REWINDING OF POWER TRANSFORMERS

When we buy an old radio, we all know what needs to be done. All capacitors should be replaced, along with out of tolerance resistors, low emission valves, bare wiring, etc. At the same time, we should be trying as much as possible to leave it in its original appearance. All of this is relatively easy to do.

The problem is when we find a burnt power transformer. Years ago, the simplest thing was to remove the transformer and take it to a specialist to rewind it. Unfortunately, many of these people are now either deceased or retired. In some cases, we can find the same transformer model. But in other cases, it is impossible to find a suitable replacement. There is also the solution of replacing a transformer with another that has the same technical characteristics. But in these cases, it is necessary to proceed to make new holes in the chassis, considerably varying its original appearance.

I personally have come across blown transformers from ATWATER KENT and JACKSON BELL. Interestingly, I have to say, that I have never come across damaged power transformers from PHILCO.

Why not rewind them ourselves? Is it that difficult? The answer is no. It is much simpler than it seems. Of course, you have to have a minimally good winder. It is impossible to do it manually. In many of these transformers, each winding may have several thousand turns.

I will approach the subject from a practical point of view. In any case, in another article I can propose the demonstration of the formulas that I am going to detail below.

When we come across a burnt-out transformer, the core of the transformer is generally not damaged. Therefore, we remove all the windings and we are left with only the core.

The formulas that we will use are three:

$$P=V.I \qquad P=S^2 \qquad N=42/S$$

Where P is the power in watts, V voltage in volts, I intensity in amperes, S area in cm² and N number of turns per volt.

Very important:

The power of a transformer depends strictly on the surface of the core. The voltages of each winding strictly depend on the number of turns. Finally, the amperages that each winding can withstand depends on the thickness of the copper cables. In the latter case we need the attached table.

We will explain the issue with an example.

In my case, I found the totally burned transformer of the model 62 "SUNRISE", the first series of the JACKSON BELL.

We can find the schematic at:
http://www.nostalgiaair.org/PagesByModel/669/M0009669.pdf

This radio has 6 tubes: 4 type 24, 1 type 45 and one type 80.

Your transformer has 5 windings - the primary and 4 secondaries.

1.- Characteristics of the valves.

80	**I_f = 2 A**	**V_f = 5 V**
24	**I_f = 1,75 A**	**V_f = 2,5 V**
45	**I_f = 1,5 A**	**V_f = 2,5 V**

2.- Windings.

80 secondary:	5 volts, 2 amps
45 secondary:	2.5 volts, 1.5 amps
24 secondary:	2.5 volts, 7 amps

3.- Core surface. See figure 1.

X = 3.2cm Y = 3.2cm

Therefore, the core surface: **S = 10.24 cm²**

4.- Maximum power.

$P = S^2 = (10.24)^2 = 104$ watts

5.- Number of turns per volt.

$N = 42/S = 42/10.24 = 4.10$ turns per volt

6.- Gauges.

PRIMARY: 230 volts (voltage we have in Europe)

I = P/V = 104/230 = 0.45 amps therefore, according to the table, a 26 gauge corresponds to it

SECONDARY:

HT Secondary: 700 volts center tapped

I = P/V = 104/(350+350) = 0.148 amps		====>	31 gauge
Secondary 80:	I = 2 amps	====>	20 gauge
Secondary 45 center tapped:	I = 1.5 amps	====>	21 gauge
Secondary 24 center tapped:	I = 7 amps	====>	14 gauge

7.- Total number of turns of each winding.

PRIMARY: 230 volts x 4.10 turns/volt = 943 turns

SECONDARY HT (CENTRAL TAP): 700 volts x 4.10 turns/volt = 2,870 turns (at turn 1,435 the central tap must be removed)

SECONDARY 80: 5 volts x 4.10 turns/volt = 20.5 turns

SECONDARY 45 (CENTRAL TAP): 2.5 volts x 4.10 turns/volt = 10.25 turns (at turn 5.125 the central tap must be removed)

SECONDARY 24 (CENTRAL TAP): 2.5 volts x 4.10 turns/volt = 10.25 turns (at turn 5.125 the central tap must be removed)

WINDING CONSTRUCTION NOTES:

1.- To wind, we will have to acquire a reel, which fits perfectly in the core.

What winding should we start with? Theoretically, it is the same, but in practice we always have to start winding with the thinnest wire. Why? By using the thinnest gauge wire for the initial winding, the turns are closer together in each pass which prevents the next winding from having any turns between the winding that is below it.

