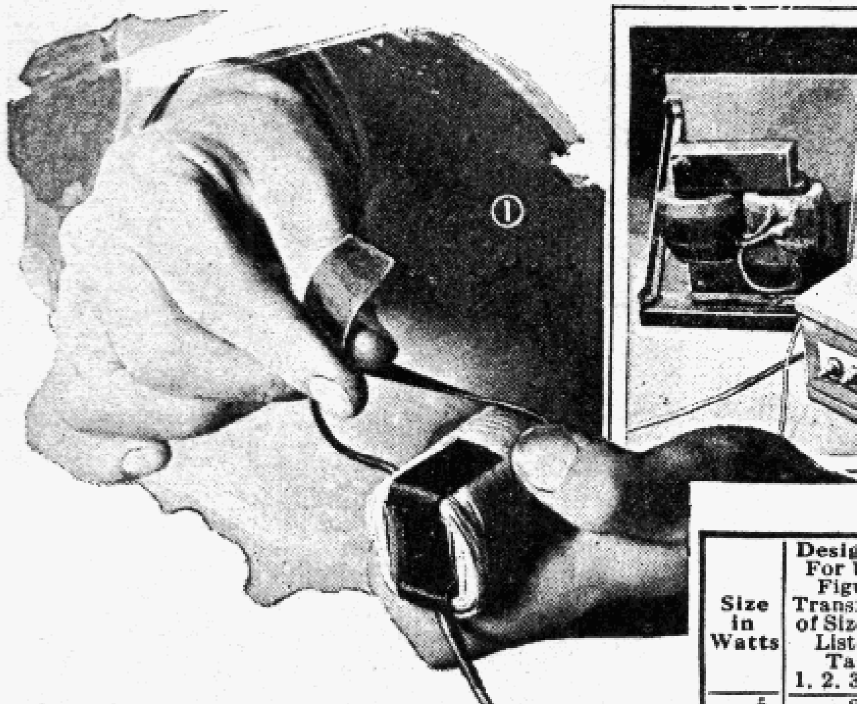
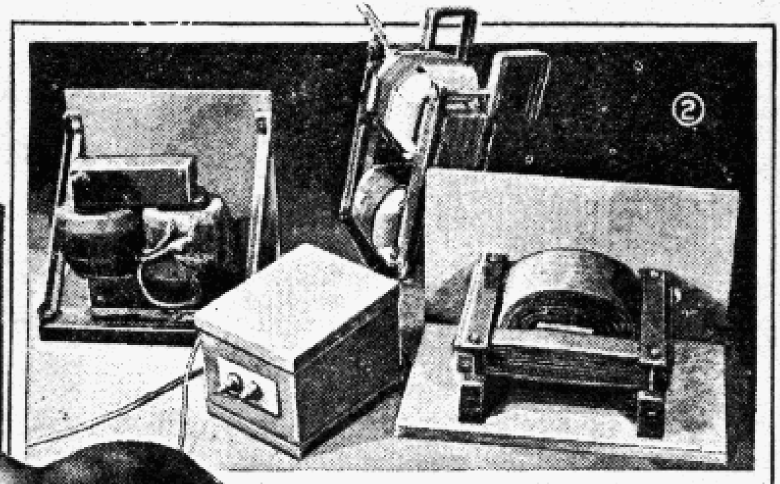
TRANSFORMER





TRANSFORMERS to suit any requirement can easily be built by carefully following the instructions contained in this article. There are two types of this apparatus, the shell and the core type, both shown in Fig. 2. They differ in that the former has its windings on a center crosspiece of the core and takes less copper, while the latter has the primary coil on one and the secondary on the other leg of the core. Cores may be built up from standard silicon-steel E and I-punchings, obtainable in many sizes, or assembled from strips of No. 26-gauge silicon steel, cut to size with tinners' shears.

The starting point in transformer design is the exact determination of the output required in watts, which is the product of amperes and volts. For example, a 6-volt transformer delivering 20 amp. has an output of 120 watts. Let us assume that we are going to build a shell-type transformer and that the frequency of our 110-volt supply circuit is 60 cycles. Referring to table No. 1,   does not give the exact size of transformer desired, one of 120

TABLE NO. 5

Size in Watts	Design No. For Use in Figuring Transformers of Sizes Not Listed in Tables 1, 2, 3 and 4	Fuse for Line		Wire Size for Primary Coil			
				Shell Type		Core Type	
		110 Volts	220 Volts	110 Volts	220 Volts	110 Volts	220 Volts
5	2.24	1	1	34	36	32	35
10	3 16	1	1	31	34	30	33
15	3.87	1	1	29	32	28	31
20	4.47	1	1	27	31	27	30
30	5.48	1	1	26	29	25	28
40	6.33	1	1	25	28	24	27
50	7.07	1	1	24	27	23	26
75	8 65	1	1	22	25	21	24
100	10.00	1	1	21	24	20	23
125	11.19	6	1	20	23	19	22
150	12.22	6	1	19	22	18	21
175	13.21	6	1	19	21	17	20
200	14.12	6	1	18	21	17	20
225	15.00	6	6	18	20	16	19
250	15.81	6	6	17	20	16	19
275	16.59	6	6	17	19	15	18
300	17.31	6	6	16	19	15	18
350	18.70	6	6	16	18	14	17
400	20.00	6	6	15	18	14	17
450	21.20	6	6	14	17	13	16
500	22.35	6	6	14	17	13	16
600	24.45	6	6	13	16	12	15
700	26.45	10	6	12	15	11	14
800	28.30	10	6	12	14	11	14
900	30.00	10	6	11	14	10	13
1000	31.60	10	6	11	14	10	13
1100	33.20	15	6	11	14	9	12
1200	34.60	15	10	10	13	9	12
1250	35.40	15	10	10	13	9	12
1300	36.00	15	10	10	13	9	12
1400	37.40	15	10	10	12	8	11
1500	38.70	15	10	9	12	8	11
1600	40.00	20	10	9	12	8	10
1700	41.20	20	10	9	12	8	10
1800	42.40	20	10	9	11	2 #10*	10
1900	43.60	20	10	8	11	2 #10*	10
2000	44.70	20	10	8	11	2 #10*	10

*Wind two #10 wires at the same time and use as 1 wire by connecting the starting ends together and the finish ends together.

