FLIR for the Shop

Using infrared vision to detect problems

BY BRIAN AND CAROL CARPENTER

HAVE YOU EVER NOTICED that when you go to work on your airplane, you always reach for that favorite screwdriver, wrench, or ratchet from your toolbox? Working with good tools makes the job enjoyable, whereas working with inadequate tools is just frustrating. Worse yet is trying to accomplish a job without the proper tools. This is the reason professional mechanics seem to have a tool for practically every possible scenario they may encounter. The time wasted dinking around without the right tool is far more costly than the actual purchase price of the tool. Being prepared and having the right tool ahead of time is what differentiates the professionals from the amateurs. As professional mechanics, we often look at tools from the perspective of how they might function for us in the future, even if we have no immediate use for them. This was the premise behind how we acquired our most recent gadget, the forward-looking infrared (FLIR) camera adapter.

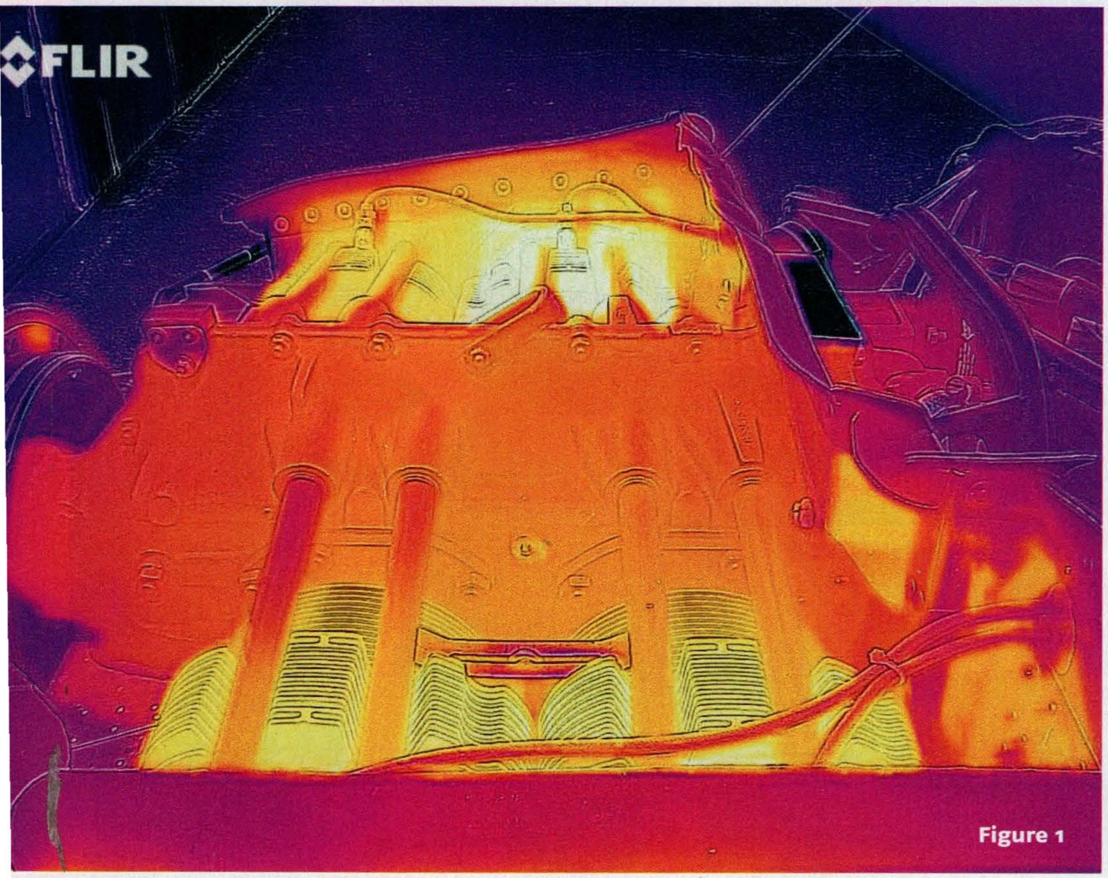

Figure 1

Infrared radiation (IR) is electromagnetic radiation (EMR) with longer wavelengths than are typically invisible to the human eye. Infrared radiation is more commonly known as "heat radiation." Thermography is an infrared imaging technique, using specialized sensors to detect radiation in the long-infrared electromagnetic spectrum for taking photographs or video. Modern digital cameras use a CMOS (complementary