Therefore, in our case we will start winding the HT, followed by the primary, then the 45, the 80, and finally the 24 secondary.

2.- Between each winding you have to use insulating tape or fish paper.

3.- The center taps do NOT have to be cut and soldered. At the halfway point you have to take the wire out and then put it back into the coil without cutting. See figure 2.

4.- Once the windings are made, we will assemble the core. The metal plates must be mounted alternately thus avoiding, as far as possible, Eddy currents. See figure 3.

5.- When we look at the gauges, in the event that we do not have an appropriate cable for the corresponding intensity, we will always choose the next thickest cable from the table. Never the thinnest.

6.- Once the transformer is assembled, the voltages of the secondaries must be checked before reassembling it inside the radio, to avoid possible errors in the windings and seriously damaging other components of the device.

FINAL NOTE: One of the most important formulas in transformers is the following:

$$N1/N2 = V1/V2 = I2/I1$$

In our case, we can verify that:

943/2870 = 230/700 = 0.148/0.45 = 0.328

When I checked the tensions, they gave the exact result. This is not difficult to achieve. But I insist, you must buy a good winder.

fig. 1

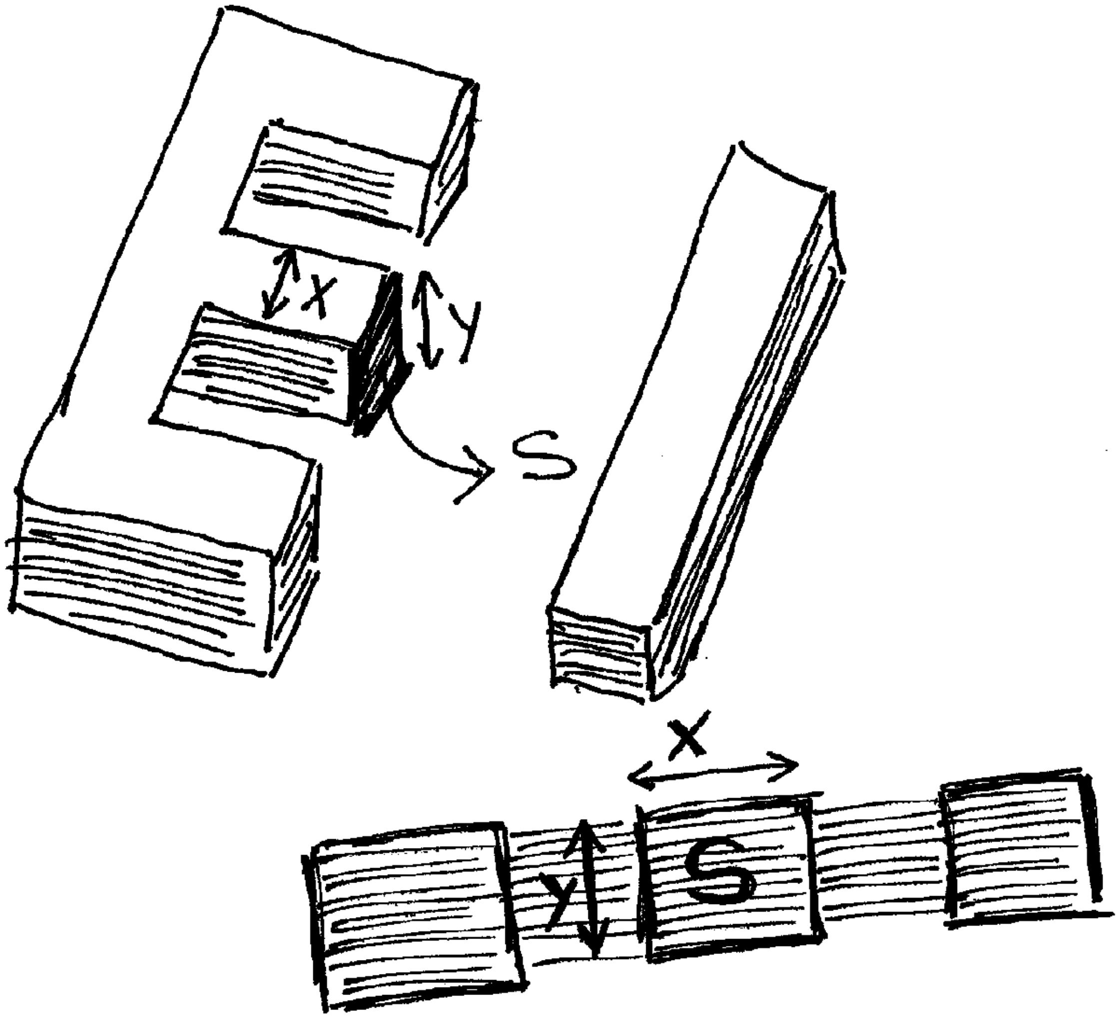

fig. 2

