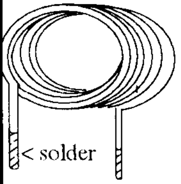
Coils & Transformers

COILS FIRST: There are dozens of coil styles (shapes, sizes) for electronic circuits. Sometimes you will have to buy the coil as it is just too complex to make by hand and you may not have access to the correct "INDUCTOR" to wind it on anyway. The core of a coil is sometimes metal (iron) or powdered iron (pressed into a cylinder shape) and sometimes just empty space, or "air' (or a cardboard tube). A coil is referred to as an inductor and sometimes the core material is also called an inductor; a bit of confusion but don't worry about it now.

We will describe a couple of simple types and you'll learn about others as you work with circuits.

The simplest type coil is an 'air-core', made of a few turns of "magnet wire". There is nothing special about magnet wire; it comes in different gauges ranging from very fine to heavy wire. So-called magnet wire is copper wire with a coat of varnish; or now most magnet wire has some form of plastic polymer coating as varnish is old fashioned.



In one of our circuits, you'll be advise that component no. L1 is a coil wound of 22 gauge magnet wire, seven turns on a 1/4" core. So, you locate some 22 gauge wire and your 1/4" drill bit and wind seven turns and leave a couple of legs sticking out to solder to. Wind the turns "should-to-shoulder or tightly with each turn touching the one before it. Sometimes you'll be told to spread the turns out so that none of the turns touch each other. Still, wind 'tight' first and spread later; you'll see how evenly a coil then spreads pulling on the ends.

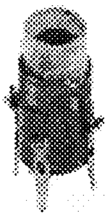
You'll need to remove the magnet wire's insulation at the point where you will solder the coil into a circuit. You can scrape it off or sand it or remove it with solvent; whatever works so that solder will stick.

When the instructions call for a 1/4" diameter and 22 gauge wire, don't fudge. Don't change the wire gauge from 22 to 23 and be sure to wind exactly six turns if that is what is called for. Coils are used as a component with a capacitor to control frequency in tuned circuits, such as radio receivers or transmitters. Changing the wire or number of turns will de-tune the circuit.

Coil values are stated in 'henrys'. These might be millihenrys mh or microhenrys uh.

A coil wound on a cardboard coil form with an iron core (usually pressure-formed iron particles) can be 'tuned', or adjusted if the core is made to move inside the coil (usually a screwdriver style movement). This kind of tuning or adjusting is referred to as 'tweaking' and should be done only with a non-magnetic tool such as plastic, nylon or beryllium. Otherwise, the tool will change the setting and you'll never get it right.

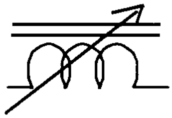
A ChokeCoil can be used to oppose changes in current flow.



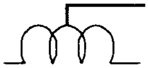
COIL: On your left is a typical 'tunable" coil. The 'slug' in the center is sintered iron filings and can be moved up and down with a plastic screwdriver. Note the three leads; this coils is tapped in the center.

The coil symbol is pretty simple; (left)

Symbol for coil with an iron core.



Symbol for an adjustable coil with an iron core.



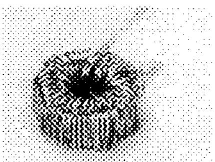
Symbol for a coil with a center tap.

tip: In the case where you are told to "spread the turns" to be, say 1/8" apart, you could simply pull the plastic insulation off of any copper 22 gauge wire and forget about buying the special 'magnet wire'. But if the turns are going to touch each other, you must use the magnet wire as its coating of insulation will assure that turns do not touch each other.

Do not use insulated hook-up wire unless you remove the insulation. Insulation has an affect on the magnetic field around the wire and changes the coils 'inductance' value.

(OK, In a Pinch *in a simple circuit*, you might be able to substitute a slightly different wire size, but don't cheat anymore than you have to. All of these coil 'specifications' are important to the coils inductance being correct. Sometimes you can use a different wire size and offset that change by spreading turns apart or pinching them together. Mostly, however, you won't get enough of a change to make it work properly.

Coil, inductor, filter, and choke are terms used for variations on the coil



A choke coil, top, can block Radio Frequency. Below, a toroid, can be used as an R.F. transformer etc.

