19 ± 0.5	6.1 ± 0.1	280	4322 020 62120
50 ± 1.3	19 ± 0.5	6.1 ± 0.1	330	4322 020 62210
131 ± 3	51 ± 1.5	17.5 ± 0.2	330	4322 020 62140 [1])

[1]) Supplied unmagnetized.

SOLID CYLINDERS

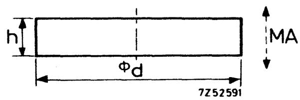
Material: see table
Direction of magnetic axis: axial
Supplied: magnetized



dimensions		material	catalogue number
d (mm)	h (mm)		
10 ± 0.5	10 ± 0.2	280	4322 020 61020
10 ± 0.5	12 ± 0.2	280	4322 020 61010
10 ± 0.5	15 ± 0.2	280	4322 020 61000

DISCS

Material: see table
Direction of magnetic axis: axial
Supplied: unmagnetized if not specified otherwise.

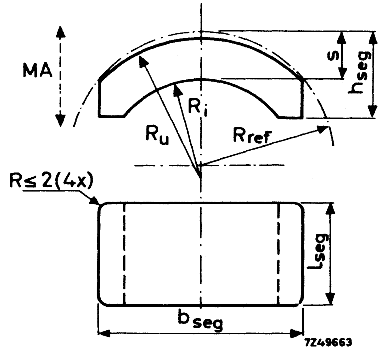


dimensions		material	catalogue number
d (mm)	h (mm)		
4.5 - 0.1	2.3 - 0.05	330	4322 020 62660
5.5 ± 0.05	1.8 ± 0.03	330	4322 020 62590
10 ± 0.5	4.6 ± 0.1	280	4322 020 62580
12 ± 0.3	6 ± 0.25	300	4322 020 62540[1])
28.8 − 0.3	12.5 ± 0.5	280	4322 020 62510
40.6 ± 1	9 ± 0.1	280	4322 020 62550
45 ± 1.1	9 ± 0.1	280	4322 020 62560
72.7 ± 1.8	15 ± 0.1	280	4322 020 62520

1) Supplied magnetized.

SEGMENTS FOR D.C. MOTORS

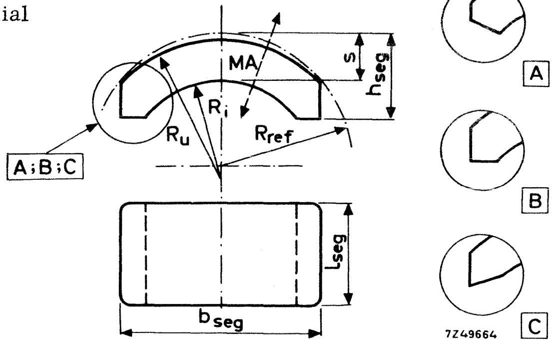
Material: Fxd 330
Direction of magnetic axis: diametrical
Supplied: unmagnetized



dimensions						catalogue number
R_i (mm)	R_u (mm)	s (mm)	h_{seg} (mm)	b_{seg} (mm)	l_{seg} (mm)	
≥ 5.77	≥ 8.25	≤ 2.43	5±0.15	12.8 ± 0.3	12 ± 0.3	4322 020 61660
≥ 8.135	≥ 12.025	≤ 3.66	8±0.6	18 ± 0.5	15 + 1	4322 020 61850
≥ 17	≥ 22	≤ 5	≤ 10.25	32.5	41.4 ± 1	4311 021 30920
≥ 20.3	≥ 29	8.7−0.3	16±0.3	42 ± 1	19.8 ± 0.5	4311 021 30490
≥ 20.3	≥ 29	≤ 8.7	16±0.6	42 ± 1	19.8 ± 0.5	4322 020 61500 [2]
≥ 20.3	≥ 29	8.7−0.3	16±0.3	42 ± 1	21 ± 0.5	4311 021 30850
≥ 20.3	≥ 29	≤ 8.8	16±0.3	42 ± 1	41 ± 1	4311 021 30660
≥ 20.3	≥ 29	≤ 8.8	16±0.3	49 ± 1	41 ± 1	4311 021 30960

[2]) Material: Fxd 280

Material: Fxd 280
Direction of magnetic axis: radial
Supplied: unmagnetized



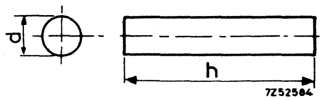
dimensions							catalogue number
R_i (mm)	R_u (mm)	s (mm)	h_{seg} (mm)	b_{seg} (mm)	l_{seg} (mm)	fig.	
≥ 17.1	≥ 23	≤ 5.9	12.88 −0.85	38 ±1	20 ±0.5	A	4322 020 61780
≥ 20.3	≥ 27.5	≤ 7.2	16 ±0.5	42 ±1	19.8 ±0.5	B	4322 020 61860
≥ 20.5	≥ 27.6	≤ 7	16.25 ±0.5	45 ±0.4	19 ±0.5	A	4322 020 61790
≥ 20.5	≥ 27.6	≤ 7	16.25 ±0.5	45 ±0.4	30 ±0.75	A	4322 020 61800
≥ 25.5	≥ 31.75	≤ 6.25	21.5 ±0.5	57 ±0.5	28 ±0.8	B	4322 020 61630
≥ 26.85	≥ 35.09	≤ 8.18	24 ±0.7	60 ±1.5	40 ±1	B	4322 020 61620
≥ 27.94	≥ 35.41	≤ 7.39	24.99 −0.93	60.71 ±2.5	25.4 ±1.27	B	4322 020 61600
≥ 28.5	≥ 35.55	≤ 7.35	21.4 −1.2	60.3 +3	39.4 ±1	C	4322 020 61580
≥ 28.5	≥ 35.55	≤ 7.35	21.4 −1.2	60.3 +3	49.4 ±1	C	4322 020 61820
≥ 28.58	≥ 35.13	≤ 6.55	25.5 +0.6	62.4 +0.4	26.7 ±0.75	A	4322 020 61510
≥ 29.03	≥ 36.02	≤ 7.49	21.79 ±0.38	≥ 62.7	27.13 $^{+0.76}_{-0.5}$	B	4322 020 61590
≥ 38.5	≥ 47	≤ 8.5	33 −1.4	85 +1	72 ±3	B	4304 099 08150

ISOTROPIC FERROXDURE

DISCS AND BARS

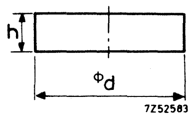
Material: Fxd 100

a) axially magnetized rods



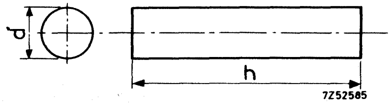
dimensions		catalogue number
d (mm)	h (mm)	
1 ± 0.1	5 - 0.5	4312 020 60230
3 ± 0.2	7.5 ± 0.25	4012 020 60130
5 ± 0.3	10 ± 0.5	4312 020 60020
5 ± 0.3	15 ± 0.5	4312 020 60090
5 ± 0.3	30 ± 0.8	3122 104 92630
6 ± 0.3	40 ± 0.6	4312 020 60170
5 ± 0.3	50 ± 1	4312 020 60150