metal-oxide-semiconductor) sensor, which has most of its spectral sensitivity focused in the visible light wavelength range. Similarly, a thermographic camera uses an FPA (focal plane array) sensor that responds to the longer wavelengths associated with infrared radiation. The newest technologies use low-cost microbolometers as FPA sensors. A microbolometer works with infrared radiation in wavelengths between 7.5-14 micrometers. The infrared radiation strikes the detector material, heating it and thus changing its electrical resistance. This resistance change is measured and processed into temperatures that can be used to create an image. (Figure 1)

We have all seen the videos of the FLIR-equipped military or police helicopters following the bad guys in the dark of night with contrast rivaling daytime photography. The clarity of the image is really quite remarkable. For the last couple of years we have now been using this same technology in the shop for troubleshooting and maintenance tasks with surprisingly positive results. In the past, these types of cameras would typically cost in the neighborhood of $2,000 for even the cheapest version. However, in recent years there has been a significant uptick in the number of manufacturers making FLIR camera adapters for smartphones. By using the smartphone computing power along with the high-resolution screen, the cost to convert your phone into an IR camera has become much more affordable.

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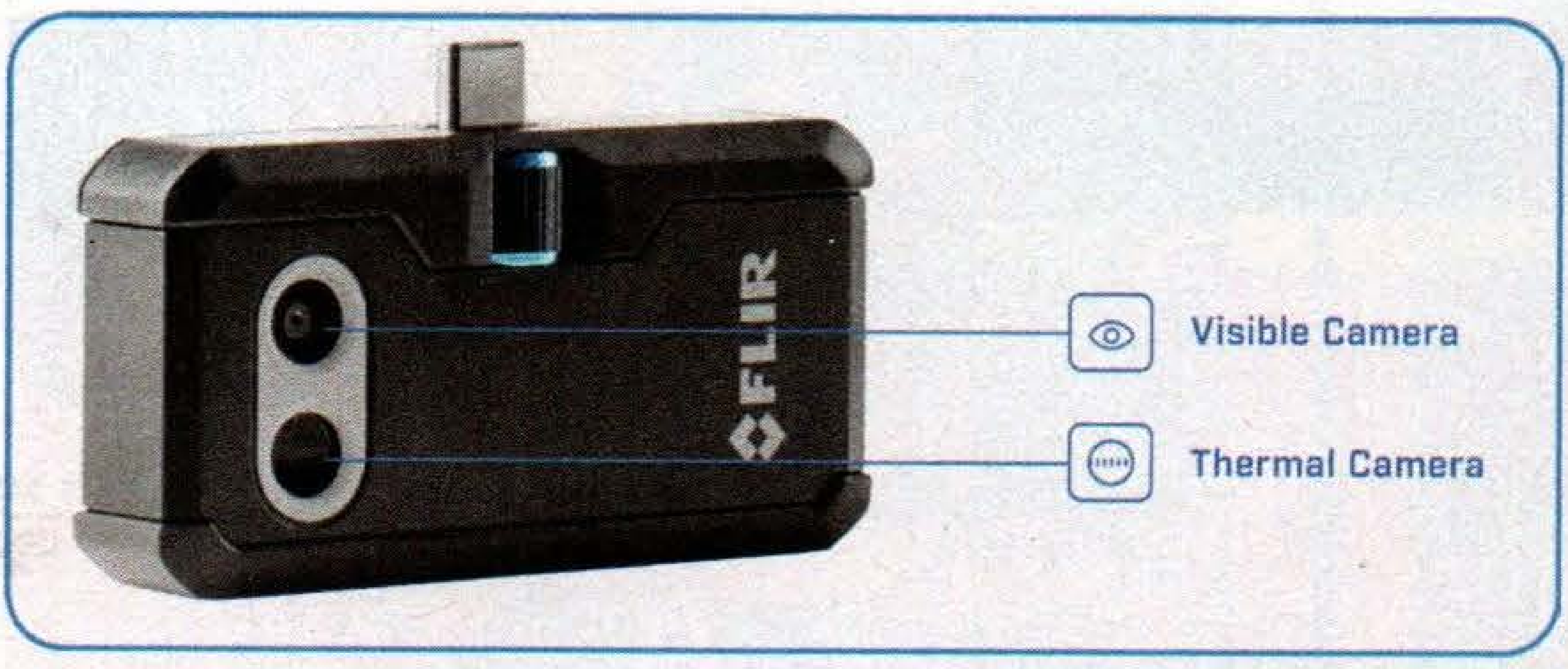

