INSTRUMENT PANEL LIGHTS

CESSNA 120/140/140A

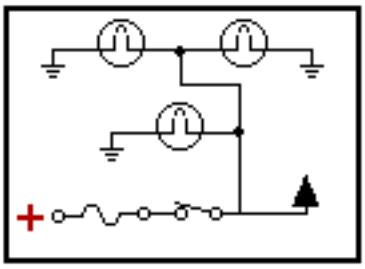
In The Beginning:

The lighting systems went through a few changes which were not well documented, making the selection of replacement parts difficult to determine. This article started out to be an aid to an owner who wanted to know which of the two values of rheostats from a catalog supplier would work best. Simple turned out not to be simple.

Cessna did poorly on the parts manuals for the planes before the 140A, and those shortcomings include this circuit. They failed to note what the values of wattage and resistance were for the rheostat, and they fail in the wiring diagram to illustrate the rheostat circuit. Later, for the 140A wiring diagrams, they fail to show the resistor they added to the circuit for those planes and the 120 kit has lamp sockets but no lamps.

Use caution when taking any statement as absolute, partly because there have been so many changes made to our planes which were not entered in the logs, and partly because a careful search of the 140 manuals will show there are six instrument lamps on the standard planes, 7 on those with an optional instrument, and 8 with another special instrument. Moreover, some 140A's could have two light control rheostats, the second added as part of the instrument kit.

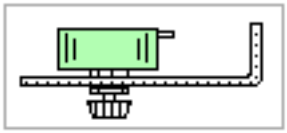
1946 Planes:



The 1946 model planes had a very simple instrument light circuit. Three lamps in sockets, a switch for these and the nav lights, a fuse that also fed the landing light motor, and wires. Grimes 3CP Red lamps gave way to type 1816, also 3 candlepower. Your choices were for lights off or lights on, and nothing between. A table later in the article presents the amperage of each of the lamps used or suggested as possible alternatives. The 1816's are still available, and, from the later tables, you have plenty of alternatives for lamps, with parameters which might better fit your needs.

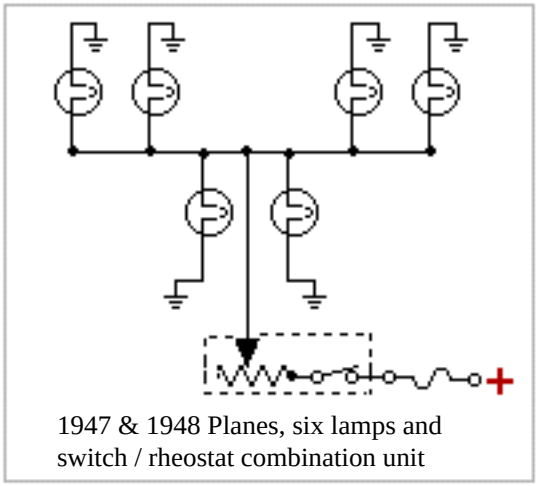
1947 and 1948 140 Changes:

The 1947 and 1948 models were fancier to match the new distributed instrument panel and "standard" planes had six 1826 lamps, the same fuse, and now a rheostat-switch combo to allow dimming, a much better arrangement. The rheostat was mounted to and forward of the right bottom edge of the instrument panel on a bracket suggested by the figure below. The parts manual representation is on the last page and my cicuit sketch is the first figure on the next page.



Cessna failed to show the circuit connections of the rheostat in the wiring diagrams but their installation figure does indicate there are only two terminals so it is definitely a rheostat that it used. The rheostat was too small, wattage-wise and being in the can meant that heat had a hard time being dissipated. Cessna also neglected to show that the rheostat's wiper could be moved off the end of the annular resistor and therefore break the circuit like a switch. The next figure illustrates those features.

There is no designated instrument panel light switch on the instrument panel. Combine that with a well-hidden rheostat and it is likely that a lot of planes flown only in daylight have their instrument panel lights on all the time. The operating manual does not acknowledge that there are instrument lights.



1947 & 1948 Planes, six lamps and switch / rheostat combination unit

The lamps for these newer planes was the G.E. 1826; the mystery is why they chose to use an 18 volt lamp with poor life for a 12 volt system. The 1826 did use a lot less current, less than half of the previously used 1816. If they had used the same lamp as on the '46 planes, the '47 and subs would have meant they would need a larger wattage rheostat but they kept the same rheostat on all the planes and reduced the current by more than half by changing to the 1826.