b) axially magnetized discs



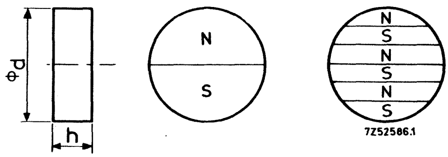
dimensions		catalogue number
d (mm)	h (mm)	
4 ± 0.2	3.5 ± 0.2	4312 020 65950
5 ± 0.3	4.2 - 0.5	4312 020 65840
5.5 ± 0.3	5 ± 0.3	4312 020 65930
8 ± 0.3	3 ± 0.3	4312 020 65910
8 ± 0.5	5 ± 0.3	4312 020 65960
10 ± 0.3	2.5 ± 0.3	4312 020 65970
10 ± 0.5	5 ± 0.5	4312 020 65940
12.5 ± 0.3	6 ± 0.3	4312 020 65920
14 ± 0.5	4 ± 0.5	4312 020 65900
14 ± 0.5	5 ± 0.3	4312 020 65890
14 ± 0.3	6 ± 0.5	4312 020 65980
20 ± 0.35	5 ± 0.3	4312 020 65880
25 ± 0.5	5 ± 0.4	4312 020 65870

c) diametrically magnetized rods



dimensions		catalogue number
d (mm)	h (mm)	
4 ± 0.1	5 ± 0.2	4312 020 60080
4 ± 0.1	10 ± 0.2	4312 020 60040
4 ± 0.1	20 ± 0.2	4312 020 60050
4 ± 0.1	30 ± 0.2	4312 020 60060
5 - 0.2	10 ± 0.2	3122 104 92850
6 - 0.05	12 ± 0.2	3122 104 94330

d) laterally magnetized discs
Application: holding purposes



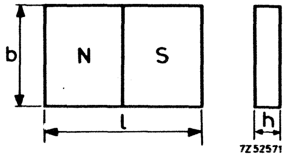
dimensions		number of poles	air gap (mm)	holding force (N)	catalogue number
d (mm)	h (mm)				
14 ± 0.5	4 ± 0.3	2	0.5	> 1	4312 020 65660
20 ± 0.5	3 ± 0.3	6	0	> 3.6	4312 020 65790
20 ± 0.35	5 ± 0.3	2	–	–	3122 104 90620
25 ± 0.5	5 ± 0.4	6	0	> 8.5	4312 020 65780
$30^{+0.2}_{-0.7}$	3 ± 0.5	6	–	–	4312 020 65630
$30^{+0.2}_{-0.7}$	5 ± 0.3	6	0.5	> 6	4312 020 65740

Blocks and strips

Material: Fdx100

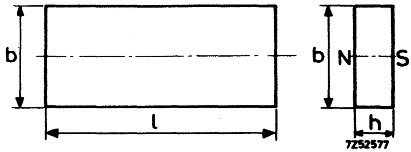
a) magnetization lateral on largest face

Application: holding purposes



l (mm)	b (mm)	h (mm)	number of poles	air gap (mm)	holding force (N)	catalogue number
10 ± 0.5	5 ± 0.5	3 − 0.1	2	–	–	4312 020 66470
20 ± 0.35	10 ± 0.25	4 ± 0.25	2	0.5	> 1.35	4312 020 66740
36 ± 1.2	15 ± 0.3	4.5 ± 0.4	4	2	> 0.95	4312 020 66720
50 ± 0.7	15 ± 0.4	6 ± 0.4	4	0	> 6.50	4312 020 66990

b) magnetization ⊥ l x b

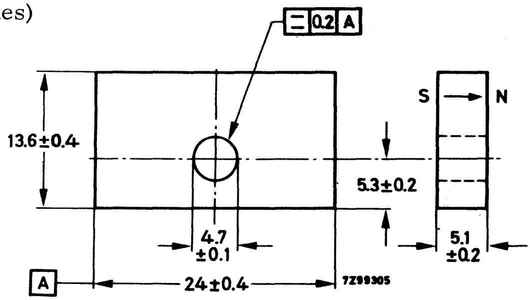


dimensions			catalogue number
l (mm)	b (mm)	h (mm)	
8 ± 0.2	8 ± 0.2	5 ± 0.2	4312 020 66880
10 ± 0.5	5 ± 0.5	3 ± 0.5	4312 020 66760
13.5 ± 0.5	7.5 ± 0.5	4.75 ± 0.25	4312 020 66940
15 ± 0.5	15 ± 0.5	5 ± 0.3	4312 020 66950*
24.5 ± 0.5	22 ± 0.55	5 ± 0.1	4312 020 66780
31.5 ± 0.8	15 ± 1.8	8 ± 0.2	4312 020 66690
50 ± 1.25	22 ± 0.55	5 ± 0.1	4312 020 66980
50 ± 1.25	43 ± 1.1	11 ± 0.28	4312 020 66960

* Supplied unmagnetized.

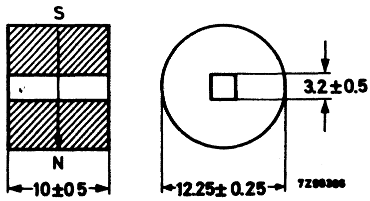
BLOCK WITH HOLE (for door latches)

Material: Fxd 100
Magnetization: axial
Catalogue number: 4312 020 66530



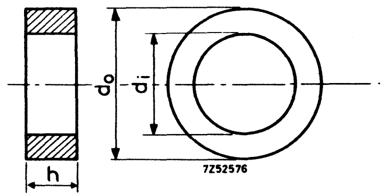
CYLINDER WITH SQUARE HOLE

Material: Fxd 100
Magnetization: diametrical
Catalogue number: 4312 020 62110



RINGS, PIERCED DISCS AND TUBES

Material: Fxd 100
a) axially magnetized



dimensions			catalogue number
ext. diam. d_o (mm)	int. diam. d_i (mm)	height h (mm)	
14 ± 0.5	1.5 ± 0.5	5 ± 0.5	4312 020 62180
14 ± 0.5	4 ± 0.25	4 ± 0.25	4312 020 62200
15 ± 0.05	6.25 ± 0.2	3 − 0.1	4312 020 62170
15.6 ± 0.3	6.25 ± 0.2	3 − 0.1	4312 020 62100
18 ± 0.45	5 ± 0.2	5 ± 0.2	4312 020 62140
29.9 − 0.05	10 ± 0.3	5 − 0.1	4312 020 62270[1])
37 ± 0.8	25 ± 0.5	3.5 ± 0.5	4312 020 62260
49.2 ± 0.7	29 ± 0.6	7 ± 0.35	4312 020 62930

1) 4 pole axially magnetized.

b) radially magnetized

dimensions			magnetization	catalogue number
ext. diam. d_o (mm)	int. diam. d_i (mm)	height h (mm)		
12 + 0.5	4.05 + 0.3	7 ± 0.5	S pole inside	4312 020 63150
12.2 ± 0.2	4.2 + 0.2	8 ± 0.3	S pole inside	4312 020 63180
18 ± 0.5	12 ± 0.5	3 ± 0.5	N pole inside	4312 020 62250
27 ± 0.7	20 ± 0.6	3.5 ± 0.5	N pole inside	4312 020 62340

c) laterally magnetized.

dimensions			magnetization	catalogue number
ext. diam. d_o (mm)	int. diam. d_i (mm)	height h (mm)		
14 ± 0.5	4 ± 0.25	4 ± 0.25	2 poles on one face	4312 020 62980
20 - 0.05	15 ± 0.15	16.5 - 0.5	2 poles on inner circumference	4312 020 62360
21 ± 0.3	10 ± 0.5	24 + 0.7	8 poles on o.circ.	4312 020 63160
24 - 0.05	10 ± 0.5	21.25 ± 0.45	8 poles on o.circ.	4312 020 62470
37 ± 0.8	25 ± 0.5	3.5 - 0.5	4 poles on one face	4312 020 62400