11.76 turns. The next higher even number, or 12 turns, should be used.

Next, we should determine the size of wire needed for the secondary, which depends on the current to be passed, already known to be 20 amp. Multiply the amperes by 750 for the shell type, or by 1,000 for to table No. 1, does not give the exact size of transformer desired, one of 120 watts, and therefore the next larger size is selected, which is 150 watts. The turns of wire required for the secondary coil is found by multiplying the turns per volt as given in table No. 1, by the volts required, which in this case is 6 volts times 1.96, or

known to be 20 amp. Multiply the amperes by 750 for the shell type, or by 1,000 for the core type to find the cross-sectional area of the wire in circular mils. In the example, this would be 15,000. Table No. 6 gives the wire sizes corresponding to the circular-mil area. As the figure 15,000 is not given, take the next one above it,

CONSTRUCTION

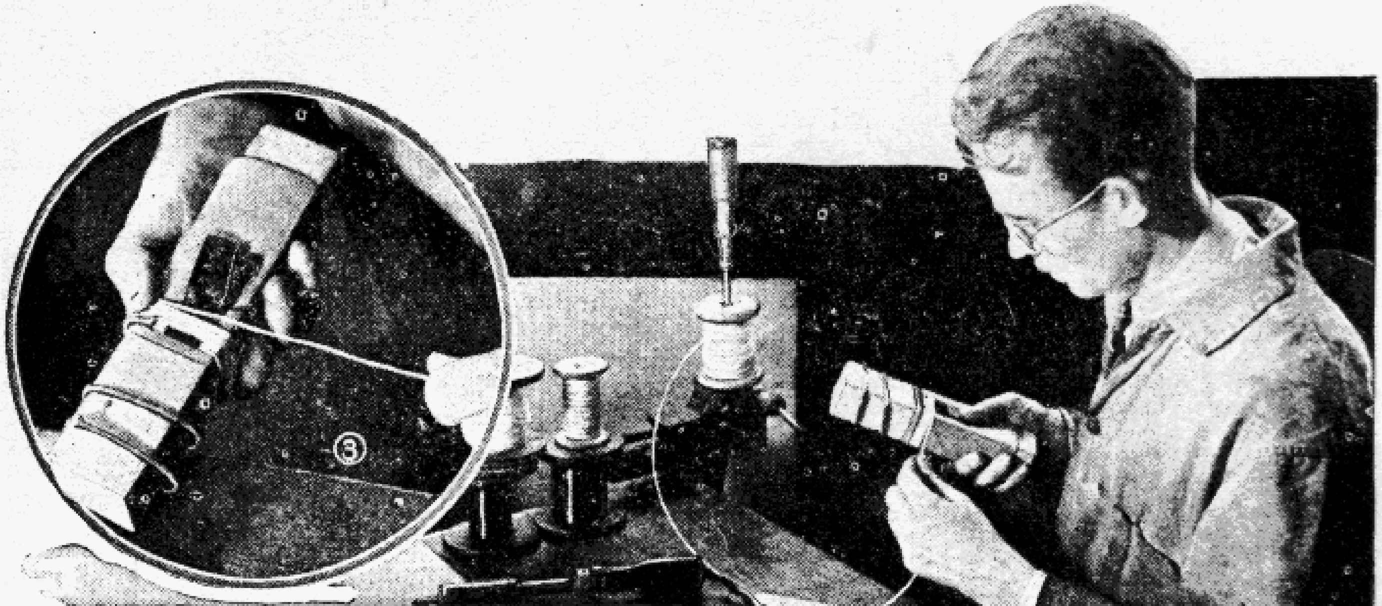


TABLE NO. 6—WIRE SIZES

B & S Gauge No.	Circular Mils	Turns per Square Inch		Pounds of Wire per Cubic Inch	
		Single Cotton Covered	Enamel Covered	Single Cotton Covered	Enamel Covered
8	16510	55	53	.228	.253
9	13090	71	66	.227	.244
10	10380	87	83	.226	.230
11	8234	104	106	.224	.236
12	6530	138	135	.223	.238
13	5178	172	168	.220	.236
14	4107	196	215	.217	.231
15	3257	265	271	.214	.232
16	2583	331	345	.210	.226
17	2048	407	433	.207	.227
18	1624	493	545	.204	.227
19	1288	618	681	.200	.225
20	1022	719	852	195	.223
21	810	836	1065	190	.221
22	642	1064	1340	183	.220
23	509	1362	1665	177	.217
24	404	1615	2100	170	.217
25	320	1946	2630	164	.217
26	254	2385	3320	157	.216
27	201	2830	4145	150	.215
28	159	3462	5250	143	.215
29	126	3760	6510	135	.213
30	100	4713	8175	128	.212
31	79	5535	10200	120	.210
32	63	6137	12650	110	.207
33	50	6920	16200	101	.200
34	39	7960	19950	093	.205
35	31	9243	25000	.083	.205
36	25	9723	31700	.075	.205

