DESIGN CHARTS FOR CONSTRUCTORS

No. 10. SINGLE-LAYER INDUCTANCE WINDING DATA 0.07μH to 3μH

by HUGH GUY

THE INDUCTANCE OF A COIL OF WIRE IS usually stated to be proportional to the square of the number of turns comprising the coil. Thus one would expect that to double the number of turns on a given coil would multiply the inductance by four. This would only be true if the volume occupied by the coil were to remain unchanged. Since this is impossible for a fixed wire gauge, then any practical formula relating the turns on a coil to its inductance must also include the effects of its changing size as the number of turns increases.

One formula does this with certain restrictions, and gives the low frequency inductance L in microhenrys as:

$$L = \frac{r^2N^2}{9r + 10l}$$

where r is the mean radius of the coil, *l* is the length, and N is the number of turns. (See Fig. 1.)

One restriction is that the coil length *l* must not be less than 80% of the mean radius r.

Despite appearances, this formula is by no means a simple one to deal with, for the following reasons:—

1. The mean radius r is the sum of the radius of the former R, and the wire diameter d, and therefore varies with wire gauge.
2. The length *l* is itself the product of the wire diameter d and the number of turns N, and consequently is again dependent on wire gauge.
3. As it stands, the formula will tell us the inductance of the coil if we know its size and its number of turns, but it will not tell us the number of turns required for a specified value of inductance, a form in which it would be more useful.

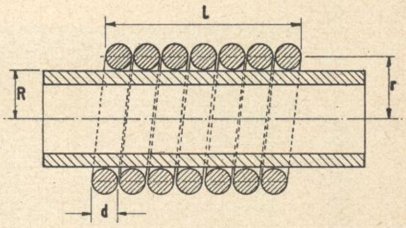
If rearranged to provide this solution, the formula is rather unwieldy:

$$N = \frac{10L}{(R + d/2)^2}\left[d + \sqrt{1.09d^2 + 0.36dR + 0.36R^2}\right]$$

Presentation in Chart Form

All the arithmetic can be removed by presenting the inductance in chart form, and the process can be further simplified by restricting the application of the chart to a standard range of coil formers, and selecting a limited number of wire gauges. Having chosen a former the maximum and minimum winding lengths are automatically fixed, and a data line can be used to cover the range of possible inductance values and appropriate number of turns for a given wire gauge.

Four wire gauges have been selected: namely 16 s.w.g., 20 s.w.g., 26 s.w.g., and 36 s.w.g., all in enamelled copper wire. Each wire gauge gives rise to its own chart, each of which, for five different sized formers, relates low frequency inductance values and corresponding turns of wire, enabling either to be determined in terms of the other.



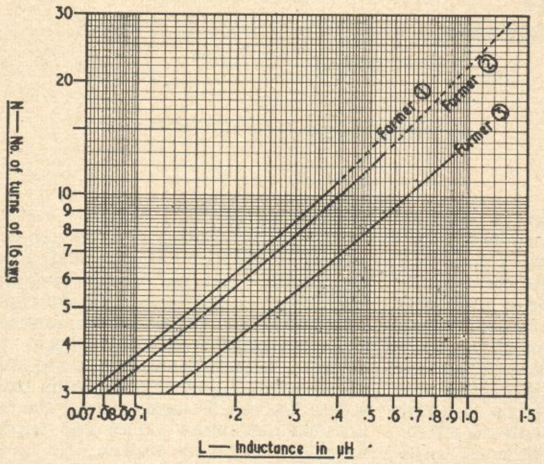
SINGLE LAYER COIL DIMENSIONS

FIG. 1

Coil Formers

Most modern coil formers are of the iron dust-cored type, adjustment of the latter providing a means of varying the inductance of the coil. Of these types the most widely encountered ones are in a group defined by three different diameters. These diameters are 0.276in, 0.300in, and 0.415in. It is upon formers of these diameters that these design charts are based.

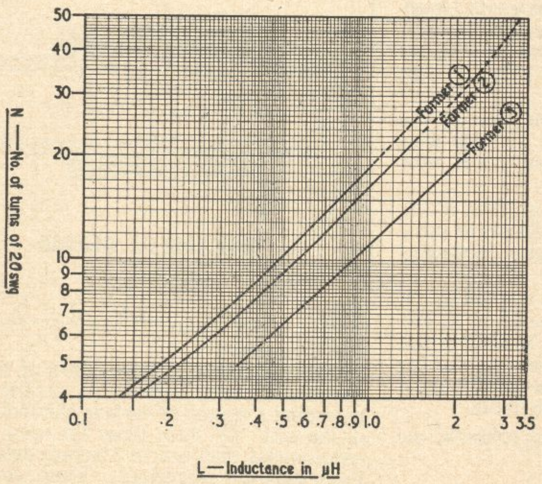
DESIGN CHART 10a



Former	Dia. ins.	Length
①	0·276	0·75 1·0
②	0·3	0·91 1·96
③	0·415	0·875

COIL DATA for 16 swg enamelled copper wire.
SINGLE LAYER CLOSE WOUND

DESIGN CHART 10b



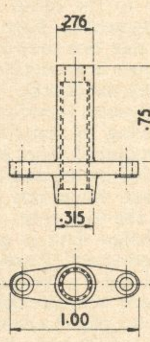
Former	Dia. ins.	Length
①	0·276	0·75 1·0
②	0·3	0·91 1·96
③	0·415	0·875