The 120's:

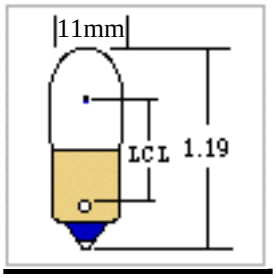
The 120's could be ordered with or without electrical systems. Many without were later modified by installing the electrical kit for the 120's. There was a separate kit for the instrument panel lighting, and their separate page and figure callout in the parts manual is typical Cessna. The holders for the three lamps are there, but no lamps are noted or called out. One must assume they meant to call out the 3 candlepower lamps as for the '46 models. Three lamps that were on when the exterior lights were on, and no rheostat for control.

Switch or No Switch?

In the sketches of the various plane circuits, I have shown switches. Rheostats are often made with a position such that the wiper can be moved from contact with the resistive wire to a "pad" of ceramic. Cessna should have included a switch on the instrument panel for the circuit; without means the lights would be on all the time since there is no indicator. I was sent an original rheostat and determined that there is a off position of the wiper; Cessna left that feature off the wiring diagram. All of my sketches show the switch/rheostat unit.

Lamps:

The lamps which fit the physical size requirements are listed to allow substitution when the original lamps are not available and to let you see what the effect might be if the currents are quite different. Compare their features as indicated in the table. All are the 12 volt type except for the 18 volt 1826, and all are size T-3-1/4, with a Miniature Bayonet base. When buying a lamp, you must use both T 3-1/4 and Miniature Bayonet as a full description because there are many lamps with one, but not both of these features; this is why the part number is important. MSCP stands for Mean Spherical Candle Power, which translates for us into relative brightness. The Life is noted, but it is really "Rated Lab Life" and may not be seen in practice in a shaky airplane. The amperage is that at the rated voltages, with the resistance derived from that relationship. When six lamps of X resistance are in parallel, the combined resistance is shown in the "Parallel R for 6" column. It is that value which determines the best rheostat and its effectivity.

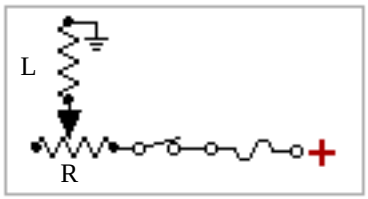


Lamp Number	Amps	MSCP	Life (hours)	Resistance	Parallel R for 6
1816 Available, acft	0.33	3	1000	36	6
1813 Available, acft	0.1	0.86	1000	120	20
1815 Available acft	0.2	1.4	3000	60	10
1891 Available, auto	0.24	2	3000	50	8.3
1889 Available, auto	0.27	2	2000	44	7.4
1893 Available, auto	0.33	2	7500	36	6
1892 Available, auto	0.12	0.75	1000	100	16.6
1826, not GE, but special Sunray	0.15 at 18V		250	120	20

Rheostat Circuits and Light Intensity:

By tests I made, one needs to get the voltage across the lamps down to about two volts for the current to barely light the filament when directly observed in the dark. This may seem a bit odd, but there is no advantage of taking the voltage lower because that would require a higher resistance value of the rheostat, very high.

The six lamps are represented in the figures by the L (load) and the Rheostat by R. When there are six items in parallel which have the same resistance, the combination resistance appears to be the individual resistance divided by six. For the 1816 or 1893 lamps, with an individual resistance of 36 Ohms (12 volts / 0.33 Amps), the L they represent together would be 6 Ohms. If you believe my contention that the voltage across the lamps needs to be reduced to about 2 volts in order to have them barely glow, the ratio of resistance values of the Load and the Rheostat is this:

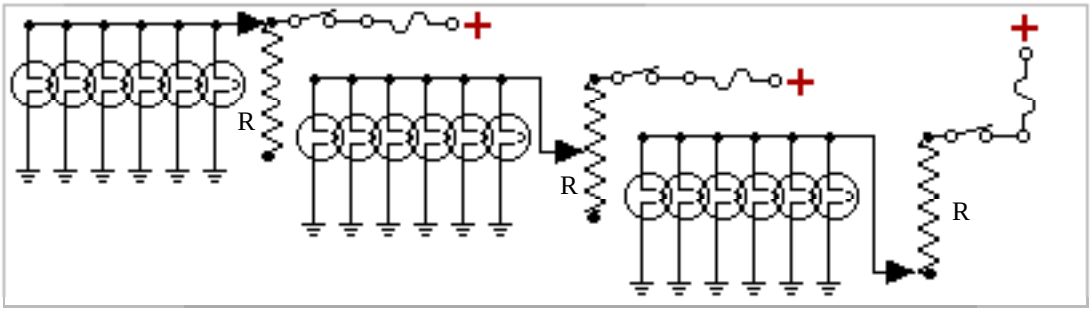


R is to 10 volts as L is to 2 volts.....R/10 = L/2.....R= (10) L/2/ R=5 L R=(5) 6 R= 30 Ohms. If you let the lowest voltage be four volts and accept the fact that you could still see the instruments in full dark, then the value of the rheostat could reduce to a more-available 12 ohms.