Said another way, a coil can be wound to pass some frequencies but not the one you want to stop; which get fouled up trying to get through. Coils can be used to block R.F. (radio frequencies) but let direct current pass.

Coils can be complicated with a lot of "taps" at various places in the windings. Worry about understanding those much later.

TRANSFORMERS are coils, the simple ones having two coils inside, both wrapped around an iron core. Picture a coil wrapped around a core having 10,000 turns; call this the primary coil. Then we wrap another coil on top with 1,000 turns and call it the secondary. When we plug the primary into the 110 volt A.C. wall outlet, guess what we get on the secondary coil ? Simply 1/10 the voltage or 11 volts. The ten to one ratio between the primary and secondary coils give us the same ratio in voltages. We could turn the coil around and plug the secondary into the wall outlet (in theory, do not do this!) and get ten times the voltage. , or 1,100 volts. The ten to one ratio can be worked in either direction.

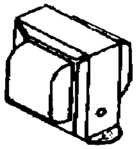
Transformers only work with A.C. (alternating current), such as that from a wall outlet or in a radio circuit or audio circuit. The constant rising and falling and reversing in one coil transfers energy as the magnetic field expands and collapses and a secondary coil(s) wrapped around the same core will pick up this energy. Small secondary coils will pick up less of the primary's energy and big secondary coils will pick up more. Transformer design is a science and serious study is required to be conversant in this field.

When a transformer converts voltage down to a lower voltage and we add some diodes in a circuit called a full wave bridge rectifier, we have a D.C. (direct current) power supply; such as the one in the column to your right. This style, called a 'wall adaptor' we know from use with our radio, laptop computer , calculator etc. Be sure to look up bridge circuits in your theory book because they are a basic component in many, many electronic circuits.

There is a lot more to transformers that we cannot cover here. Such as the secondary having a 'tap' . A tap in the center of the secondary will yield 1/2 the voltage of the complete secondary. Transformers can have several taps. And transformers can be made for audio instead of power. Or made for radio frequencies, and the shapes become quite different from the power transformer.

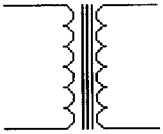
When placing a transformer into a circuit, you absolutely must connect the primary in the right place and the secondary as well. Sometimes the transformer will have color code lead wires and the manufacturer packs a 'schematic' with the unit. And sometimes the transformer will be made for printed circuit mounting with 'pins' sticking straight down through the board to be soldered into the PC board. In this case, the unit may be designed so that you can only install it facing the correct direction. —‡

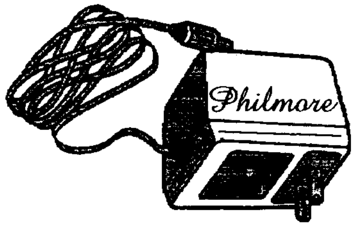
NOTE: After you get a feel for building kits and assembling circuits, think about building a power supply. A good power supply circuit, or several power supplies for different voltages, can save you money that might otherwise go for tons of batteries.



TRANSFORMER

The drawing to you left is a familiar transformer shape; you'll see this type in sizes from very small up to to 5" on a side or larger. Note that the symbol looks like a couple of coils with an iron core ; that is what a transformer is.





POWER SUPPLY

Above is a sketch of a typical "wall adaptor" which is just layman terms for either a transformer or power supply. If the output is A.C., it is simply a transformer. It the output is D.C., it is a power supply with a bridge (rectifier) circuit and probably a filter capacitor to reduce 'ripple'.

Depending upon the transformer's windings, the voltage can be just about anything; from 3 volts to 18 volts D.C. is very common. Because the transformer is small, power is usually just 200 or 300 mA (milliamps) or, two to three tenths of an ampere.

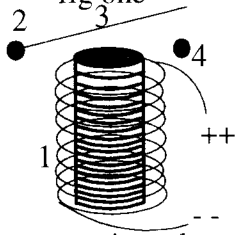
These are typically not ***regulated power supplies,*** which means that the voltage may be a lot higher than the unit's rating when nothing is connected to the unit, and close to the rated voltage when in use at the peak rated current. The voltage of an unregulated power supply will be high with no load, and drop further and further as the current draw increases.