COIL DATA for 20 swg enamelled copper wire.
SINGLE LAYER CLOSE WOUND

G 570

TYPICAL COIL FORMERS SUITABLE FOR USE WITH DESIGN CHARTS

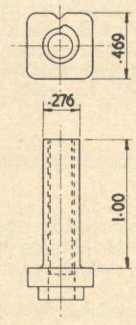
FORMER ①



TEE BASE

Chart Code — Former ①

Aladdin Types-5961, 5959

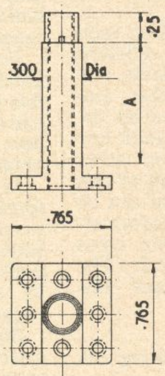


CAM BASE

Chart Code — Former ①

Aladdin Types-5947, 5948

FORMER ②



MOULDED BAKELITE

Chart Code — Former ②

Aladdin Type — 5938

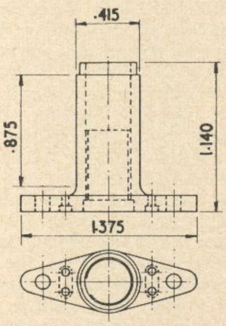
A 0.910 ins.

Chart Code — Former ②

Aladdin Type — 5937

A 1.96 ins.

FORMER ③



MOULDED BAKELITE

Chart Code — Former ③

Aladdin Types — 5892, 5925

SCREW DUST CORES FOR FORMERS

Dia. m/m	Pitch m/m	Length ins.	Aladdin Type	Associated Former Type
6	0.75	0.500	5921	5947, 5959
6	1.0	0.315	5972	5937
6	1.0	0.375	5942	5938
6	1.0	0.500	5839	5961
6	1.0	0.625	5884	5948
8	0.75	0.675	5920	5925
8	1.25	0.500	5918	5892
8	1.25	0.675	5804	

DRAWINGS REPRODUCED BY KIND PERMISSION OF 'ALADDIN RADIO INDUSTRIES' GREENFORD. Q 371

Now each of these types is available in several different lengths and styles depending on the whims of the manufacturer, but the reader will recognise several from the outline drawings of Fig. 2 which shows a typical range produced by Aladdin Radio Industries of Greenford. In the figure, the types are listed under three headings defined by their respective diameters.

Other manufacturers supply formers of differing lengths, but for convenience the charts have been designed around those indicated in the figure.

The maximum number of turns that it is possible to wind on a particular former is governed by its length. Since two types of each of former 1 and former 2 exist, then the winding lengths will differ for each.

For example, a line will be found on each chart labelled Former 1. Two different formers under this heading are available, one of winding length 0.75in, the other 1in. Obviously more turns can be wound on the latter; and thus, on the chart, the solid line covers turns that can be wound on either former while the dotted continuation of this line will cater only for the turns that can be accommodated on the longer (i.e. 1in) former. This system also applies to the two types available under the heading Former 2. The legend on each chart summarises this information.

Using the Charts

Having selected a coil former, using the charts is extremely simple.

Suppose that it is proposed to wind an inductance of 2μH on a former of type 2. Then the two charts published this month, numbers 10a and 10b covering 16 s.w.g. and 20 s.w.g. respectively, show that 20 s.w.g. wire must be used. Thus on chart 10b it can be seen that 30 turns is the required number since the inductance value of 2μH intersects 30 on the turns scale at the data line marked former 2. Furthermore, since the data line is dotted at this intersection, the larger type of former 2 should be used.

Practical Points

These charts cover the low frequency inductance values of single layer coils. That is to say that the coil of 2μH just considered, for example, could only be guaranteed to have this value at low frequencies. Invariably, of course, such a coil would be required for a much higher frequency than that for which this specification holds. Consequently for very small values of inductance, such as are covered by these two design charts, it is possible to get an apparent error of as much as 2 : 1 in the values of these coils when they operate at high frequencies.

This is due largely to the effect that the leads to the coils themselves have on the inductance, and as a rule one may expect to find the inductance larger in practice over t[illegible] range than indicated by the charts.

For all practical purposes, therefore, it is a good policy when having to make a coil of this type to halve its required value and wind one to the data provided by the charts to this new value. The exact value can then be obtained by inserting the iron core.

In all cases, the design data is given for formers with the core removed. Consequently to ensure that the final coil is of an inductance whose value is produced with the core about half-way in, it is a good plan to design coils of somewhat less inductance than the required value.

Styles of core vary, of course, as does their electrical performance, but as a rule most cores provide up to a 2 : 1 variation in inductance up to medium frequencies. At high frequencies, however, say from 30 Mc/s upwards, certain cores are responsible for eddy current losses with consequent worsening of the Q or magnification factor of the circuit in which the coil is connected.

A list of iron cores suitable for use with the formers mentioned is given also in Fig. 2.

Next month the two charts covering 26 and 36 s.w.g. enamelled copper wire will be given to provide design data for coils of up [illegible] 60μH inductance.

New Mullard High Power Triode for Industrial R.F. Generators

The TY7–6000 is a new Mullard triode specially developed for use in industrial r.f. generators such as are used for r.f. heating. It will deliver an output of 6kW at frequencies up to 50 Mc/s and has been conservatively rated to ensure adequate margins of safety when used in industrial heating applications, where the valve may be subjected to mains and load variations, which can result in intermittent overloads.

The new triode is available in two versions, the TY7–6000A which is designed for forced air cooling, and the TY7–6000W which is a water-cooled version. The maximum permissible anode dissipation is 6,000 watts in either case, and anode voltages up to 7kV may be used. The valves have directly heated thoriated tungsten filaments, and external anodes.