Figure 2

A while back, we purchased a FLIR One professional IR camera adapter that cost around $400. Today, there are many of these same type of smartphone IR cameras that cost less than $200. The adapter has the ability to measure temperatures between -4°F and 752°F (-20° to 400°C). The manufacturer of this camera has combined both a visual camera along with a 160-by-120 thermal camera. (Figure 2) The advantage of this is that it provides a proprietary process called MSX that embosses visible edges from the 1440-by-1080 HD camera onto thermal imagery to create a sharper, easier to understand picture. (Figure 3) This is particularly helpful when you're trying to pinpoint the source of a specific problem on your aircraft.

The powerplant on an aircraft is simply an energy converter. Chemical energy (fuel) is converted into heat energy (combustion) which is in turn converted into mechanical energy (torque). Being able to visualize the heat within an engine can reveal a lot about its operation. Although an unusual condition, Figure 4 shows an example and heat signature of an engine with two fouled spark plugs on the No. 4 cylinder (left rear). This shows the dramatic difference in temperatures after only five minutes of run time. We have found the FLIR camera to be helpful in myriad similar scenarios while working in the shop. As a result, an aircraft that arrives for an annual inspection will typically get a series of thermal pictures taken of the engine, engine compartment, as well as the cockpit area immediately upon arrival. This provides us with an entirely new layer of information when determining the health of the aircraft.