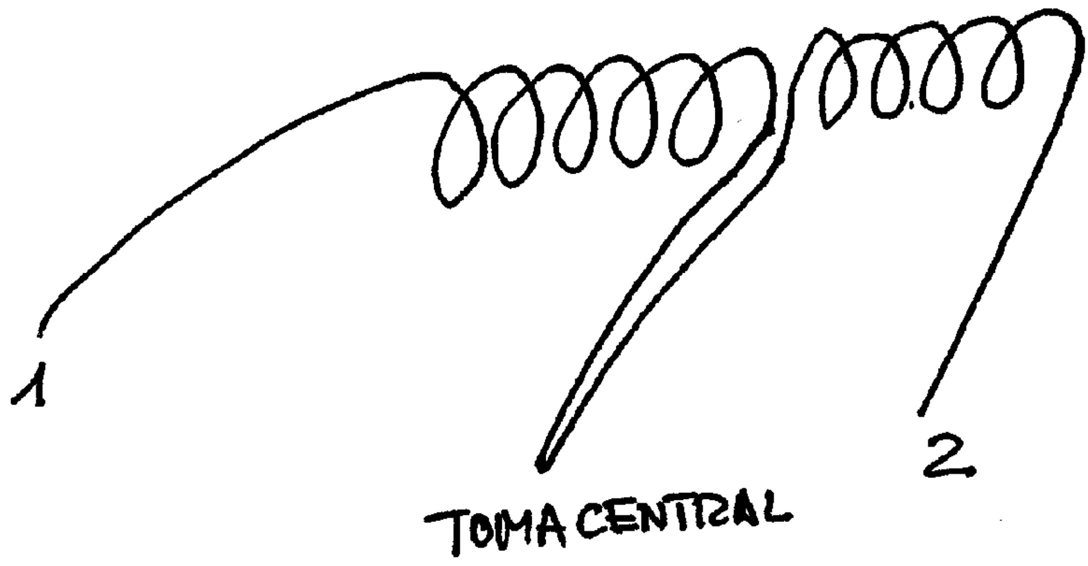

fig.3

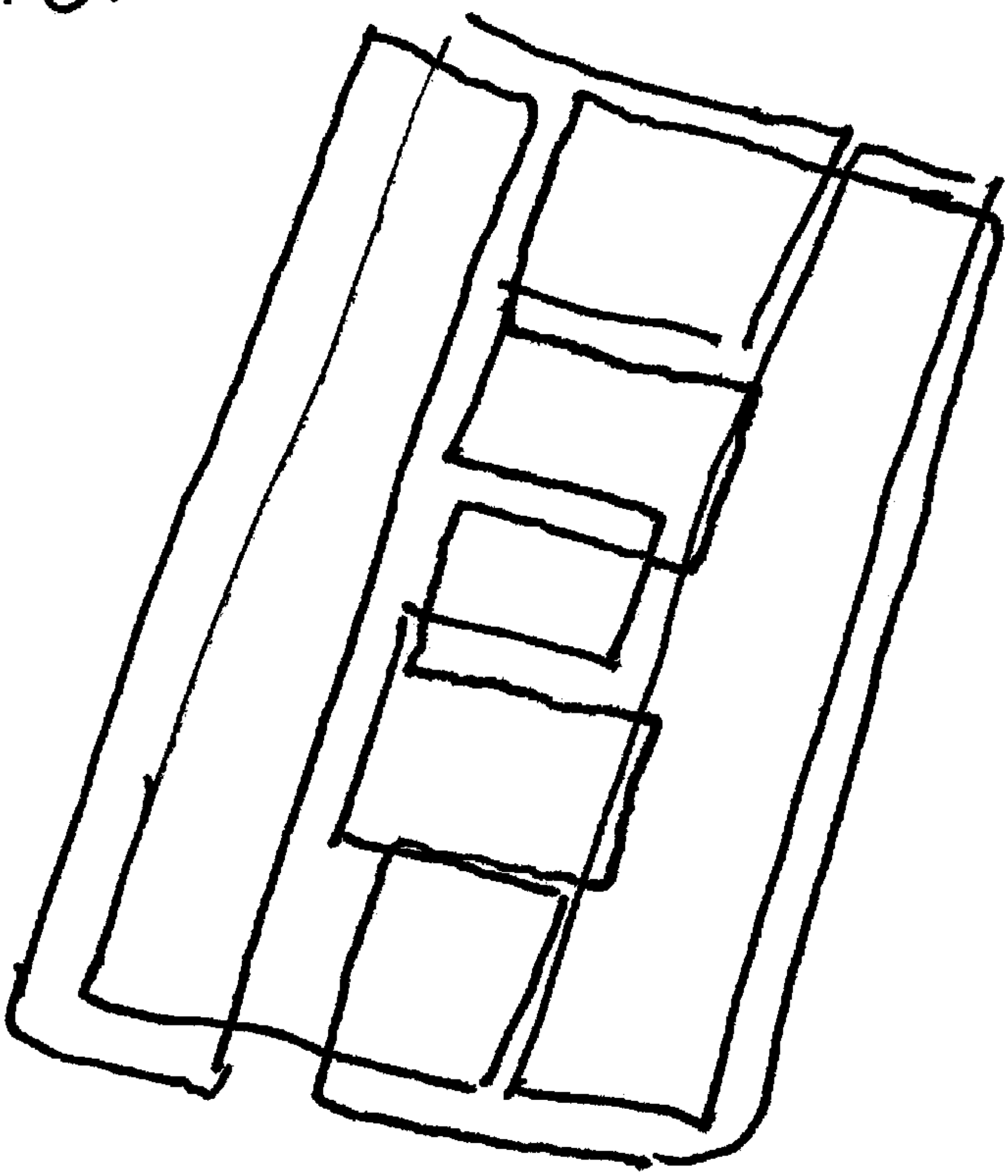

TABLA DE EQUIVALENCIAS DE GROSORES AWG

AWG	Dia-mils	TPI	Dia-mm	Circ-mils	Ohms/Kft	Ft/Ohm	Ft/Lb	Ohms/Lb	Lb/Kft	*Amps	MaxAmps
0000	459.99	2.1740	11.684	211592	0.0490	20402	1.5613	0.0001	640.48	282.12	423.18
000	409.63	2.4412	10.405	167800	0.0618	16180	1.9688	0.0001	507.93	223.73	335.60
00	364.79	2.7413	9.2657	133072	0.0779	12831	2.4826	0.0002	402.80	177.43	266.14
AWG	Dia-mils	TPI	Dia-mm	Circ-mils	Ohms/Kft	Ft/Ohm	Ft/Lb	Ohms/Lb	Lb/Kft	*Amps	MaxAmps
0	324.85	3.0783	8.2513	105531	0.0983	10175	3.1305	0.0003	319.44	140.71	211.06
1	289.29	3.4567	7.3480	83690	0.1239	8069.5	3.9475	0.0005	253.33	111.59	167.38
2	257.62	3.8817	6.5436	66369	0.1563	6399.4	4.9777	0.0008	200.90	88.492	132.74
3	229.42	4.3588	5.8272	52633	0.1970	5075.0	6.2767	0.0012	159.32	70.177	105.27
4	204.30	4.8947	5.1893	41740	0.2485	4024.7	7.9148	0.0020	126.35	55.653	83.480
5	181.94	5.4964	4.6212	33101	0.3133	3191.7	9.9804	0.0031	100.20	44.135	66.203
6	162.02	6.1721	4.1153	26251	0.3951	2531.1	12.585	0.0050	79.460	35.001	52.501
7	144.28	6.9308	3.6648	20818	0.4982	2007.3	15.869	0.0079	63.014	27.757	41.635
8	128.49	7.7828	3.2636	16509	0.6282	1591.8	20.011	0.0126	49.973	22.012	33.018
9	114.42	8.7396	2.9063	13092	0.7921	1262.4	25.233	0.0200	39.630	17.456	26.185
AWG	Dia-mils	TPI	Dia-mm	Circ-mils	Ohms/Kft	Ft/Ohm	Ft/Lb	Ohms/Lb	Lb/Kft	*Amps	MaxAmps