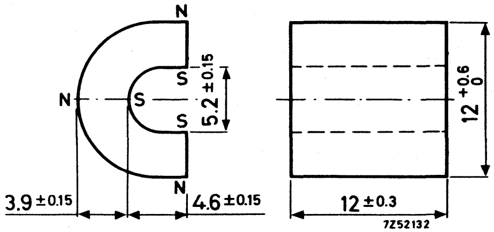
d) laterally magnetized rings for radial couplings

Magnetization: lateral, poles on opposing cylindrical surfaces, neutral zones longitudinal

ext. diam. d_o (mm)	int. diam. d_i (mm)	height h (mm)	number of poles	static torque (Nm)	catalogue number
48 ± 0.05	30 ± 0.05	12 ± 0.1	14	0.2	4312 020 62750
72 ± 0.05	52 ± 0.05	12 ± 0.1	14		4312 020 62790
55 ± 0.05	15 ± 0.5	13 ± 0.1	12	0.4	4312 020 62430
78 ± 1.5	58 ± 0.05	13 ± 0.1	12		4312 020 62420
86 ± 0.2	32 ± 0.5	23 ± 0.1	8	1	4312 020 62440
120 ± 0.5	96 - 0.2	23 ± 0.1	8		4312 020 62450

SPECIAL PART FOR COLOUR TELEVISION

Material: Fxd 100
Magnetization: radial, see drawing
Catalogue number: 4312 020 61550



Material: P40 (plastic bonded fxd)
Magnetization: radial, see drawing
Catalogue number: 3122 104 93771

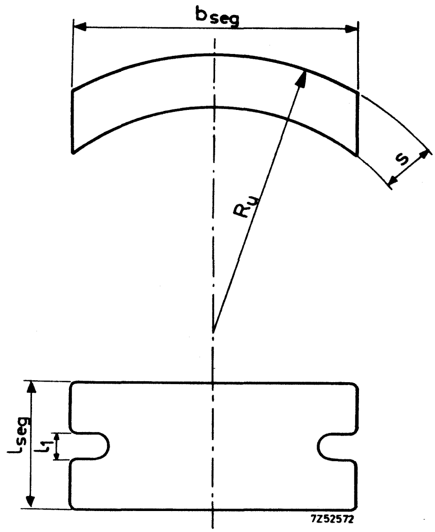
SEGMENT

Material: Fxd 100
Supplied: unmagnetized

Dimensions in mm

R_u	=	54.55	+ 2.5
b_{seg}	=	54	± 0.5
l_{seg}	=	27	± 0.3
l_i	=	5.2	+ 0.5
s	=	7.4	± 0.2

Catalogue number: 4312 020 61500



We are prepared to discuss the supply of other shapes of segment if the quantities envisaged are commercially significant.

ISOTROPIC PLASTIC-BONDED FERROXDURE

Material: see table
Direction of magnetic axis: see table
Supplied: magnetized, if not specified otherwise

article	dimensions (mm)	material	direction of magnetic axis	catalogue number
strips	(8±0.1) x (3±0.1)	P40	unmagnetized	4312 020 70090
	(8±0.25) x (3.5±0.15)	P40	2 poles lateral	4312 020 70160
	(8±0.1) x (4.3±0.1)	P40	2 poles lateral	4312 020 70110
	(9±0.3) x (3±0.1)	P40	2 poles lateral	4312 020 70020
	(9.5−0.2) x (3.5−0.2)	P40	unmagnetized	4312 020 70170
	(9.8−0.2) x (3.1±0.1)	P40	unmagnetized	4312 020 70080
	(20±0.3) x (2.5±0.2)	P40	2 x 4 poles lateral	4312 020 70040
	(25±0.4) x (1±0.2)	P40	7 poles lateral	4312 020 70100
	(35±0.5) x (1.6±0.2)	P40	6 poles lateral	4312 020 70050
	(35±0.5) x (1.6±0.2)	P40	2 x 6 poles lateral	4312 020 70060
	(48±0.4) x (1±0.2)	P40	12 poles lateral	4312 020 70070
bar	(Ø5±0.2) x (40−1)	P40	axial	3122 104 90360
tube	(Ø12+0.6) x (Ø3.35±0.15) x (4±0.4)	P30	diametrical	4312 020 72020
blocks with Ø3 central fixing hole	(13+0.6) x (13+0.6) x (3±0.15)	P30	diametrical	4312 020 76990
	(10.6−0.6) x (10.6−0.6) x (3±0.15)	P30	diametrical	3122 104 93540
	(9.3−0.6) x (9.3−0.6) x (3±0.15)	P30	diametrical	3122 104 93590
	(8.4−0.6) x (8.4−0.6) x (3±0.15)	P30	diametrical	3122 104 94120

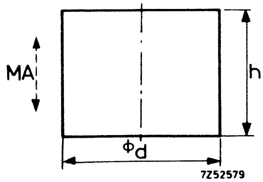
Material: see table
Direction of magnetic axis: see table
Supplied: magnetized, if not specified otherwise

article	dimensions (mm)	material	direction of magnetic axis	catalogue number
rings (for d.c. motors)	(Ø28±0.1) x (Ø20.5±0.1) x (16.5±0.25)	D55	2 p.on int.circ.	4312 020 72040
	(Ø29−0.15) x (22.75+0.08) x (19±0.15)	SP130	2 p.on int.circ.	4222 017 20200
rings with lobes (for TV deflection units)	(Ø50−0.5) x (Ø35.6+10.2) x (1.7+0.2); 2 lobes	SP10	2 p.on int.circ.	3122 104 93980
	(Ø49±0.25) x (Ø36.7+0.5) x (1.7+0.2); 2 lobes	SP10	2 p.on int.circ.	4312 020 72090
	(Ø50−0.5) x (Ø35.6+0.2) x (1.7+0.2); 3 lobes	SP10	2 p.on int.circ.	4312 020 72080
	(Ø50−0.5) x (Ø35.6+0.2) x (1.7+0.2); 1 lobe	SP10	2 p.on int.circ.	4312 020 72110
	(Ø90±0.3) x (65.1+0.4) x (2±0.15); 3 lobes	SP10	2 p.on int.circ.	3122 104 94210
special part for colour TV	See Isotropic Ferroxdure			

ANISOTROPIC 'TICONAL'

SOLID CYLINDERS

Material: see tables
Direction of magnetic axis: axial
Supplied: unmagnetized

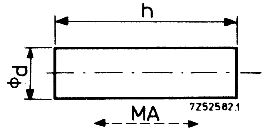


dimensions		material	catalogue number
d (mm)	h (mm)		
9.1 +0.2 −0.1	5 − 0.05	"Ticonal"750	4322 059 75000
9.1 +0.2 −0.1	10 − 0.05	"Ticonal"750	4322 059 75010
12.7 +0.2 −0.1	10 − 0.05	"Ticonal"750	4322 059 75060
15.1 − 0.03	11.5 ± 0.05	"Ticonal"750	4322 059 75040
15.8 − 0.1	13 + 0.1	"Ticonal"750	4322 059 75030
18 − 0.4	12 − 0.1	"Ticonal"600	4322 059 60000
19.3 ± 0.4	13.25 ± 0.05	"Ticonal"600	4322 059 61020
19.4 ± 0.3	9.4 ± 0.1	"Ticonal"750	4322 059 75080
19.4 ± 0.3	15.4 ± 0.1	"Ticonal"750	4322 059 75070
21 ± 0.5	16 ± 0.05	"Ticonal"600	4322 059 60010
21 ± 0.5	22.5 ± 0.05	"Ticonal"600	4322 059 60040
21.3 ± 0.4	15.9 ± 0.05	"Ticonal"600	4322 059 61030
24. ± 0.5	16 ± 0.05	"Ticonal"600	4322 059 60020
25 ± 0.5	20 ± 0.05	"Ticonal"600	4322 059 60140
25.3 ± 0.4	16.45 ± 0.05	"Ticonal"600	4322 059 61050
27.5 ± 0.5	18.5 ± 0.05	"Ticonal"600	4322 059 60030
28.3 ± 0.4	19.45 ± 0.05	"Ticonal"600	4322 059 61060
34.7 ± 0.4	19 ± 0.05	"Ticonal"600	4322 059 61080

Cylinders in "Ticonal"750 can be supplied in any length. Standard diameters are between 12 and 22 mm; others available if required.