Repeating that equation, but for the type 1815 lamp, which takes 0.2 Amps at full brightness, each would have a resistance of 12 / 0.2 = 60 Ohms. Six in parallel would be ten Ohms. To arrive at the value of the rheostat which would give a lowest voltage across the lamps of 2 volts: R/10 = 10/2 R= 100/2 R=50 Ohms.

A more appealing value could be realized if you let the minimum voltage be about 4 volts. For the 1891, 1893, and 1816, I tested at four volts and found that the illumination is "mellow". You will be able to see by the lamps at this setting when it is very dark, but they would have small effect on your night vision for looking outside. If four volts minimum lighting is acceptable, then the 1891's would achieve that value if you used a rheostat of 16 Ohms, close enough to the 15 Ohms/25 Watts of the Spruce catalog. A rheostat of 30 Ohms could reduce the voltage of the 1893 and 1816 lamps to 2 volts at the dim end, and 2 volts would give you very little glow.

To determine the wattage necessary for the rheostat, multiply the maximum current for the six lamps of the contemplated selection and multiply that by 14 (the actual bus voltage when charging) and you will see you are at 25 watts for those which use 0.33 Amps maximum and 16.8 watts for those using near the 0.2 Amps range. The design rule for a rheostat is that you are "supposed" to select a wattage for the highest current that could be seen by the unit, even though only one segment of the wirewound unit is actually in the circuit at full brightness, and full current. The recommended wattage? 25. The wattage of the Cessna unit is less than 25 based on the admonition in the 140A book to not use anything but the lower current 1826 because the 1816 used in the '46 planes would cause the rheostat to get too hot and burn up.



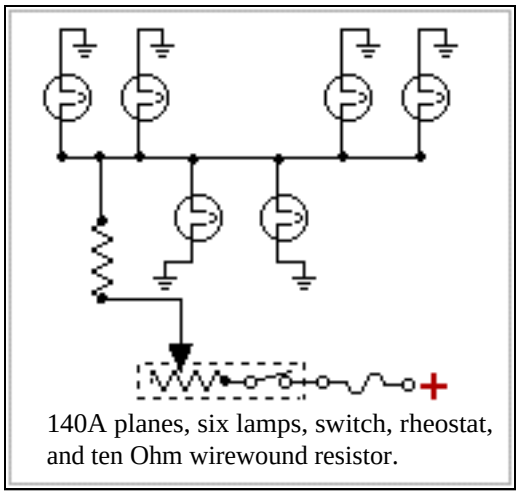
In the three circuits shown you have the three positions; A) full voltage across the lamps with the rheostat doing nothing and the lights at full bright; B) partial voltage for an intermediate intensity; and C) with the rheostat's entire resistance in the circuit and the lights as dim they can be, dependent on the ratio of the lamp resistance and the rheostat resistance.

One way to further lower the brilliance of the lamps would be to add a resistor, and that is what they did for the 140A planes.

140A:

The 140A planes also used the six type 1826 lamps and the same rheostat but Cessna added a ten Ohm resistor in the control circuit, but again forgot to show it in the wiring diagrams (both of them). There had to be a reason for the changes but Cessna did not say "why" so the guess is that the resistor either kept the rheostat from overheating or they needed to further reduce the light from the lamps when Dim, or perhaps both reasons. They mounted the rheostat as on the 47/48 planes and the tiny sketch in the manual appears to show this relationship of the rheostat and the adjacent 10 Ohm wirewound resistor, with a wire from the rheostat to the resistor. A better sketch follows later on this page.

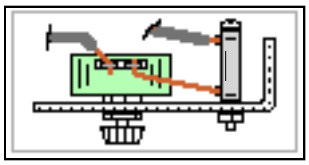
The figure shows the circuit used on the 140A to control their six 1826 lamps of the instrument lighting. GE has not listed the 1826 for more than 15 years according to my GE documents. One member noted that he had purchased some "GE 1826" lamps, red coated, from a company near Los Angeles. That note, the data, and the cost are at the end of this article. Weird stuff. The lamp is an 18 volt model, with a current at that voltage of 0.15 Amps. These substitutes are not made by GE, but "for us", which usually means Taiwan.