A handy power supply for the builder to have is one that can be switched to different voltages, such as the Philmore number BE226 (up to 300mA) or the BE240 (up to 800 mA).

more "COILS' TWO ...

Another 'COIL' that you will run into very early in your kit building career, will be the one in the RELAY. Like the nail on the last page, the relay has an iron core that looks a bit like a nail, it's an iron rod. Around this iron core, turns of magnet wire are 'wrapped' so that an electro-magnet is created when a voltage/current is applied to the two ends of the coil, just like the nail on the last page. (We marked the coil ends "++ - -" in our sketches, and we don't show power applied to the coil ends so just imagine that there is power in figures two and three, applied at ++ and - - .

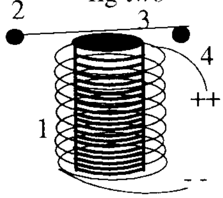
fig one



not activated

In most cases, you won't see the relay's coil; it will be hidden inside a plastic case or insulating sleeve or some such. You will see the coil's contacts as well as the contacts for the ***switch*** that the relay coil operates. Relay coils will come rated at different voltages, which is the amount of voltage that should be used to trigger them.

fig two

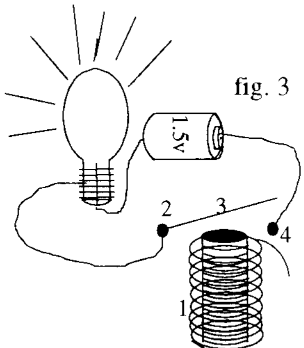


coil energized

Now this is a neat idea. When electricity is applied to the coil (at ++ and - -), an electro-magnet results and pulls on an armature (3) to move it so that it touches an electrical contact (4). When no power is applied to the coil (as in figure one) the armature we call '3' is spring loaded and stays away from the coil's iron core. . Voltage cannot between the contacts at at '2' and '4' to complete the circuit unless the coil pulls in the armature, which happens in figure two .

We are asking you to imagine a voltage applied to the coil in these sketches; which might be a little battery.

fig. 3



When activated, the light will come '

With power applied to the coil , the coil is *energized, which means it becomes an electro-magnet* (fig. two) and the armature is pulled in toward the coil's iron core. Then, the armature touches an electrical contact and closes the circuit and voltage can flow from contacts 2 to 4. The armature will stay pulled in as long as the coil is energized but will spring back to the position in fig one as soon as you remove the power from the coil.

How the relay is used. The relay is a switch, an electrically activated switch. The switch contacts at nos. 2 and 4 are the switch connections. Let's say that we connect the contacts at 2 and 4 into a circuit with a battery and a light bulb; as in the sketch at figure three. When this circuit is *closed* by putting power into the coil which pulls in the armature (3), the bulb is going to light.

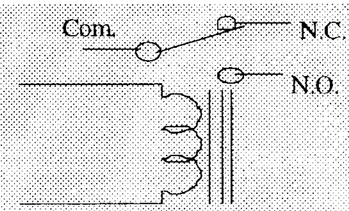
Where the relay is used. You use a relay often, probably everyday. One common use is in the automobile for the headlights. Headlights take a lot of power and a small dashboard switch is practical.

When the thermostat in the refrigerator senses a certain temperature level, its delicate little contacts switch a relay that turns on the compressor motor, which is a big, brute of a power user. Same thing in your home washing machine. These big motors require big relay contacts

When you push a button in an elevator, it triggers a circuit that turns on the elevators motor. And, finally, one common use for the relay is on the output of a logic circuit. Alarm systems, for example, have low voltage circuitry and when it 'triggers' a small voltage is all that is available. That low voltage can be applied to a relay coil to switch 'on' the much larger voltage of a siren or horn or turn on lights etc.

There are more complex types of relays in addition to our simple SPST (single pole, single throw) unit in the sketches. You could also have a closed circuit that is opened when the relay is actuated. OR, two circuits could be switched at one time, such as a light and a siren.

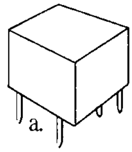
Solid State relays are replacing Coil-types in some applications and we expect to see more of this as time goes by.



Here is a schematic symbol for a relay. The contact marked "N.O." is ***normally open***; i.e. when no power is applied to the coil, there is no contact: the circuit is 'open'.