RODS

Material: "Ticonal"500
Direction of magnetic axis: axial
Condition: see table

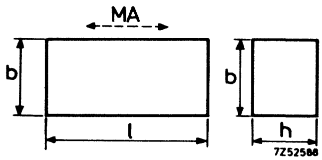


dimensions		condition	catalogue number
d (mm)	h (mm)		
4 ± 0.2	6 ± 0.2	unmagnetized	4322 059 50070 1)
5 ± 0.3	19.5 ± 1	magnetized	4322 059 50090
5.5 − 1	25 ± 0.5	magnetized	4322 059 50100 1)
8.1 − 1	65 ± 0.5	magnetized	4322 059 50110 1)

1) Rods in these and other small diameters can be supplied in any length between 6 and 100 mm.

BLOCKS

Material: see table
Direction of magnetic axis: ⊥ b x h
Condition: see table

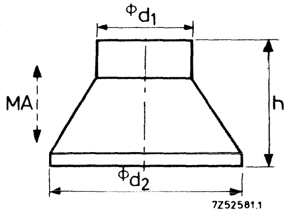


dimensions			material	condition	catalogue number
b (mm)	h (mm)	l (mm)			
2 ±0.05	2.6±0.05	2.25-0.03	"Ticonal"900	unmagnetized	4322 059 90000
4 ±0.05	4 ±0.05	5 ±0.02	"Ticonal"900	unmagnetized	4322 059 90010
8 −0.1	5 −0.4	14 −1	"Ticonal"400	magnetized	4322 059 40020
27 −1	20 ±0.5	17 ±0.05	"Ticonal"450	unmagnetized	4322 059 45130
21.5±0.5	14.5±0.5	22 +0.2	"Ticonal"500	magnetized	4322 059 50120
23 ±0.6	21 ±0.6	25 ±0.05	"Ticonal"600	unmagnetized	4322 059 60110
100 ±1	12 ±0.05	29.1 ±0.05	"Ticonal"500	unmagnetized	4322 059 50130 1)
22 ±0.3	9.1−0.4	40 ±0.1	"Ticonal"500	magnetized	4322 059 50140
32 ±0.5	20.8±0.5	40 ±0.05	"Ticonal"500	unmagnetized	4322 059 50150 2)
10 ±0.5	5 ±0.5	50 ±1	"Ticonal"500	magnetized	4322 059 50160
10.5±0.2	17 ±0.3	40 ±0.05	"Ticonal"500	unmagnetized	4322 059 50170

1) With two mounting holes.
2) With one mounting hole.

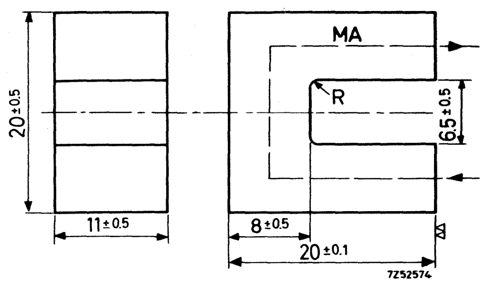
SPECIAL SHAPES

Material: see table
Direction of magnetic axis: axial
Supplied: unmagnetized



dimensions			material	catalogue number
d_1 (mm)	d_2 (mm)	h (mm)		
13.2 - 0.5	18 - 0.5	13 ± 0.05	"Ticonal"600	4322 059 60050
18 - 0.3	26 ± 0.5	17.5 ± 0.05	"Ticonal"600	4322 059 60060

Catalogue number: 4322 059 40030
Material: "Ticonal"400
Supplied: unmagnetized



DESIGN ADVISORY SERVICE

Our Application engineers offer technical assistance on the use and design of permanent magnets and complete permanent-magnet systems. Guidance is also offered on ancillary problems such as installation, handling and magnetisation. If you require more specific information than is provided here please send your enquiry to us.

Orders for new magnet shapes can be dealt with more easily if they are accompanied by the following information:

(1) The purpose for which the magnet is to be used.

(2) A sketch or drawing of the magnet showing its shape and dimensions, with tolerances.

(3) The direction of the magnetic axis or the arrangement of poles.

(4) Surfaces to be ground and shape tolerances.

(5) The material of the magnet.

(6) Whether the magnet is to be supplied magnetised or unmagnetised.

(7) The quantity required and the desired rate of delivery.

THEORY OF PERMANENT MAGNETS

The magnetic quantities are expressed in the S.I. system of units (V, A, s, m) or in the cgs system of units (Gs, Oe).

When a magnetic material is subjected to a magnetising field, the extent of the resulting magnetisation of the material will depend on the nature and immediate history of the material, and on the direction and magnitude of the magnetising field.
This dependence will be explained by describing the magnetic changes in a permanent magnet material accompanying a complete cycle of magnetisation and demagnetisation (hysteresis loop), and also the changes accompanying smaller variations in field strength (recoil line).

HYSTERESIS LOOP

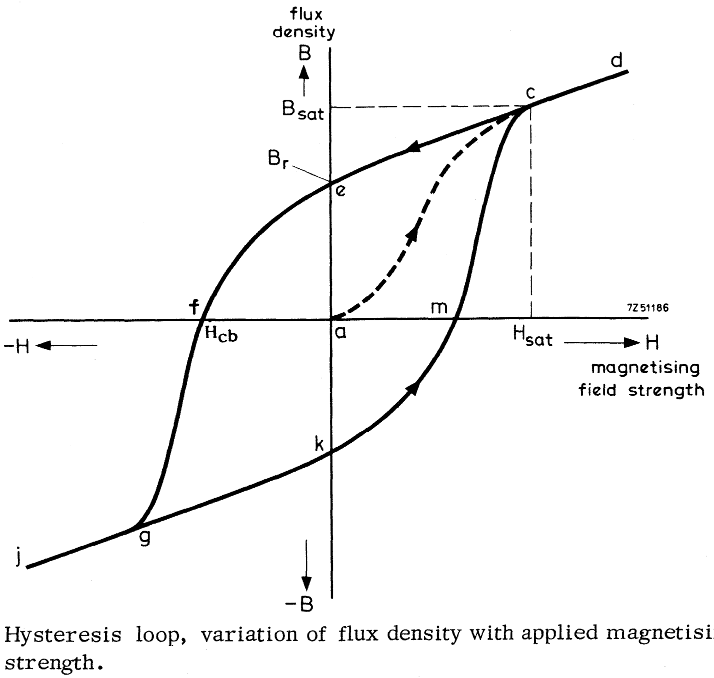


Fig.1. Hysteresis loop, variation of flux density with applied magnetising field strength.

If the material is assumed to be completely unmagnetised before the magnetising field is applied, then the state of the material can be represented by the point a on the graph of Fig.1, which shows the variation of flux density B in the material with magnetising field strength H applied to the material. If H is increased steadily from zero, the corresponding values of B will increase in accordance with the "initial magnetising curve" ac. If H is increased further, B will increase linearly, the slope of the straight line being constant*. Point c corresponds to the magnetic saturation of the material. The material no longer contributes to the increase in flux density, the further increase in B being attributable entirely to the relationship between the magnetising field strength and the flux density of the free space coincident with the magnetic material ($\frac{dB}{dH} = \mu_0$). The point c is defined as the point of magnetic saturation.