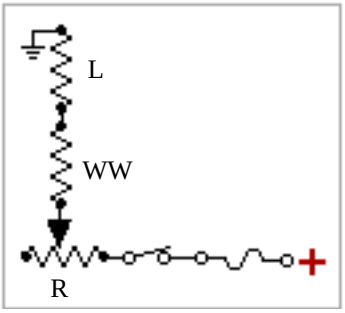
140A planes, six lamps, switch, rheostat, and ten Ohm wirewound resistor.

Why did Cessna use the only 18 volt lamp ever listed? To reduce the current was the reason in my old note, to keep the rheostat from burning up and because there was too much light at the Dim setting with the previous lamps. The Cessna note stated that substitution of the higher current lamps such as those used in the '46 models would burn up the rheostat. None of the listings of the lamps show the suffix R as in 1826R, which would mean they were coated in red paint so as to glow red but it is possible they were coated and that fact hidden by using the special Cessna part number instead of the generic lamp part number. If coated in red material, the light yielded from any lamp would have been much less than that from non-coated lamps. There was a period when red lighting was thought to be the way to preserve night vision and then they found that red-light-illuminated things cannot be as easily read, with colored markings on maps turning black or disappearing altogether, so white lights were again the "in" thing to have. You choose.

From our equations earlier, you can determine that with a ten Ohm resistor feeding six lamps which have a combined resistance of 20 Ohms (six 1826's), the lamps could never see more than the ratio of 20 ohms to 10 ohms or two thirds of the applied voltage, say 8 volts, and that only when the rheostat is on bright.



The ten Ohm resistor, tubular ceramic wirewound type, is mounted next to the rheostat with a screw through the resistor secured by a nut. This is an excellent method of using little space and getting rid of the heat.



Following their lead, could you do the same and add a resistor if the lamps are too bright when the rheostat is at Dim? Yes. In the circuit noted the L represents the effective 20 Ohms for the six 1826 lamps. The wirewound resistor WW could assist in taking some of the strain off of the rheostat. Use a ten Ohm resistor, about 15 watts size. To complicate the 140A a bit, they could have had a seventh lamp if they bought an option for an instrument, and they could have an eighth if they got another option but then they also put in a second rheostat. Pay attention to WireWound if you add the resistor; they are a lot tougher physically.

My Tests, Volts and Current at the lamps vs Light intensity:

Volts at the lamp	1815 mA	1893 mA	1826 mA	1826 lamp light appearance
2	60	90	55	barely perceptible glow
4	90		80	perceptible
6	110		100	usable
8	145		126	getting readable
10	170		142	good light
12	185	300		Full brightness
14	195	315	170	Very (too) bright

The breakthrough in determining how the 1826 functioned in the circuit with the voltages possible with the rheostat was finding one and then testing it. At a decades-old store, there were some in the back, no longer listed in their computer (they have not been made in decades). Now it can be seen that the values of voltage driving the lamps when using the 15 Ohm rheostat give you a quite reasonable range of brightness, a very large surprise to me. Without the ten Ohm resistor and with the rheostat on Bright, you would not have been able to stand the intensity!

The Choices:

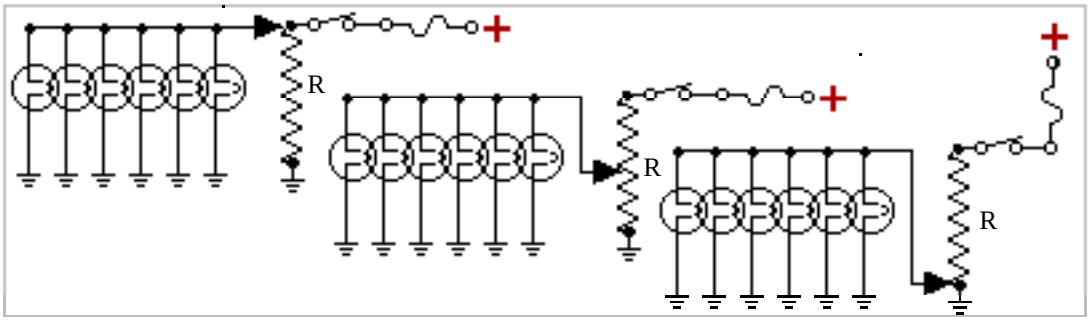
1826 lamps plus a rheostat:
with the rheostat of any value turned to bright.....too bright
with the rheostat of any value turned to bright but with red coloring, maybe acceptable
with a rheostat of eight Ohms at Dim, the voltage across the lamps would be 8.6 volts, too bright
with a rheostat of 15 Ohms at Dim, the voltage across the lamps would be 6.8 volts, a soft glow
1826 lamps plus a rheostat and resistor:
with the 8 Ohm rheostat turned to dim with a 10 Ohm resistor in series, 6.3 volts, might be okay
with the 15 Ohm rheostat turned to dim with a 10 Ohm resistor in series, 5.3 volts, nice soft glow

With red coloring, all the last three choices would be acceptable for the Dim position.