10	101.90	9.8140	2.5881	10383	0.9989	1001.1	31.819	0.0318	31.426	13.844	20.765
11	90.741	11.020	2.3048	8233.9	1.2596	793.93	40.122	0.0505	24.924	10.978	16.468
12	80.807	12.375	2.0525	6529.8	1.5883	629.61	50.593	0.0804	19.765	8.7064	13.060
13	71.961	13.896	1.8278	5178.3	2.0028	499.31	63.797	0.1278	15.675	6.9045	10.357
14	64.083	15.605	1.6277	4106.6	2.5255	395.97	80.447	0.2031	12.431	5.4755	8.2132
15	57.067	17.523	1.4495	3256.7	3.1845	314.02	101.44	0.3230	9.8579	4.3423	6.5134
16	50.820	19.677	1.2908	2582.7	4.0156	249.03	127.91	0.5136	7.8177	3.4436	5.1654
17	45.257	22.096	1.1495	2048.2	5.0636	197.49	161.30	0.8167	6.1997	2.7309	4.0963
18	40.302	24.813	1.0237	1624.3	6.3851	156.62	203.39	1.2986	4.9166	2.1657	3.2485
19	35.890	27.863	0.9116	1288.1	8.0514	124.20	256.47	2.0648	3.8991	1.7175	2.5762
AWG	Dia-mils	TPI	Dia-mm	Circ-mils	Ohms/Kft	Ft/Ohm	Ft/Lb	Ohms/Lb	Lb/Kft	*Amps	MaxAmps
20	31.961	31.288	0.8118	1021.5	10.153	98.496	323.41	3.2832	3.0921	1.3620	2.0430
21	28.462	35.134	0.7229	810.10	12.802	78.111	407.81	5.2205	2.4521	1.0801	1.6202
22	25.346	39.453	0.6438	642.44	16.143	61.945	514.23	8.3009	1.9446	0.8566	1.2849
23	22.572	44.304	0.5733	509.48	20.356	49.125	648.44	13.199	1.5422	0.6793	1.0190
24	20.101	49.750	0.5106	404.03	25.669	38.958	817.66	20.987	1.2230	0.5387	0.8081
25	17.900	55.866	0.4547	320.41	32.368	30.895	1031.1	33.371	0.9699	0.4272	0.6408