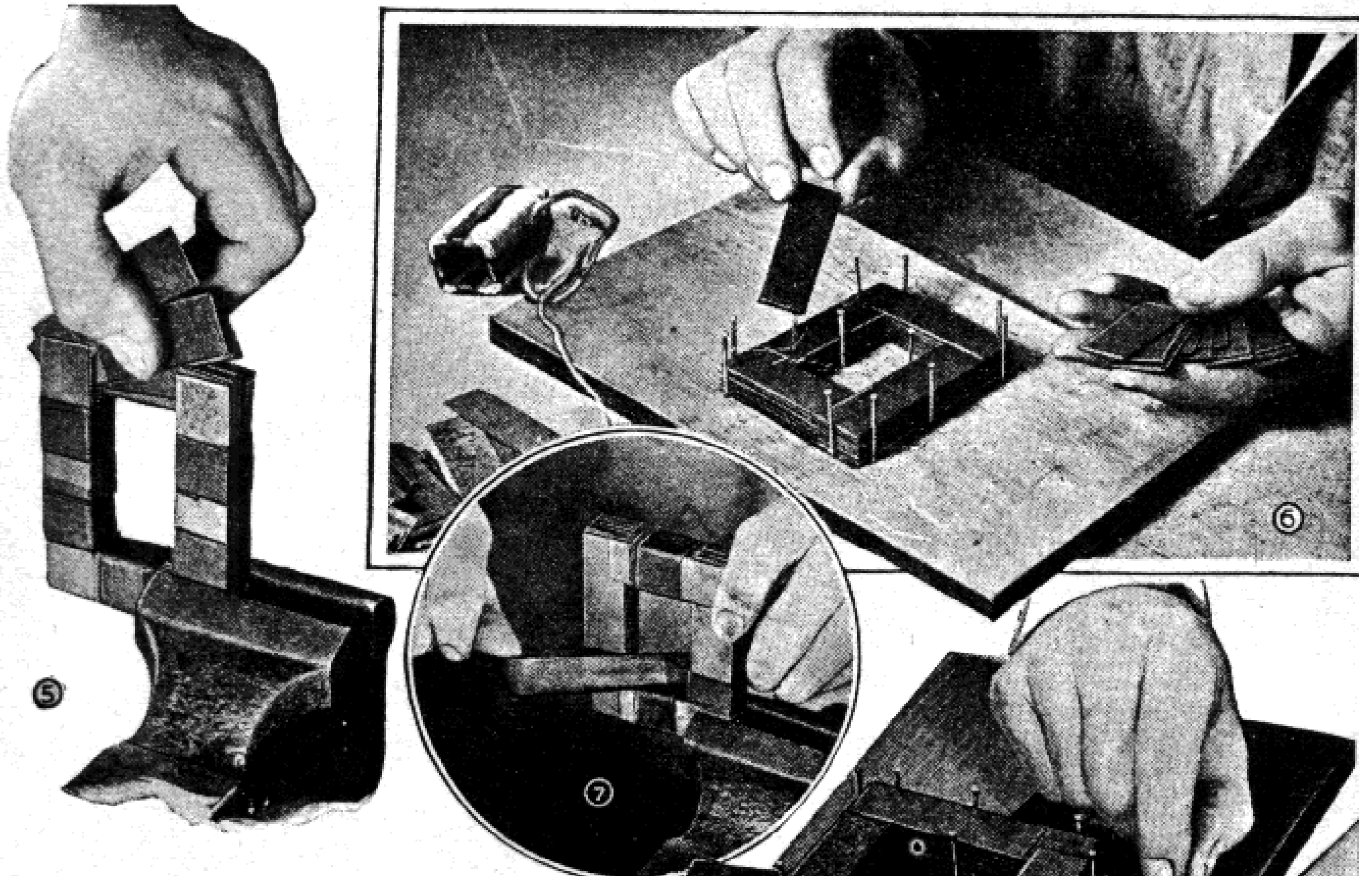
which is 16,510, corresponding to No. 8 wire, which is the correct size to use. How much wire is needed for the secondary coil depends on the size of the core on which it is to be wound, the number of turns already being known. To estimate the weight of wire needed, consult table No. 6, where we find that No. 8 s.c.c. wire will wind 55 turns per square inch. Dividing our turns, or 12, by this number we get .218 sq. in. as the cross-sectional area of tiplying this number by 1.8 cu. in. we get .46 lb., or the approximate weight of wire for the secondary coil.

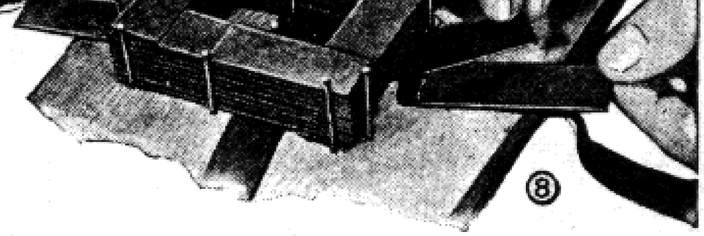
The next step is to find the size of the core and its weight. From table No. 1 we find that the width of the core leg on which the coil is wound should be 1¼ in. This table also gives the thickness of the core as 2¹³⁄₁₆ in. and the approximate weight of silicon steel required as 5.8 lb. Fig. 13 shows how all the core dimensions are based on the width of the core leg which is indicated by W. It only remains to determine the turns, wire size and weight of wire required for the primary or input coil. Referring again to table No. 1 you will find that there are to be 212 turns, and that the winding will weigh about .9 lb. Refer to table No. 5 to find the size of wire needed, which in this case is No. 19.