Potentiometer:

Note that the potentiometer has three connections, not the two of a rheostat and the "third" contact is attached to ground. (A potentiometer is sometimes used as a rheostat by not connecting the third contact but the opposite is not possible.)

On the left in the next diagram, the lights would have the full bus voltage applied to them and would be at maximum brightness. In the middle, the setting such that half of the bus voltage is applied to the lamps and they would still exhibit a healthy glow. On the right, the "near-off" position where the filament would appear to be not lighted at all. All positions between maximum brightness and no light output are possible.



The potentiometer is always carrying power at every position of the wiper. For the 6 Ohm potentiometer suggested by one member, it would carry 12/6 = 2 Amps by itself when the lamps are at full brightness. Here is the hazard. Two Amps through the potentiometer means it would be using two times more power than the lamps use. At full brightness, the circuit that initially carried the 1 Amp of the six lamps at full brightness (for the 1826) with the rheostat now must be sized to carry 1 for the lamps plus 2 for the potentiometer for a three Amp total. For a circuit which has a ten Amp fuse which also feeds other circuits, that change could be significant. See the difference? With a rheostat, the current in the light circuit could never be more than 1 Amp with the 1826's but for the lamps and the potentiometer, the 1 Amp has shifted to a maximum of 3. Recommendation is to not use a potentiometer.

The panel light bulbs (GE 1826) are available from Sunray Lighting, Inc., and ran about $20 for a box of 10 red bulbs. They also come in clear. His lead about Sunray was very useful, because I had given up finding a GE 1826 since they stopped making it many, many years ago.

The Question that started it all:

Re: Rheostat Posted by Carl Nordstrom on Fri - Sep 15 - 4:56pm:
Checking Aircraft Spruce, there are two Ohm (ic) choices on a rheostat to buy - does anybody know if the rheostat for instrument lighting (sic) is 8 Ohm or 16 (sic, actually 15) Ohm? Thanks for any wisdom shed on the subject. I have little red bulbs...:) there is no number on them, they are small and flat on the sides. So here's what I propose - I can change them to anything since I want to buy new ones anyway. There are six of them. What would you suggest? My aircraft serial number is 14578 if that makes any difference (140) Thanks for your help, Carl

Other:

An RHS6RO 6 Ohm 25 Watt $32 at Galco Industrial Electric www.Galco.com
1826 lamps, by/from Caltronics of Canoga Park (did not verify this one)
www.SUNRAYLIGHTING@att.net 1-800-8-LIGHT (near Los Angeles): The 1826 lamp rating is 18.0 volts at 0.15 Amps. Your cost for this lamp is 1.29ea if left clear, or, If Sunray paints this lamp red, your cost is 2.29ea

Cessna's 0413126-2 is the part number of the rheostat on all the planes that had them. 0413126 without a dash is the assembly number, and that consisted of the rheostat and knob and the support bracket and maybe some of the wiring. Via Cessna dealers, the year 2000 cost of the rheostat is $81.xx.
From Newark, the huge electronics catalog supplier, the 25 watt wirewound rheostats cost $31, and $37 for the 50 watt size if the user has lots! of lights. Many values of rheostats. They are on the net and ebay.

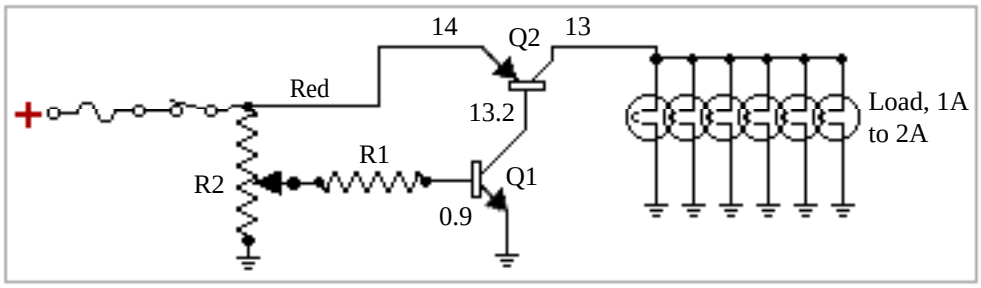
My solutions?:

If you want to stay "original", the expensive object from Cessna is the right ticket for you but make sure of your lamps. If you want function but no odor of a hot component, then the 15 Ohm, 25 Watt rheostat offered by Aircraft Spruce would suffice if you continue to use the 1826 or surrogates; if the lamps you use with it are too bright, coat them or do as Cessna did....or add a 10 Ohm, 15 watt wirewound resistor adjacent to the rheostat and wire it in series with the rheostat as in their circuit. New planes use electronic type dimmers with transistors such as the offering from RST (Radio Systems Technology) of years past. From the tables and formulas (I know, formulae) given, the availability of the auto lamps suggests using them.

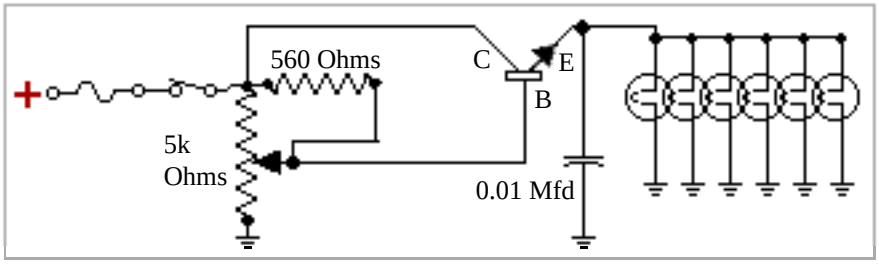
Electronic Dimmers

Electronic dimmers are of two main types. One uses a circuit that acts like a rheostat and the other chops the current. The on-off cycle rate is varied to produce the brightness you want. The sometimes feature with this type is that the chopping causes noise in the intercom or radio audio. Get a good one if you go this route.

The electronic dimmer control made from a kit from RST such that you can have any voltage between zero and the full bus voltage applied to the lamps; losing a lamp in flight does not change the dynamics or brightness. RST doesn't make the kit any more, but there are lots of dimmer circuits in the trade magazines. Make sure your A&I is in on the decisions.



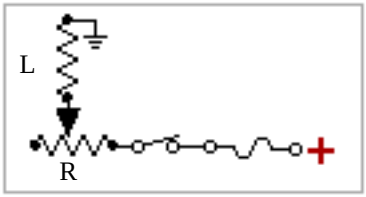
A typical dimmer circuit, capable of up to 2 amps without a heat sink, or more with a heat sink. The circuit is from RST. The voltages shown are with a 14 volt input, and R1 selected to provide 1.2 volts across the emitter and collector of Q2 when the load is 2 Amps and R2 is on full. R2 is 5k Ohms. The cost of the components, including box, is expected to be less than ten dollars. Compare that to the $35 for a rheostat or the $81 from Cessna for its rheostat.

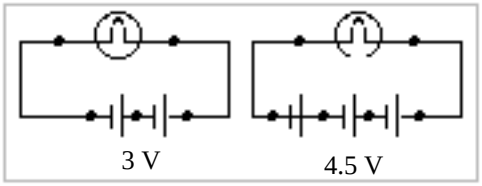


This circuit appeared as a hint for homebuilders. The 2N3055 transistor at Radio Shack is a bit over two dollars and is the most expensive part shown, though the metal box would be more. If you heat sink the transistor, using the insulator and heatsink grease, this circuit can handle up to 15 Amps, but without the heat sink it would have a limit of 5 Amps. The capacitor is to prevent amplification of bus transients which would make the lamps flicker.

Heat sinking either power transistor means insulating them from the case and using thermal grease to ensure good transfer of the heat.

Finding out for yourself:





The resistance of a single lamp is determined by dividing the voltage, 12, by the current of the lamp, or 12V/0.33 A= 36 Ohms. The current value of a lamp is given in many catalogs.

To determine the lowest voltage applied to a set of lamps when the rheostat of a particular ohmic value is set for Dim, you have to find the ratio of the Load resistance to the Rheostat resistance. L in the figure is the effective Load, the resistive value of the individual lamps divided by the number of lamps (for 6 lamps, 36 Ohms each, 36/6=6 Ohms effective Load).

The formula for the effect is: $12L/(L+R)$ for the dim voltage at the lamp where 12 means the 12 volts of the bus.