Saturation field strength H_{sat}

This is the minimum field strength that has to be expended to reach the region of magnetic saturation. Here the magnetisation curve and the hysteresis loop coincide.

Saturation induction (saturation flux density) B_{sat}

This is the value of the induction corresponding to H_{sat}.

If after saturation has been reached, H is steadily reduced, the value of B corresponds to the curve ce. When H is zero, flux density corresponding to ae resides in the material. This residual flux density is termed the remanence B_r of the material.

Remanence B_r

This is the induction of a magnet remaining in a closed magnetic circuit if after attaining of the saturation state the field strength returns to zero (point of intersection of the hysteresis loop with the B-axis).
The units for the induction are gauss (Gs) or tesla (T).
1 Gs = 10^{-4} T (= 10^{-4} Wb/m^2)

*) In fact the slope is not yet constant at point c, but up to a certain value of H a further increase in H will cause only reversible changes in the polarisation which do not influence the course of the demagnetisation curve.

When the magnetising field is reversed and is increased steadily in the opposite direction, the flux density decreases along the "demagnetisation curve" ef. At f, the flux density is zero, and the corresponding field strength is defined as the coercivity H_{cb} of the material.

Demagnetisation curve

The operating range of permanent magnets lies in the second quadrant of the hysteresis loop. This part is the demagnetisation curve.

Coercivity H_{cb}

This is the magnetic field strength at which the induction of a magnet previously magnetised up to saturation becomes zero (point of intersection of the demagnetisation curve with the H-axis).
The units for field strength are A/m or oersted.

1 Oe = 79.6 A/m (or nearly 0.08 A/mm)
1 A/mm = 12.6 Oe

Permanent magnets have a high coercivity, i.e. broad hysteresis loops, while magnetically soft materials have a low coercivity. The difference may be greater than three powers of ten.

As the magnetising field strength is increased beyond H_{cb}, the flux density increases in the opposite direction along the curve fg. The point g is reached which corresponds to magnetic saturation in the opposite sense to that occurring at c.

Any further increase in the magnetising field gives rise to increases in B along the straight line gj. The same phenomena occur as with the part cd.

If, after saturation in the negative direction is reached, the magnetising field is reduced to zero, the flux density follows the curve gk. If the magnetising field is again reversed, the flux density follows the curve kmc, so that the loop cefgkmc is completed.

INTRINSIC HYSTERESIS LOOP

The flux density plotted in Fig. 1 is the algebraic sum of the intrinsic flux density B_i of the material and the flux density B_0 of the space that the material occupies.

$$B = B_i + B_0 = B_i + \mu_0 H$$

B_i is also called magnetic polarisation (symbol J).
If B_i is plotted against H, the effect of B_0 is excluded, and the resultant loop is shown in Fig. 2 together with the B/H loop.

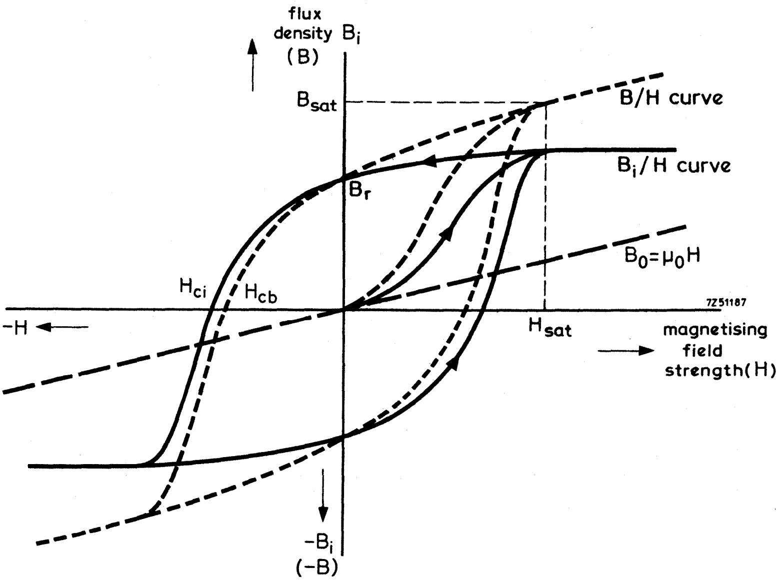


Fig. 2. Comparison of variations of flux density and intrinsic flux density with applied magnetising field strength.

At saturation, the intrinsic hysteresis curve is horizontal. For zero applied field, the intrinsic flux density equals the flux density, and equals the remanence of the material. The magnetising field required to remove the intrinsic flux density is shown by the intersection of the curve and the horizontal axis. This field strenght - the intrinsic coercivity H_{ci} - is greater than the coercivity H_{cb}. The difference between H_{cb} and H_{ci}, however, depends on the shape of loop: if the loop cuts the horizontal axis at a small angle, the difference will be significant; if the loop cuts at an angle approaching 90^o, it will be negligible.

Intrinsic coercivity H_{ci}

This is the magnetic field strength at which the intrinsic flux density (magnetic polarisation) of a magnet previously magnetised up to saturation becomes zero (point of intersection of the intrinsic demagnetisation curve with the H-axis).

DEMAGNETISATION CURVE

Complete hysteresis loops are important when considering soft magnetic materials, but with hard or permanent magnetic materials, it is the second (or fourth) quadrant that is of importance to the designer. The second quadrant shows the response of the magnetised material to demagnetising fields, and is therefore called the demagnetisation curve.

A typical normal demagnetisation curve for permanent magnetic materials is shown in Fig.3. Also shown in Fig.3 is a curve indicating the variation of the product BH with B. The product BH indicates the energy available in the material for a given value of B. It can be seen that a maximum value of BH-product exists, and this is designated $(BH)_{max}$. This maximum corresponds to a flux density of B_d and demagnetising field strength H_d and these, in general, represent the ideal operating point for the most efficient use of the material under static conditions.

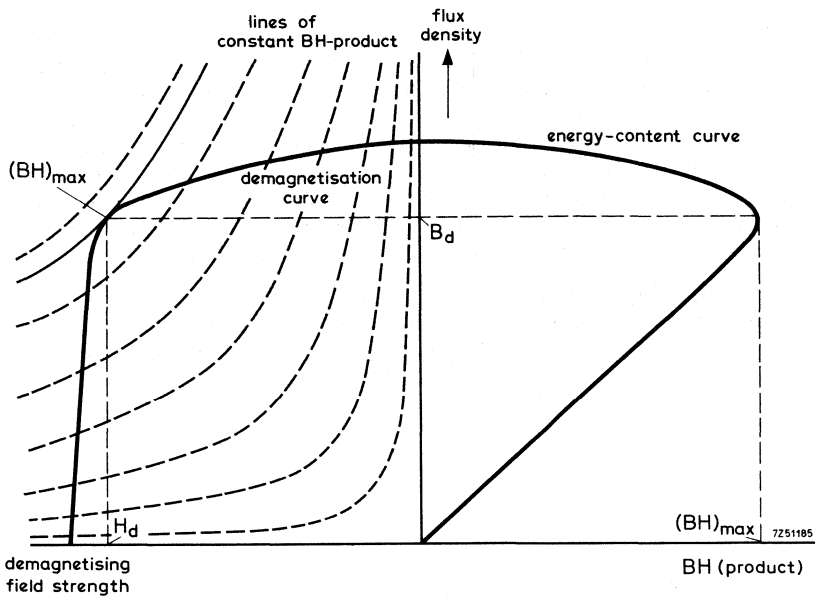


Fig.3. Demagnetisation curve with contours of constant BH-product, and energy-product curve.