The coils are wound on a wooden form, as in Fig. 4. The primary is wound first.

our turns, or 12, by this number we get .218 sq. in. as the cross-sectional area of the wire on the coil. Multiplying this number by the distance around the core, as found in table No. 1, we get $8\frac{1}{8}$ times .218, or 1.8, which is the number of cubic inches of wire needed for the coil. Table No. 6 also gives the number of pounds of No. 8 s.c.c. wire per cubic inch as .228. By mul-

The coils are wound on a wooden form, as in Fig. 4. The primary is wound first. The form is cut to a width and thickness slightly greater than the dimensions of the core, which in this case is $1\frac{1}{4}$ by $2\frac{13}{16}$ in., and is covered with two or three layers of heavy brown paper for a distance equal to the length of the coil, which in turn is made $\frac{1}{4}$ in. less than the length of the



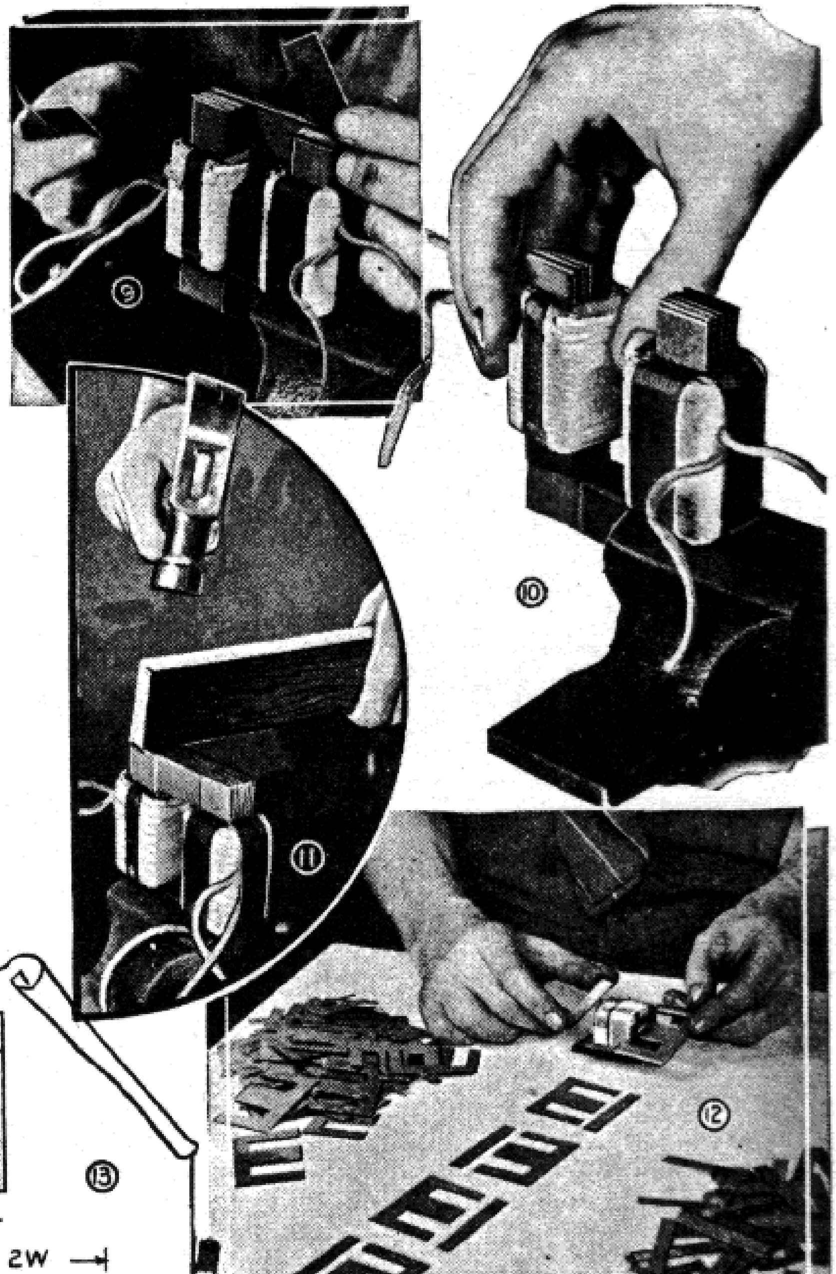


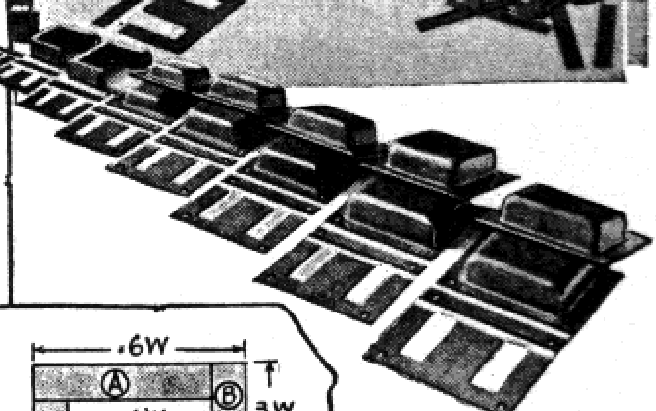
window space. This can be calculated by referring to the lower detail of Fig. 13, and in the example being followed, this length, or 1½ W, will be 1⅞ in. The paper wrapping is held in place with two turns of friction tape. If the first and last three turns of each layer of wire are wound over a length of friction tape, and this is doubled back over the coil, as shown in Fig. 3, the end turns will be securely held in place. A thin sheet of tough paper should be wound between layers of wire if space permits. If there is not room for this, use a sheet between every other, or every third layer. When the primary coil has been completed, cover it with two layers of heavy brown paper and wind on the secondary coil. Great care should be taken to prevent contact between the two coils. When completed, they are slipped off the form and bound with tape, as in Fig. 1. The core is then slipped into the coils, as shown in Fig. 12. After the core and coil have been assembled, they should be impregnated with orange shellac or electrical-coil varnish. If orange shellac is used, heat for 2 or 3 hours. Shell-type transformers may be completed by bolting on a pair of standard pressed-steel end plates obtainable in various sizes corresponding to the core punchings shown in Fig. 12.