And then there is a contact marked "N.C." or ***normally closed.*** This contact is connected to the ***Common*** contact when no power is applied to the coil. You will sometimes see these terms marked on the relay's case. If the case is not marked, you can identify the leads with an ohm meter.

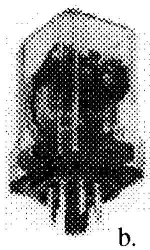
RELAY TYPES



a.

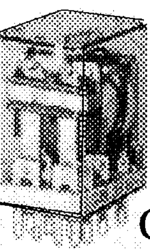
Relays often don't look like coils and contacts anymore. To your right is a sketch of a typical modern PC mounting relay, slightly smaller than actual size. The case is plastic and very tough. The pins sticking down below the case are made to pass through a PC board and soldered in place. These pins, of course, are the connections for the coil and switch contacts.

A relay made in this style is very tough, can pass through automated assembly and PC board washing (soap and water) equipment without fear of damaging the interior contacts.



b.

Some relays are made to fit into a socket, which makes quick replacement easy. Automobiles use this approach but you'll see many in electronics as well. Here is one picture (b.) of a relay made to fit an octal socket, which is an ancient design that was originally developed for vacuum tubes back in the 1930's.



C.

Relay "C" has solder type lugs for the contacts and the manufacturer also makes a socket; so you may use it either way. Note that the coil and armature with contacts are visible through a clear plastic case. The photo is about 80% of full size of this relay. ‡ ‡ ‡

Odds and ends..

Magnet wire, a solid copper wire usually insulated with enamel or varnish, is normally used in the winding of iron-core transformers. In most applications, the wire is evenly wound around the core in rows adjacent to each other. Additional layers may be applied on top of the preceding layer. Sometimes, especially in the case of high-frequency switching power supplies, these layers might be separated with an insulating material between each layer. Take an old transformer apart and have a look. And save the magnet wire for use later in projects.

Magnet wire is used in transformers, speaker voice coils, solenoids, buzzer coils, relay coils as well as radio frequency (R.F.) coils and chokes. And that is not to mention non-electronic items such as electric motors. Some types have an insulation that is stripped by heating, such as soldering. Other magnet wire insulation may be plastic and tough to scrape away but easy to dissolve in toluene or other solvents.

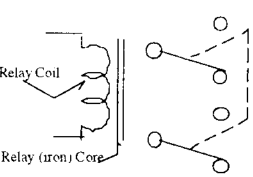
Suppliers of electronic components (in every major town) will have magnet wire in many different gauges

What to look for in a relay..

When you buy a relay, there are two very important features to begin with. The first is the ***coil voltage***. This is the voltage that is needed to 'work' the coil. You will see relays available from about 1.5 volts on up to 3, 6, 9, 12 volts D.C. and up and also with a coil voltage of 110 Volts A.C. Of secondary interest will be the coil current; which is the amount of current (amperage) that the relay will draw at the stated voltage.

Once you have found a relay that will operate at the desired coil voltage, you need to be sure that the ***contact ratings*** are high enough. Contacts are generally rated in Amps and if you will be switching a circuit (or lamp etc.) that requires seven amps, buy a relay with contacts rated at ten amps. Using a unit that is a bit (or more) above the circuits maximum current is playing it safe.

You'll also note that , like switches, relays will be available with much more than an SPST switch. There will be many varieties of relay switch contacts, including, DPDT etc. But remember that if you want to switch just one circuit, you can always use a DPDT or SPDT etc. and just use one set of contacts. And remember that you can also use a relay to turn a circuit 'off' when it is activate if the relay has a normally closed set of contacts when not activated.



A more complex relay. Note the schematic diagram of a relay to your left. The coil is wound around an iron core. You can recognize the coil and the two bars representing the core in this schematic symbol. This symbol represents a relay with two switch 'wipers' in it; two different circuits can be switched. Shown here at rest, you can see the common contacts are making contact with the 'normally closed' contacts. The dotted line indicates the two wipers will move in unison; i.e. they are *mechanically linked.* When activated (voltage to the coil) the magnet pulls the wipers, breaking contact on one set of terminals and making contact with the normally open set of contacts. You can check a relay with your ohm meter to see which set of contacts are normally closed. §