Maximum energy product $(BH)_{max}$

This is the maximum product of the flux density and corresponding field strength of a permanent magnet attained on the demagnetisation curve. The maximum energy in the field external to the magnetic material, per unit volume of the permanent magnet, is:

$$\frac{(BH)_{max}}{2}$$

The units of $(BH)_{max}$ are megagauss.oersted or kilojoule/m^3

$1 \text{ MGs.Oe} = 8 \text{ kJ/m}^3 = 8 \text{ mJ/cm}^3$

$(1 \text{ T.A/m} = 1 \text{ Wb.A/m}^3 = 1 \text{ Vs.A/m}^3 = 1 \text{ Ws/m}^3 = 1 \text{ J/m}^3)$

The values of B and H at $(BH)_{max}$ are designated B_d and H_d.

Energy content can also be represented by contour lines of constant BH-product superimposed on the demagnetisation curves. The maximum energy product of a material occurs at the point on the demagnetisation curve where a contour line would just touch it.

RECOIL LINE

The demagnetisation curve of a permanent magnetic material is a smooth curve indicating the decrease in flux density with a steadily increasing demagnetising field. If a constant demagnetising field is applied to the magnetic material, the corresponding value of flux density can be obtained from the curve. However, under practical conditions, the demagnetising field will probably not be constant. Small variations can be caused by small local magnetic fields, and large variations can occur in motors and generators (which are subject to varying armature reaction and can even have their armatures removed completely). It is therefore necessary to study the effects of such variations in the demagnetising field.

If a demagnetising field of strength H_1 is applied to magnetic material which has been saturated, the flux density will fall from its remanence value B_r to some value B_1 which corresponds to the point A_1 on the demagnetisation curve of Fig.4.

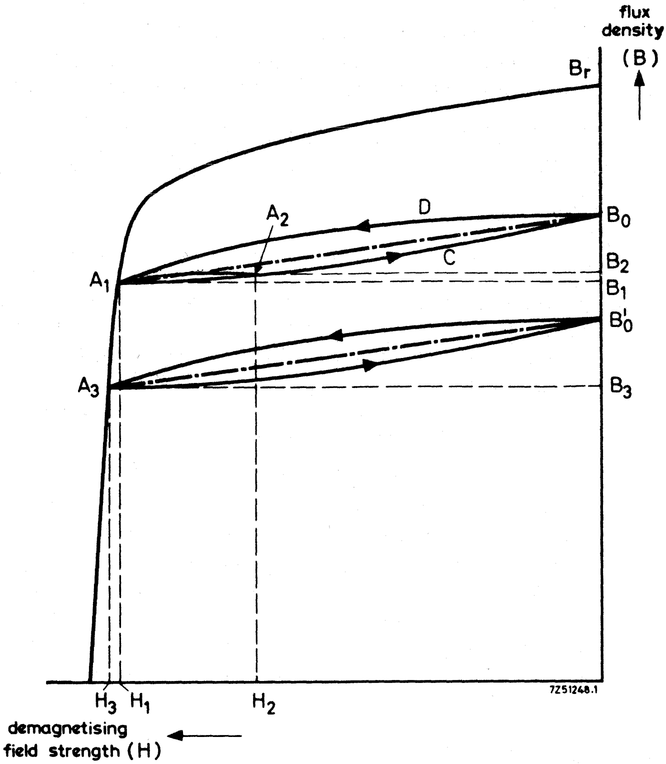


Fig.4. Recoil lines.

If H is reduced to zero, the flux density does not follow the demagnetisation curve back to the starting point, but follows a path A_1CB_0 which leaves the demagnetisation curve abruptly. If H_1 is now restored, the flux density follows the path B_0DA_1 which ends in A_1, but which deviates from the path A_1CB_0.

The loop $A_1CB_0DA_1$ so formed constitutes a minor hysteresis loop of the material. If the demagnetising field strength H_1 is only reduced to some value H_2 instead of being removed completely, and is then restored, another minor hysteresis loop is formed ($A_1A_2A_1$). For permanent magnetic materials, these minor hysteresis loops are very slender, and can be considered to form the straight line joining A_1 and B_0. This line is called a recoil line. The slope of the recoil line is the recoil permeability. It can be shown that the slope of a recoil line is approximately equal to the slope of the demagnetisation curve at its intersection with the vertical axis.

Recoil line

Actually a very narrow hysteresis loop which touches the demagnetisation curve, if at all; it is traversed during a limited variation of the demagnetising field strength in a permanent magnet.

Recoil permeability or reversible permeability μ_{rec} or μ_{rev}

The relative permeability corresponding to the slope of a recoil line.

If the demagnetising field strength H_1 is increased to some value H_3, the operating point will move along the demagnetisation curve to the point A_3 corresponding to a flux density of B_3. Reduction of the demagnetising field strength to H_1 does not restore the working point to A_1, but moves it along another recoil line $A_3B'_0$, parallel to A_1B_0. Any reduction in H_3 will only cause the working point to move along the recoil line: the point A_1 can only be regained by resaturating the material and then applying the demagnetising field strength H_1.

The effects of increases in the demagnetising field when the operating conditions of the material correspond to a point on the demagnetisation curve are thus irreversible (except by the expedient of resaturation), so in designs where a high degree of magnetic stability is required it is usual to operate on a recoil line. A demagnetising field greater than that likely to be encountered in normal use is applied, and this is then reduced to the normal working value (stabilisation). Fluctuations in the demagnetising field will then only cause fluctuations of the working point along a recoil line.

TEMPERATURE COEFFICIENT

To characterise the behaviour of the material of a permanent magnet with changes in temperature the temperature coefficient of the remanence or of the coercivity is indicated in percent per degree centigrade.

$$\alpha_{Br} = \frac{1}{B_r} \frac{dB_r}{dT} \times 100 \ \%/\text{deg C}$$

$$\alpha_{Hc} = \frac{1}{H_{cb}} \frac{dH_{cb}}{dT} \times 100 \ \%/\text{deg C}$$

CURIE TEMPERATURE AND TRANSITION TEMPERATURE

At the Curie temperature the material becomes practically non-magnetic, and the magnetism can only be restored by renewed magnetisation below this temperature. At the transition temperature the crystal structure is changed (e.g. formation of mixed crystals); this also leads to irreversible changes of the magnetisation, but these cannot be nullified by renewed magnetisation. The limit for the practical application of permanent magnet materials is in specific cases set by whichever of these temperatures is the lower.

MAGNETIC CIRCUIT DESIGN

Dimensions of magnet

The principal object of magnet circuit design is to provide efficiently a specified magnetic field in a given load (or air gap). The design of the circuit is governed by the required field strength, the dimensions of the air gap, the flux leakage from the surfaces of the magnet and the reluctance of the assembly.

In the simple circuit of Fig.5, A_g and L_g are the area (assumed equal to that of the pole pieces) and length of the air gap respectively, and A_m and L_m are the area and length of the magnet necessary to produce the required gap field strength H_g.