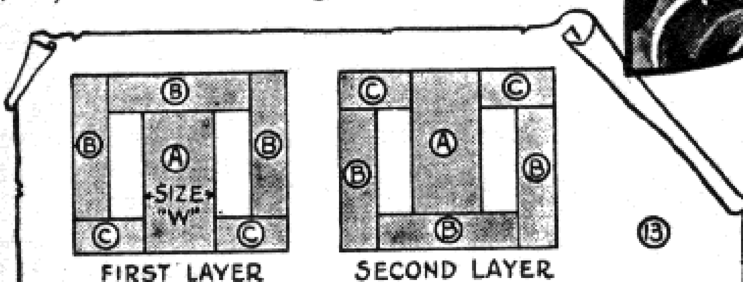
Core-type transformers are easily assembled in a jig, as in Fig. 6, the strips being piled alternately, as shown in the detail above table No. 7. The cores must be bound together and securely taped while held in a vise to avoid hum. Figs. 7 and 8 show the steps for binding a core of this type. The coils are wound separately and slipped on each leg of the core, as in Fig. 10. To do this, remove the laminations from one side of the core, as shown in Fig. 5, replacing these, as in Fig. 9, after the coils have been placed in position. A mallet or block is used, as in Fig. 11, to force the laminations down evenly, after pregnated with orange shellac or electrical-coil varnish. If orange shellac is used, dilute it with an equal volume of alcohol. A large can will serve as a dipping tank. Allow the assembly to soak for about 12 hours, after which it is left to dry thoroughly for an equal period. To complete the drying, bake the transformer at a low

mallet or block is used, as in Fig. 11, to force the laminations down evenly, after which they are taped securely. The transformer may be clamped with channel iron or angle-iron brackets, as shown in Fig. 14, and mounted in a metal box, as in Fig. 16. The cord, which connects the transformer to the supply circuit should be brought into the can through a porcelain bushing. Low-voltage secondary connections are made to brass screws or binding posts mounted on a fiber or Bakelite strip, as in Figs. 16 and 18. Then the can is filled with melted insulating tar, Fig. 17, obtainable at battery-service stations.

If you need a size of transformer not covered in the tables, refer to table No. 5. Locate the desired size, or the nearest one of higher value, in the first column. Opposite this size is a design number needed for figuring the other values. This table also gives the wire size to be used for the primary coil. Let us assume that you want to build a core-type transformer to convert 110 volts to 220 volts on a 60-cycle circuit, and that you will need 5 amp. from the secondary. The watts will be 5 times 220 or 1,1000. Consulting table No. 5,







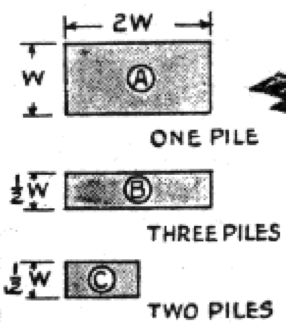


TABLE NO. 7

DIMENSIONS FOR SHELL TYPE OF TRANSFORMER STEEL		
Size "W"	Area of 1 Window in Sq. In.	Weight of Core 1" Thick Lb.
⅝	.29	.50
¾	.42	.73
⅞	.57	.99
1	.75	1.30
1⅛	.92	1.65
1¼	1.16	2.03
1⅜	1.41	2.46
1½	1.68	2.92
1⅝	1.97	3.44
1¾	2.27	3.96
1⅞	2.62	4.58
2	3.00	5.20
2¼	4.22	6.63
2½	4.70	8.25
2¾	5.60	9.90
3	6.70	11.70
3½	9.20	15.90
4	12.00	20.80
4½	15.20	26.40

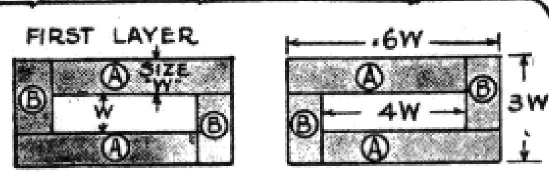
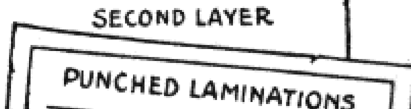


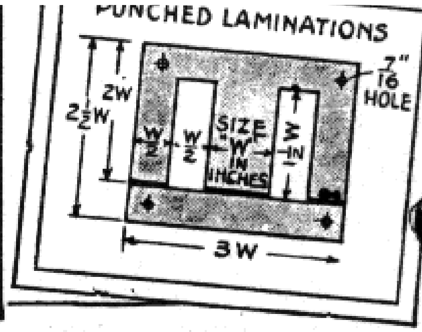
TABLE NO. 8

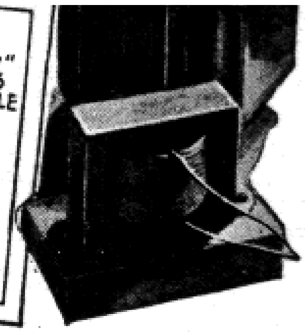
DIMENSIONS FOR CORE TYPE TRANSFORMER STEEL			
	Dimensions of Core	Area of	Wt. of