26	15.940	62.733	0.4049	254.10	40.815	24.501	1300.1	53.061	0.7692	0.3388	0.5082
27	14.195	70.445	0.3606	201.51	51.467	19.430	1639.4	84.371	0.6100	0.2687	0.4030
28	12.641	79.105	0.3211	159.80	64.898	15.409	2067.3	134.15	0.4837	0.2131	0.3196
29	11.257	88.830	0.2859	126.73	81.835	12.220	2606.8	213.31	0.3836	0.1690	0.2535
AWG	Dia-mils	TPI	Dia-mm	Circ-mils	Ohms/Kft	Ft/Ohm	Ft/Lb	Ohms/Lb	Lb/Kft	*Amps	MaxAmps
30	10.025	99.750	0.2546	100.50	103.19	9.6906	3287.1	339.18	0.3042	0.1340	0.2010
31	8.9276	112.01	0.2268	79.702	130.12	7.6850	4145.0	539.32	0.2413	0.1063	0.1594
32	7.9503	125.78	0.2019	63.207	164.08	6.0945	5226.7	857.55	0.1913	0.0843	0.1264
33	7.0799	141.24	0.1798	50.125	206.90	4.8332	6590.8	1363.6	0.1517	0.0668	0.1003
34	6.3048	158.61	0.1601	39.751	260.90	3.8329	8310.8	2168.1	0.1203	0.0530	0.0795
35	5.6146	178.11	0.1426	31.524	328.99	3.0396	10480	3447.5	0.0954	0.0420	0.0630
36	5.0000	200.00	0.1270	25.000	414.85	2.4105	13215	5481.7	0.0757	0.0333	0.0500
37	4.4526	224.59	0.1131	19.826	523.11	1.9116	16663	8716.2	0.0600	0.0264	0.0397
38	3.9652	252.20	0.1007	15.723	659.63	1.5160	21012	13859	0.0476	0.0210	0.0314
39	3.5311	283.20	0.0897	12.469	831.78	1.2022	26496	22037	0.0377	0.0166	0.0249
AWG	Dia-mils	TPI	Dia-mm	Circ-mils	Ohms/Kft	Ft/Ohm	Ft/Lb	Ohms/Lb	Lb/Kft	*Amps	MaxAmps
40	3.1445	318.01	0.0799	9.8880	1048.9	0.9534	33410	35040	0.0299	0.0132	0.0198