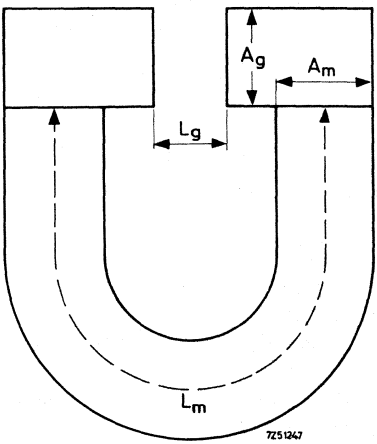


Fig.5. Simple magnetic circuit

If, initially, flux leakage is neglected, then all lines of flux in the magnet cross the air gap. Therefore the total flux in the gap equals the total flux in the magnet. By definition, total flux equals the product of flux density and area. Thus:

$$B_m A_m = B_g A_g,$$

where B_g and B_m are the flux densities in the gap and magnet respectively. Since for an air gap, $B_g = \mu_0 H_g$, this equation can be written:

$$B_m A_m = \mu_0 H_g A_g. \qquad (1)$$

NOTE: When B is expressed in gausses and H in oersteds, then μ_0 = 1 gauss/oersted; when B is expressed in T and H in A/m, then $\mu_0 = 4\pi.10^{-7}$ H/m.

Magnetic flux is produced by magnetomotive force, and the ratio between m.m.f. and flux is termed the reluctance of the magnetic circuit. (This relationship is the magnetic analogy of Ohm's Law, flux, m.m.f., and reluctance corresponding to current, voltage, and resistance respectively.) In the cgs system the m.m.f.

between two points is the work done in moving unit magnetic pole between two points. It is thus the product of the force exerted on unit pole (that is, the field strength) and the distance through which the pole moves. In Fig.5 the m.m.f. across the air gap is thus the product of the field strength H_g in the gap and the length L_g of the gap. The m.m.f. across the magnet is similarly the product of the field strength H_m in the magnet and the length L_m of the magnet. If there is no leakage from the surfaces of the magnet these values of m.m.f. are equal. Therefore:

$$H_m L_m = H_g L_g \text{.(irrespective of sign)} \qquad (2)$$

Equations (1) and (2) give the formulas for the design of magnetic circuits, assuming no flux losses. In practice, a loss or leakage factor must be introduced into each equation. The practical design equations thus become:

$$B_m A_m = p\mu_0 H_g A_g \qquad (3)$$

and

$$H_m L_m = q H_g L_g \qquad (4)$$

where p and q represent the loss or leakage factors.

Leakage factor

The total flux in a magnetic circuit is made up of the useful flux and the leakage flux. A certain amount of leakage can never be avoided completely, and it becomes appreciable particularly in a magnetic circuit with small magnetic conductance of the air gap. In the calculation of a magnet the leakage is taken into account by the leakage factor

$$p = \frac{\text{total flux required}}{\text{useful flux in air gap}}$$

The leakage factor p in the equation (3) varies widely from one application to another. It will be a minimum when the magnet is as close to the working gap as possible. The precise calculation of p is extremely difficult, and an acceptable estimate must be based on experience. As a guide, some typical leakage factors are given in the following table.

Application	approximate leakage factor
Loudspeaker with "Ticonal" centrepole magnet, 19 mm ($^3/4$ in) speech coil, up to 6.5 kGs	2
Loudspeaker with "Ticonal" centrepole magnet, 25 mm (1 in) speech coil, up to 8 kGs	2
Loudspeaker with ferroxdure ring magnet, 36 mm ($1\frac{1}{2}$ in) speech coil, up to 15 kGs	2

Application	approximate leakage factor
Loudspeaker with ferroxdure ring magnet, 61 mm ($2\frac{1}{2}$ in) speech coil, up to 14.5 kGs	2
Loudspeaker with "Ticonal" ring magnet, 25 mm (1 in) speech coil, up to 12 kGs	3
Loudspeaker with "Ticonal" ring magnet, 25 mm (1 in) speech coil, up to 16 kGs	6
Loudspeaker with "Ticonal" ring magnet, 36 mm ($1\frac{1}{2}$ in) speech coil, up to 16 kGs	5
Moving coil meter using "Ticonal" rectangular magnets	3
Moving coil meter using "Ticonal" semicircular magnets	2
Moving coil meter using "Ticonal" internal core magnet	1.5
Motors using ferroxdure segments	1.1
Motors and generators, "Ticonal" two-pole type	2
Motors and generators, "Ticonal" four-pole type	4

The loss factor q in equation (4) is attributable to unwanted reluctances in series with the useful air gap. Compensation for these can generally be effected by assuming a value of q of about 1.1 (thus increasing the required length of magnet by 10%).

Equations (3) and (4) can be rewritten as:

$$A_m = \frac{p\mu_0 H_g}{B_m} \cdot A_g, \qquad (5)$$

and

$$L_m = \frac{q H_g}{H_m} \cdot L_g. \qquad (6)$$

The product of equations (5) and (6) gives:

$$V_m = \frac{pq\mu_0 H_g^2 V_g}{B_m H_m}, \qquad (7)$$

where V_m and V_g are the volumes of the magnet and gap respectively.

For a given magnetic material, and therefore a given demagnetisation curve, an infinite number of combinations of length and area of magnet can be chosen for a given volume by varying the point $B_m H_m$ on the demagnetisation curve. However, the minimum volume of material will be given when the product $B_m H_m$ is a maximum. Thus the most efficient use of the material is obtained by operating at the design points B_d and H_d, corresponding to maximum BH-product, $(BH)_{max}$.

Thus for greatest efficiency, the design equations become;

$$A_m = \frac{p\mu_0 H_g}{B_d} \cdot A_g, \tag{8}$$

and

$$L_m = \frac{q H_g}{H_d} \cdot L_g, \tag{9}$$

Equations (3) and (4) can be combined to give:

$$B_m = \left\{ \frac{p}{q} \cdot \frac{A_g}{A_m} \cdot \frac{L_m}{L_g} \right\} \cdot \mu_0 H_m, \tag{10}$$

which can be represented as the straight line OP_1 (load line), in Fig.6, having a slope

$$\cot \alpha = \frac{B_m}{H_m} = pA_g L_m \mu_0 / q A_m L_g. \tag{11}$$

The intersection of the load line and the demagnetisation curve, P_1, is the working point which, if the design is for maximum efficiency, will be the point having the coordinates B_m, H_m = B_d, H_d.
However, operation on the demagnetisation curve does not give maximum stability: for highly stable operation the working point should lie on a recoil line.

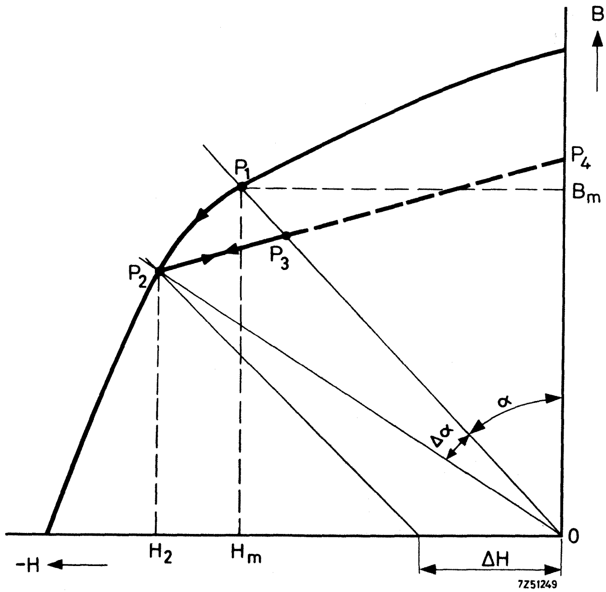


Fig.6. Demagnetisation curve with load line and recoil line.