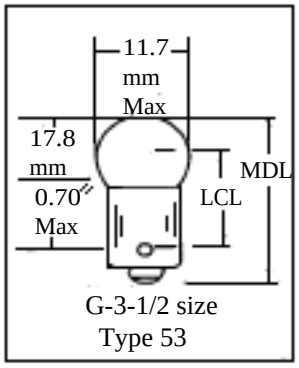
In the case of the 36 Ohms lamp, L=6, R is, for example, 15 Ohms. 6/(6 + 15) X 12 = 6/21 X 12 = 0.28 X 12 = 3.43 volts. To see if that will be dim enough for your purposes apply that voltage to one lamp when you are observing it in the dark. If you have no controllable supply, take two alkaline batteries in series with one lamp in series (just over 3 volts in series) as in the figure above and observe. If dim enough, quit. Recognize that the bus voltage will be a bit above 12, maybe 13.5 if you wish to test to more realistic values. The figures show the connections to give 3 volts and 4.5 volts across a lamp.

Every time I write one of these articles, I find out new things from the readers and some of their data is deserving of presentation. A member sent me the picture of the box which was around the potentiometer sold to him by Cessna with the rheostat part number on it from our parts manuals. Talk about confusing. It was the wrong size, wrong type of unit, but Cessna is selling it at an outrageous $60 and then it gets hot! Arghhh! Mallory M6PN 6 ohms, 4 watts cessna p/n 0413126-2 marked on the box. Always runs hot..... he really needed a 25 watt unit for the number of lights he had. If offered one of these Cessna things, even if free, let the bargain go.

Type	Dia	Amps	Volts	Light	O'all length	Light center
1816 Lamp	11 mm dia	0.33Amps	13 V	3 CP	1.19 IN	LCL 0.62 IN
53	11.7 mm	0.12	14.4	1 CP	0.94 IN	LCL 0.5 IN

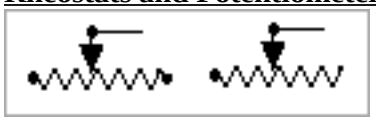
Victor used the shorter GE 53 shown here because the normal lamps were too long and would rub on the back side of the floating panel. A good clue as to the adequacy of the lighting is that with the 53's, Victor has enough when using lamps with a third of the light of the 1816s. Lab lifetime of both is 1,000 hours.

He and others talk about painting the back of the floating panel white and all those I have seen have been that way.



G-3-1/2 size
Type 53

Rheostats and Potentiometers:

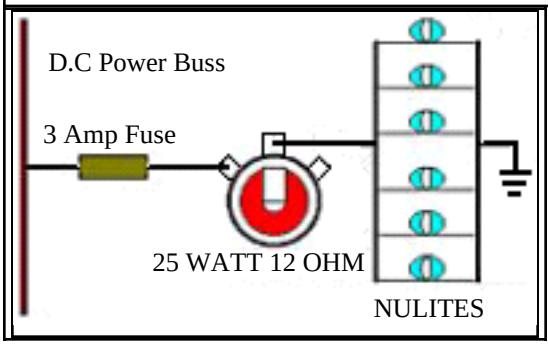


Rheostats use only two contacts but might have three to allow the rotation to increase or decrease the resistance. The movable contact is referred to the as the wiper. A potentiomer uses all three contacts usually but can be used as a rheostat by connecting only to two of the lugs. Nulite, in the next section, uses potentiometers....as rheostats. I found some very good prices for rheostats on ebay.

email: I installed Nulites:

My response....
The rheostat from Cessna won't hack it if all the instruments have a nulite.

This from their site:
"In the event no dimming circuit is available, we recommend a fuse, potentiometer and see our site for the right-sized pot."



Me? 25 watt size is good.

I always wonder about an electrical outfit that does not undertand that buss means kiss and bus means common carrier...an electrical circuit uses a bus, not a buss.

The heat sink for the rheostat is not mentioned by anyone, either in these letters or in the Nulite site but it is important as well. Cessna's solution was to mount the rheostat (and the resistor later) on a piece of sheet metal attached to the instrument panel so the metal would drain off a lot of the heat.

From the Chief catalog, this option: A "Cessna" lighting Rheostat for $135 in 2000, $224 in 2004, and finally all gone in 2005. The knob's price rose to nearly $40.

Sockets are still available. I believe I found them in the Allied catalog (on the net…Allied electronics in Chicago).