TRANSFORMER STEEL

Size "W"	Dimensions of Core		Area of Window Sq. In.	Wt. of 1" Thick Core
	A	B		
7/8	7/8 x 4 3/8	7/8 x 1 3/4	3.06	2.9
1.0	1 x 5	1 x 2	4 00	3.8
1 1/8	1 1/8 x 5 5/8	1 1/8 x 2 1/4	5.06	4.8
1 1/4	1 1/4 x 6 1/4	1 1/4 x 2 1/2	6.25	5.9
1 3/8	1 3/8 x 6 7/8	1 3/8 x 2 3/4	7.55	7.2
1 1/2	1 1/2 x 7 1/2	1 1/2 x 3	9.00	8.6
1 5/8	1 5/8 x 8 1/8	1 5/8 x 3 1/4	10 60	10.1
1 3/4	1 3/4 x 8 3/4	1 3/4 x 3 1/2	12 5	11.6
1 7/8	1 7/8 x 9 3/8	1 7/8 x 3 3/4	14 1	13.3
2	2 x 10	2 x 4	16 0	15.2
2 1/4	2 1/4 x 11 1/4	2 1/4 x 4 1/2	20.25	19.1





SHELL-TYPE TRANSFORMERS, TABLE No. 1—50 TO 133 CYCLES

Size of Transformer in Watts	Primary Coil				Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core				
	For 110 Volts		For 220 Volts							
	Turns of Wire	Approximate Wt. of Wire in Pounds	Turns of Wire	Approximate Wt. of Wire in Pounds		Cross-Sectional Area of Core in Sq. In.	Core Size See Core Table No. 7 for Dimensions	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	368	0.4	736	0.4	3.40	2.0	1	2	2.6	.48
100	260	0.7	520	0.6	2.40	2.9	1 1/8	2 9/16	4.3	.60
150	212	0.9	424	0.9	1.96	3.5	1 1/4	2 13/16	5.8	.75
200	184	1.0	368	1.0	1.70	4.1	1 1/4	3 9/32	6.7	.75
250	164	1.3	328	1.2	1.52	4.6	1 3/8	3 11/32	8.2	.95
300	150	1.5	300	1.4	1.38	5.0	1 3/8	3 21/32	9.0	.92
400	130	1.7	260	1.6	1.20	5.8	1 3/8	4 7/32	10.4	.86
500	116	2.1	232	2.0	1.08	6.5	1 1/2	4 5/16	12.6	1.00
600	106	2.6	212	2.5	98	7.1	1 5/8	4 3/8	15.0	1.32
700	98	2.3	196	2.2	91	7.7	1 7/8	4 1/8	18.9	1.87
800	92	3.3	184	3.2	.85	8.2	1 7/8	4 3/8	20.0	1.92
900	87	3.4	174	3.3	.80	8.7	2	4 3/8	22.8	2.10
1000	82	3.3	164	3.2	76	9.2	2	4 5/8	24.2	2.15
1250	75	3.5	150	3.5	.70	10.0	2	5.0	26.0	2.15
1500	67	4.2	134	4.1	.62	11.2	2	5 5/8	29.4	2.00
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	2,600 / Design No.	See Table No. 6 for Pounds per Cubic Inch	5,200 / Design No.	See Table No. 6 for Pounds per Cubic Inch	24 / Design No.	.29 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 7	Check to See if Your Coils Will Fit Space

SHELL-TYPE TRANSFORMERS, TABLE No. 2—25 TO 40 CYCLES

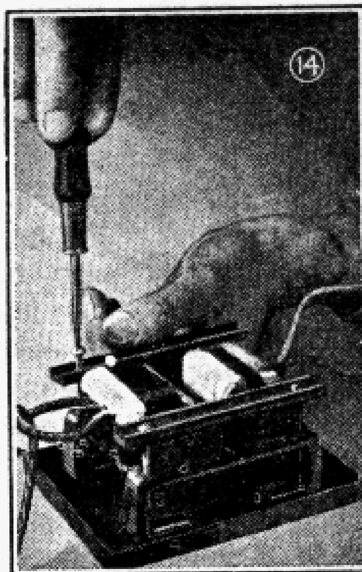
Size of Transformer in Watts	Primary Coil — For 110 Volts: Turns of Wire	Primary Coil — For 110 Volts: Approximate Wt. of Wire in Pounds	Primary Coil — For 220 Volts: Turns of Wire	Primary Coil — For 220 Volts: Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core: Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 7 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	565	0.8	1130	0.7	5.23	3.2	1⅜	2 11/32	5.8	.99
100	400	1.2	800	1.0	3.70	4.5	1½	3	8.8	1.18
150	327	1.7	654	1.6	3.02	5.5	1⅝	3 13/32	11.7	1.35
200	283	2.0	566	1.9	2.62	6.4	1¾	3 21/32	14.5	1.59
250	253	2.2	506	2.1	2.34	7.1	1¾	4 1/16	16.0	1.56
300	231	2.6	462	2.4	2.14	7.8	1¾	4 7/16	17.6	1.52
400	200	3.0	400	2.9	1.85	9.0	1⅞	4 13/16	22.4	1.81
500	179	3.6	358	3.4	1.66	10.0	1⅞	5 11/32	24.4	1.74
600	164	4.2	328	4.0	1.52	11.0	2	5½	29.6	2.01
700	151	4.6	302	4.4	1.40	11.9	2¼	5¼	29.8	2.08
800	141	4.6	282	4.4	1.30	12.7	2¼	5⅝	31.6	3.16
900	134	6.4	268	6.2	1.23	13.5	2½	5 13/32	44.5	3.33
1000	127	6.2	254	6.0	1.17	14.2	2½	5 11/16	47.0	3.40
1250	117	7.0	234	6.9	1.08	15.5	2½	6 7/32	50.1	3.23
1500	104	8.3	208	8.1	.96	17.4	2½	6 15/16	57.5	3.19
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	4,000 / Design No.	See Table No. 6 for Pounds per Cubic Inch	8,000 / Design No.	See Table No. 6 for Pounds per Cubic Inch	37 / Design No.	45 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 7	Check to See if Your Coils Will Fit Space