VARIABLE WORKING POINT AND STABILISATION

If the dimensions of a magnet and its air gap are given, the working point on the demagnetisation curve is fixed. However, when changes in the dimensions of the air gap occur, these bring about changes in the slope of the load line (see equation 11 and $\Delta\alpha$ in Fig. 6), or when an additional magnetic field occurs (ΔH in Fig. 6) the load line is shifted to a parallel position. The working point may move, by one of these events, to P_2 on the demagnetisation curve. If the change is reversed again, the working point returns along the recoil line; the new working point then lies at P_3, the point of intersection of this line with the old load line. (The slope of the recoil line equals $\mu_0 . \mu_{rec}$.)
For adequate stabilisation, a stabilising demagnetising force should be applied to the magnet greater than the maximum demagnetising influences likely to be encountered during normal operation.

Note: As long as the change from P_1 to P_2 takes place along the straight part of the demagnetisation curve, the working point P_3 will not differ appreciably from P_1.
It is therefore sometimes worth while to let the load line not pass through the point of $(BH)_{max}$ but to choose a smaller angle α, in order to remain always within the straight part of the curve. Especially with permanent magnets which will be magnetised outside their system or which may be taken out of their system it is then necessary to investigate whether, after assembly, the new working point will still lie on the straight part of the demagnetisation curve.

Changes in the induction will also take place on account of temperature changes below the Curie or transition temperatures, and are determined by the temperature coefficient. Such a change of the induction with temperature is only reversible within a certain temperature region. The irreversible changes may become particularly great if the working point on account of the temperature changes moves down beyond the knee of the demagnetisation curve. Also for this reason it is often advisable to arrange for the working point, by means of appropriate dimensioning of the system, to lie sufficiently far above the knee.

SYMBOLS

A_g	=	cross sectional area of the air gap perpendicular to the lines of flux
A_m	=	cross sectional area of permanent magnet perpendicular to direction of magnetisation
B	=	(magnetic) flux density/(magnetic) induction
B_d	=	flux density at the point $(BH)_{max}$ on the demagnetisation curve
B_g	=	flux density (induction) in the air gap
$(BH)_{max}$	=	maximum energy product/peak energy product
B_i, J	=	intrinsic flux density, magnetic polarisation
B_m	=	flux density (induction) in the magnet
B_r	=	residual flux density, residual induction, remanence
B_{sat}, B_s	=	saturation flux density/saturation induction
F_m	=	magnetomotive force
H	=	magnetic field strength
H_{cb}, H_{cB}	=	coercivity
H_{ci}, H_{cJ}	=	intrinsic coercivity
H_d	=	demagnetising force at $(BH)_{max}$ on the demagnetisation curve
H_g	=	magnetising force (field strength) in the air gap
H_m	=	demagnetising force (field strength) in the magnet
H_{sat}, H_s	=	magnetising force required for saturation/saturation field strength
$l_g (L_g)$	=	length of the air gap parallel to the lines of flux
$l_g (L_m)$	=	effective magnetic length of magnet
N	=	total number of turns
P_m or Λ	=	permeance
P_c	=	core loss
P_e	=	eddy current loss
P_h	=	hysteresis loss

R_m = reluctance

μ = permeability/normal permeability

μ_{dif} = differential permeability

μ_{rec}, μ_{rev} = recoil permeability/reversible permeability

(ϕ) = magnetic flux/total flux

APPLICATIONS OF PERMANENT MAGNETS

CLASSIFICATION ACCORDING TO MAGNETIC FUNCTION

As a rule, permanent magnets function as energy transducers which transfer energy from one kind into another, without permanently losing energy of their own. In keeping with this, permanent magnets may be classified as follows.

Magnets for the transfer of

- electrical energy into mechanical
  such as in motors, meters, loudspeakers, beam deflectors, mass spectrometers;
- mechanical energy into electrical
  such as in generators, alternators, cycle dynamos, microphones, phonographic pick-ups, electric stringed instruments, magnetic detectors;
- mechanical energy into other mechanical energy
  such as for attraction and repulsion, holding and lifting (e.g. in industrial and household appliances, separators, chucks, thermostats, toys, etc.);
- mechanical energy into heat
  such as in hysteresis-torque and eddy-current instruments, e.g. speedometers, brakes of watt-hour meters, balances, etc.
- A fifth group of magnets accomplish special effects such as the Hall effect, magnetic resistance and nuclear magnetic resonance.

EXAMPLES OF INDUSTRIAL USE

There is practically no industrial sector in which some means equipped with permanent magnets is not used. A few examples:

The ceramics industry	- separators.
Shipbuilding	- welding terminals.
Navigation	- attachment of rust-preventing anodes.
Typography	- magnetic cylinders for iron/rubber blocks.
Mining	- separators; non-skid cable wheels.
Rolling mills	- conveyors; plate lifters.
Office machines	- paper guides and holders.
Cattle raising	- garbage separation.
Foods and allied products	- separators.
Oil trade	- filling machines.
Machining	- chucks.
Miscellaneous	- clocks and watches.

ENUMERATION OF APPLICATIONS

Electrotechnical

Measurement and control

- Galvanometers
- Ammeters
- Voltmeters
- Fluxmeters
- Photometers
- Tachometers
- Speedometers
- Kilowatt-hour meters
- Recording instruments
- Vibrographs
- Oscillographs
- Cardiographs
- Seismographs
- Pressure gauges

Switchgear

- Spark extinguishers

Motors and generators

- Alternators
- Magnets for IC engines
- Cycle dynamos
- Hand dynamos
- Hysteresis motors
- Synchronous motors
- Clock motors
- D.C. shunt motors
- Screenwiper motors
- Fan motors
- Toy motors
- Aeronautic motors and generators
- Gyroscopes
- Electrodynamic tachometers
- Pulse generators

Electro-acoustics and communications

- Tone generators
- Telephones
- Hearing aids
- Cutting heads
- Pick ups
- Stringed instruments
- Tape recorders
- Dictaphones
- Magnetrons
- UHF directional isolators

Radio and TV

- Loudspeakers
- Transformers
- Vibratory convertors
- Picture tubes
- Focusing units

Applied physics

Scientific

- Magnetostrictive devices
- Resonance measurements
- Resistance modification

Industrial

- Compass compensation
- Material selection
- Hardness testing
- Film-thickness measurement
- Crack detection
- Polarity indicators
- Water softening

General

- Compasses
- Coin check in vending machines
- Replacement of springs
- Magnetising yokes

Mechanical

Measurement and control

Flow meters
Level indicators
Maximum thermometers
Thermocouples
Eddy-current brakes
Valves

Consumer goods

Visual demonstration
Calendars
Card-index systems
Guides of many kinds
Lamp holders
Inspection lamps

Switchgear and connectors

Switches
Microscopy
Buttons
Couplings
Pumps
Calorimeters
Mixers
Drives through a wall
Frictionless drives
Centrifugal couplings
Polarised contacts

Industrial

Holding devices
Plate lifters
Conveyors
Drain plugs
Filters
Separators
Floor cleaners
Indicating boards
Frictional brakes
Hammers
Screwdrivers
Refrigerators

Miscellaneous

Accessories

Cigarette holders
Name plates
Parking plates
Soap holders
Tin openers

Medical

Extraction of steel splinters
Blood testing
Prothesis

Toys

Toys of all kinds
Draughtsmen
Chessmen

Sundries

Magnetic drags
Veterinary uses

Contents

A	Properties of manganese zinc and nickel zinc ferrites
B	Ferrites for radio, audio and television
C	Small coils, assemblies and assembling parts
D	Ferroxcube potcores and square cores
E	Ferroxcube transformer cores
F	Ferroxcube memory cores
G	Piezoxide
H	Permanent magnet materials

Printed in The Netherlands

9399 491 15201