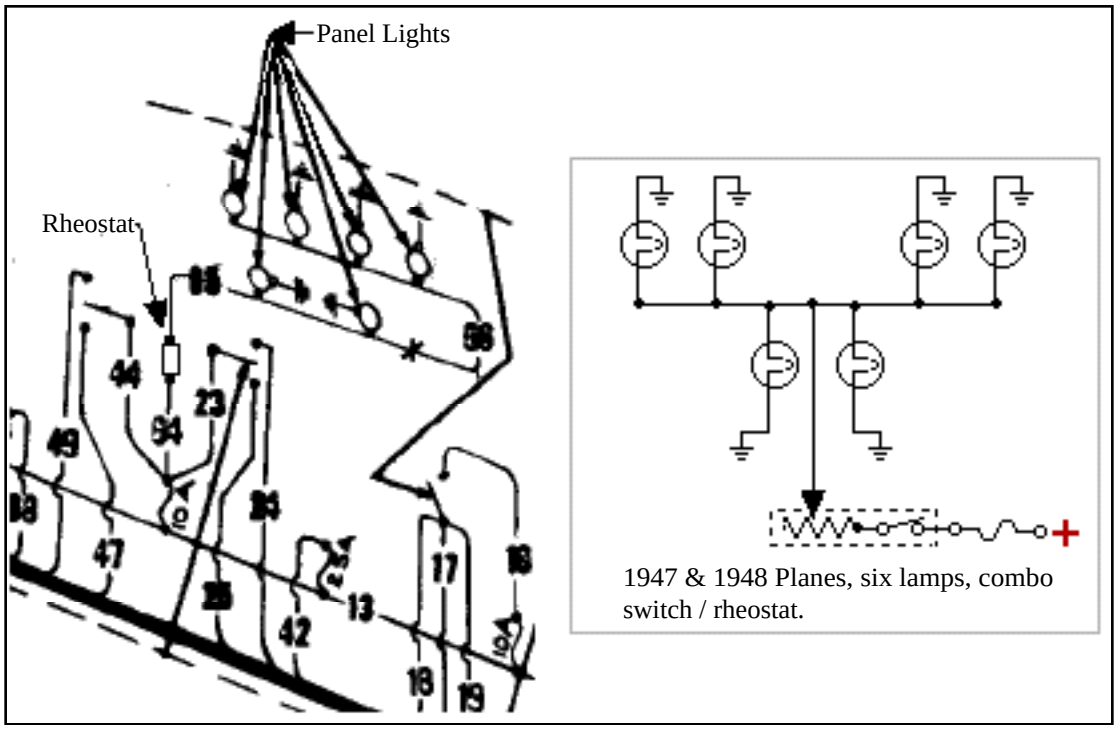
From the 120/140 pilot's information manual:

NAVIGATION LIGHTS:

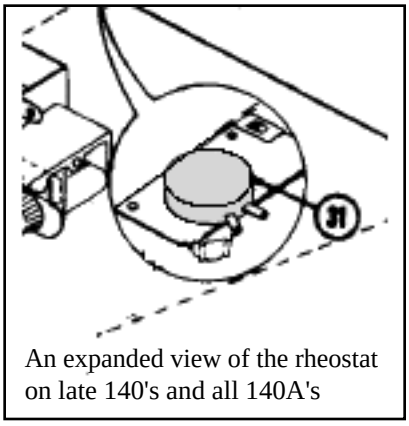
The navigation light switch is located on the instrument panel and controls the wing lights, rudder light, and the instrument panel lights in the Model 140. The later model of the 140 has an independent rheostat switch for the panel lights located on the bottom edge of the instrument panel just right of center. A word of precaution is worthwhile here. Prior to installation of the rheostat the instrument panel light bulbs used were Grimes T 3¼-3 CP having a rating of .33 amperes each. The bulbs used with the rheostat are G. E. No. 1826 having a .12 ampere rating. The earlier model bulbs have high enough ampere capacity to allow the rheostat to get too hot with possible burning out of the unit. Make sure when replacing instrument panel bulbs that the correct bulb is used as they will both go into the same socket. The model number of the bulb is marked on the base. The electrical system is available as optional equipment on the Model 120, but does not include the instrument panel lights.

Grimes T-3-1/4- 3CP bulb Red 12V was the original in '46 but Grimes quit making them decades ago.

From the 140A manual, use only the 1826. Any other lamp is likely to cause the rheostat to overheat.



On the left, as Cessna shows the Rheostat and on the right the way the circuit should have been indicated with the switch a feature of the rheostat.



Suggestions for improvement of the data and information will be incorporated in the next revision.

Neal Filed as: Instrument Lights 2005
Revised October 2005 Removed the section about using L-pads. If anyone wants it, let me know.

Neal F. Wright COUGARNFW@AOL.COM