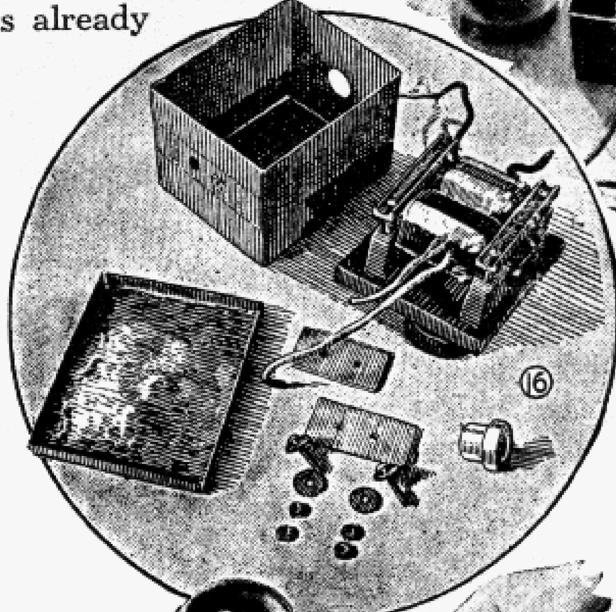
CORE-TYPE TRANSFORMERS, TABLE No. 3—50 TO 133 CYCLES

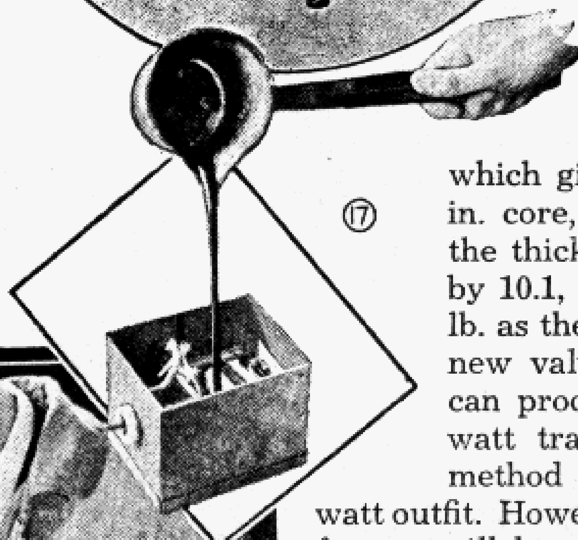
Size of Transformer in Watts	Primary Coil: For 110 Volts — Turns of Wire	Primary Coil: For 110 Volts — Approximate Wt. of Wire in Pounds	Primary Coil: For 220 Volts — Turns of Wire	Primary Coil: For 220 Volts — Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core: Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 8 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	1100	1.3	2320	1.2	10.60	.657	7/8	3/4	2.2	2.06
100	820	2.0	1640	1.8	7.50	.93	1.0	15/16	3.6	3.00
150	670	3.2	1340	2 9	6.13	1.14	1 1/8	1 0	4.8	3.46
200	580	3 6	1160	3.4	5.30	1.32	1 1/8	1 3/16	5.7	3.36
250	518	3.7	1036	3.5	4 74	1.47	1 1/8	1 5/16	6.3	3.36
300	473	4 5	946	4 3	4.33	1.62	1 1/4	1 5/16	7 8	4.25
400	410	4 9	820	4.7	3.75	1 86	1 1/4	1 1/2	8 9	4.25
500	368	5.7	736	5 5	3.36	2.08	1 3/8	1 1/2	10.9	5.35
600	335	7.3	670	7 0	3.06	2.28	1 1/2	1 1/2	13.0	6.40
700	310	9.7	620	9.4	2.84	2.46	1 5/8	1 1/2	15.2	7.40
800	290	9.2	580	8 9	2.65	2.63	1 5/8	1 5/8	16 4	7 60
900	273	10 2	546	9.9	2.50	2.79	1 5/8	1 3/4	17.7	7 40
1000	260	9 9	520	9.7	2.38	2.94	1 5/8	1 13/16	18.3	7 50
1250	239	11.8	478	11.6	2.18	3.20	1 5/8	2.0	20.5	7.10
1500	212	15.7	424	15.5	1.94	3.60	1 3/4	2 1/16	24.0	8 40
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	8,200 / Design No.	See Table No. 6 for Pounds per Cubic Inch	16,400 / Design No.	See Table No. 6 for Pounds per Cubic Inch	75 / Design No.	.093 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 8	Check to See if Your Coils Will Fit Space

CORE-TYPE TRANSFORMERS, TABLE No. 4—25 TO 40 CYCLES

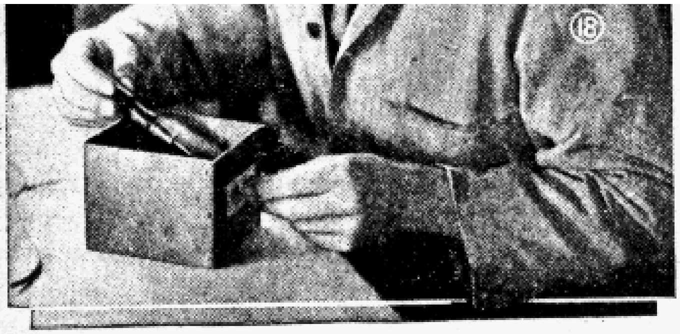
Size of Transformer in Watts	Primary Coil: For 110 Volts: Turns of Wire	Primary Coil: For 110 Volts: Approximate Wt. of Wire in Pounds	Primary Coil: For 220 Volts: Turns of Wire	Primary Coil: For 220 Volts: Approximate Wt. of Wire in Pounds	Turns per Volt for Secondary Coil	Dimensions for Silicon-Steel Core: Cross-Sectional Area of Core in Sq. In.	Core Size (See Core Table No. 8 for Dimensions)	Thickness of Compressed Core	Approximate Wt. of Core	Sq. In. of Window Left for Sec. and Insulation
50	1795	2.5	3590	2.1	16.40	1.01	1	1	3.8	2.5
100	1270	3.8	2540	3.5	11.60	1.44	1 1/8	1 1/8	5.4	3.1
150	1036	5.9	2072	5.5	9.50	1.76	1 3/8	1 1/8	8.1	5.0
200	898	6.4	1796	6.0	8.20	2.19	1 3/8	1 9/16	11.2	5.0
250	802	6.9	1604	6.6	7.33	2.28	1 3/8	1 11/16	12.1	4.9
300	733	8.6	1466	8.2	6.69	2.50	1 1/2	1 11/16	14.5	6.0
400	634	9.4	1268	8.9	5.80	2.88	1 1/2	1 15/16	16.6	5.9
500	568	11.5	1136	10.9	5.20	3.22	1 5/8	2.0	20.5	7.1
600	519	13.5	1038	13.0	4.75	3.52	1 3/4	2.0	23.2	8.6
700	479	18.3	958	17.7	4.38	3.81	1 7/8	2.0	26.6	9.2
800	448	17.3	896	16.7	4.10	4.07	1 7/8	2 3/16	29.1	9.5
900	423	19.2	846	18.7	3.87	4.33	1 7/8	2 5/16	30.8	9.2
1000	402	18.7	804	18.2	3.67	4.55	1 7/8	2 7/16	32.4	9.6
1250	369	22.4	738	22.0	3.37	4.95	2.0	2 1/2	38.0	10.6
1500	328	36.0	656	35.4	3.00	5.57	2 1/4	2 1/2	48.0	13.9
EASY METHOD OF FIGURING VALUES FOR OTHER SIZES										
Select Size to Suit Purpose	12,700 / Design No.	See Table No. 6 for Pounds per Cubic Inch	25,400 / Design No.	See Table No. 6 for Pounds per Cubic Inch	116 / Design No.	144 × Design No.	Select Core Size with Window Large Enough for Windings	Cross-Sectional Area / Core Size	Weight = Thickness of Core × Wt. per Inch. See Table No. 8	Check to See if Your Coils Will Fit Space







you find the design number for 1,100 watts to be 33.20, and that the primary coil should be wound with No. 9 wire. Remembering this, you turn to table No. 3, which contains formulas for calculating 60-cycle, core-type transformers. In the space under the first column listing the size in watts, write 1,100, which you have already found. For the second column divide the design number, or 33.20, as found in table No. 5, into 8,200 and you will get 247 for the number of primary turns. The weight of primary wire for the next column, and the weight of secondary wire may be calculated later by the same method as has already been outlined. The secondary turns per volt is next determined by dividing 75 by the design number, in this case 33.20, which gives 2.25. Likewise, multiplying .093 of the next column by 33.20 gives 3.08 for the cross-sectional area of the core. To decide on a core size, look up the column and select a size proportional to those given for other sizes of transformers. In this case $1\frac{5}{8}$ in. will be satisfactory. The thickness of core needed can now be figured by dividing the area already found, or 3.08, by the core size, or $1\frac{5}{8}$ in., which gives 1.89, although we can use a $1\frac{15}{16}$-in. core to make it even. The weight of steel needed can be found by referring to table No. 8, which gives the weight of a $1\frac{5}{8}$-in. core, 1 in. thick. Multiplying the thickness of the core, or $1\frac{15}{16}$ by 10.1, gives approximately $19\frac{1}{2}$ lb. as the core weight. With these new values for table No. 3, you can proceed to design the 1,100-watt transformer by the same method as was used for the 150-watt outfit. However, the 1,100-watt transformer will have more turns on the secondary than on the primary, and is therefore a step-up transformer. Special care



ondary than on the primary, and is therefore a step-up transformer. Special care should be used to assure good insulation when high-voltage coils are built.

When designing transformers, one should always check the window space of the core to make sure that it is large enough. If the coil requires more space, select a core of the next larger size. In changing the core size, divide the cross-sectional area of the core, as given in tables No. 1 to 4, by the width of the new core, to find the proper thickness to use. For low-voltage transformers, where the amperage is high, it is best practice to wind several small wires side by side at the same time, connecting them together at each end, instead of using a single large wire. The total circular-mil area of the small wires must be equal to that of the single wire for which they are substituted. Welding transformers, passing several hundred amperes, should have secondary windings of heavy copper ribbon or strips of sheet copper. To figure the number of amperes a strip of copper can carry safely, multiply the width by the thickness to get the cross-sectional area in square inches, and multiply this product by 1,275. Copper ribbon or strips of sheet copper are insulated before winding by wrapping them with plain linen tape or strips of varnished cloth. Splices must be soldered.