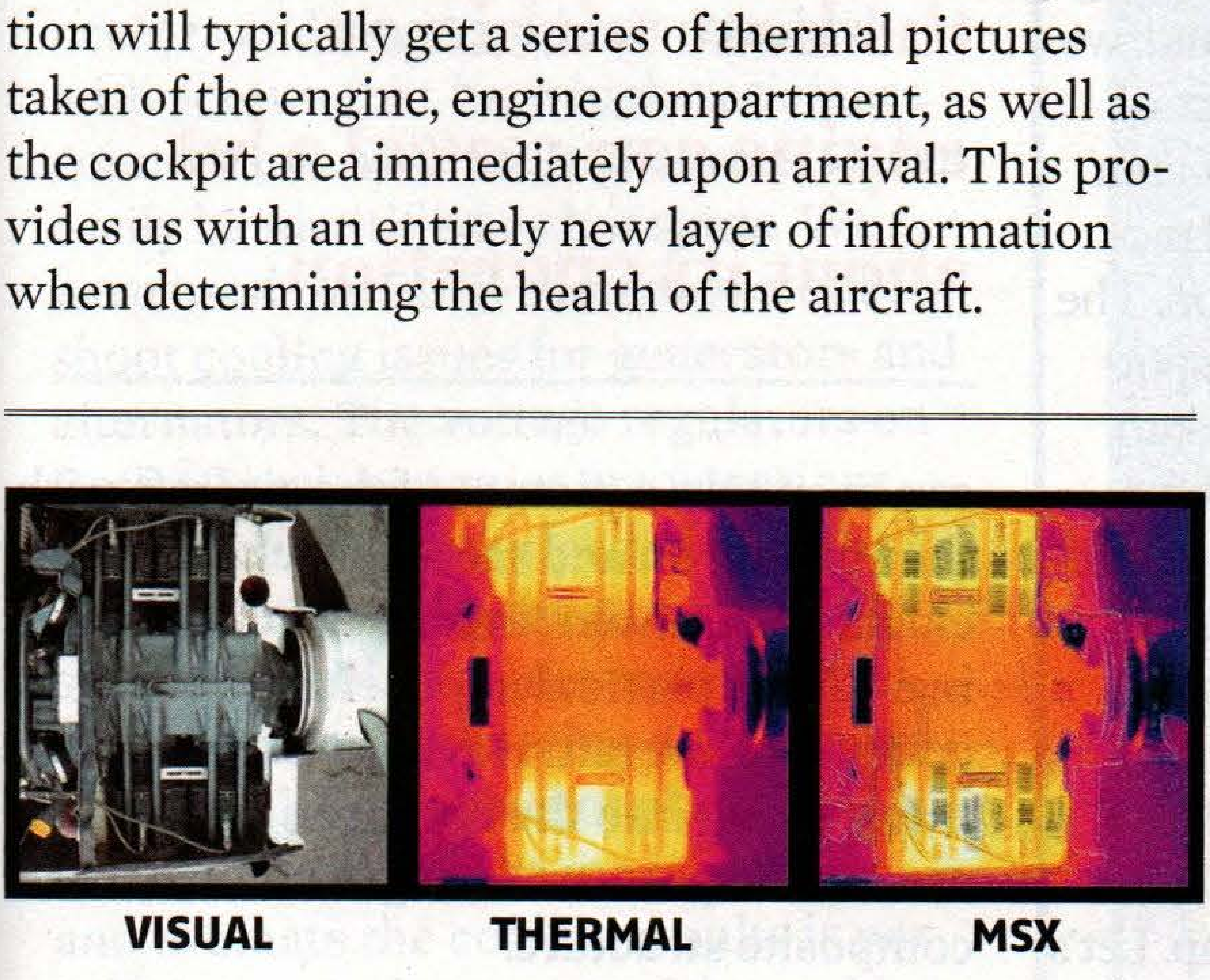

Figure 3

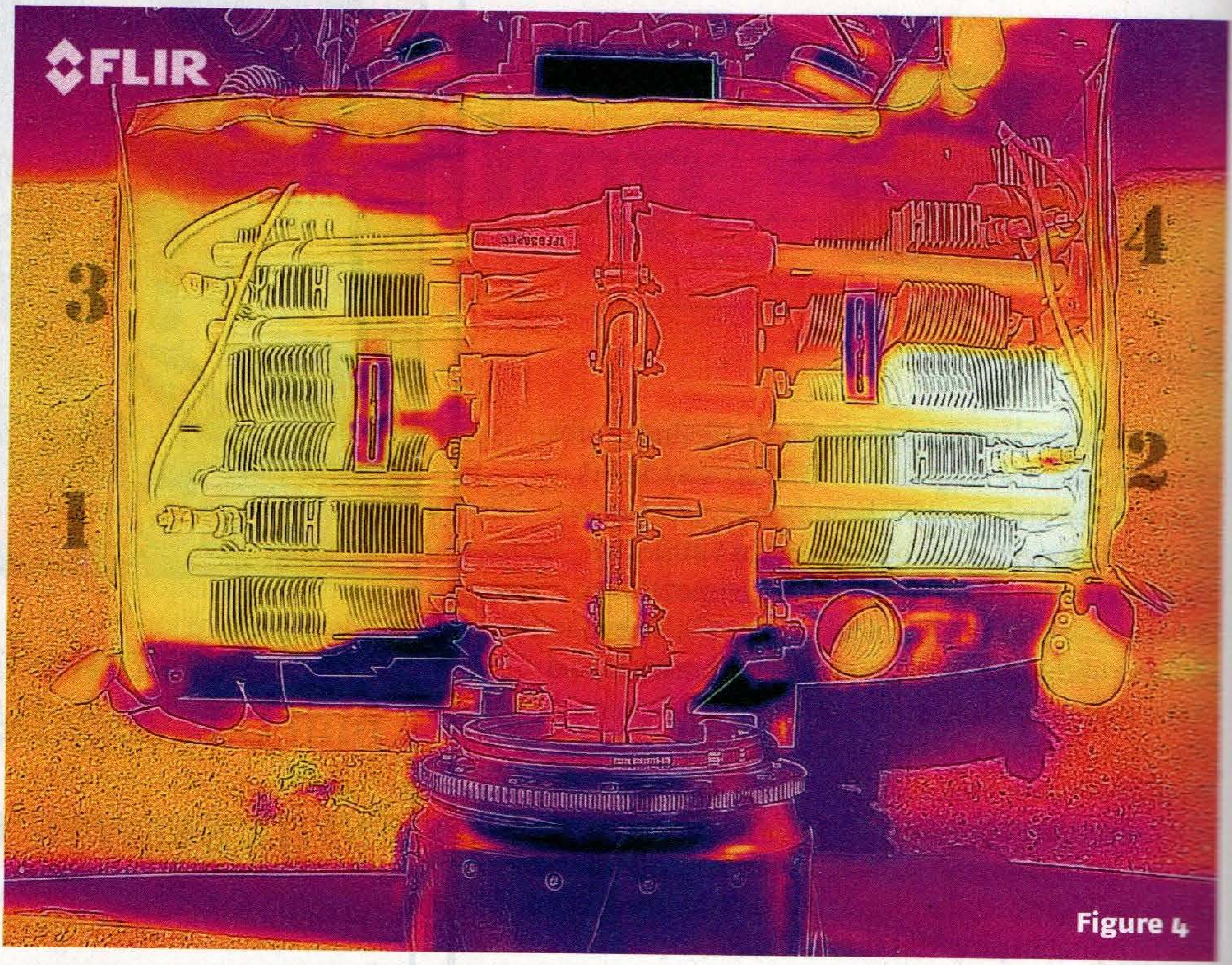

Figure 4

Although we started writing this article back in May, the outside air temperatures had consistently started to exceed 100°F. Having heat from the engine compartment penetrating into the already high-temperature cockpit can get rather annoying, so we took one of our Varga Kachinas flying one night to see if we could pinpoint the source of the additional heat in the cockpit. (Figure 5) The thermal image showed that the firewall blanket, overall with a few exceptions, was doing a fairly reasonable job. On the other hand, we were able to identify the primary source of the problem to be the air valve for the cabin heat. While in the air, we took thermal pictures of the entire cockpit for evaluation. The FLIR One camera allows for multiple spot-temperature indicators to be overlaid onto the photograph (Figure 6), as well as the option to evaluate the overall temperature of specific areas. Out of all the Garmin radios, the transponder appeared to be the hottest. However, the spot temperature indicator revealed the face to be a comfortable 87.9°F. This is just one example of how we've been able to use the FLIR camera in the shop. Let's review a few of our other uses that have proven to be effective.

Exhaust systems: The high temperatures encountered in the exhaust system can reveal a whole range of potential problems. A crack in the exhaust system shows up readily during an engine run. Leaks in exhaust clamps, ball joints, or base gaskets are also easy to detect. You can even take a picture of the aircraft with the cowling on and see areas where the exhaust is transferring heat into the cowling. This is particularly useful with a composite aircraft. Having excess heat transferring into the fiberglass cowling can lead to premature degradation of the composite structure.

Being able to visualize the heat within an engine can reveal a lot about its operation.

Electrical systems: This is one area where the FLIR really shines. You can

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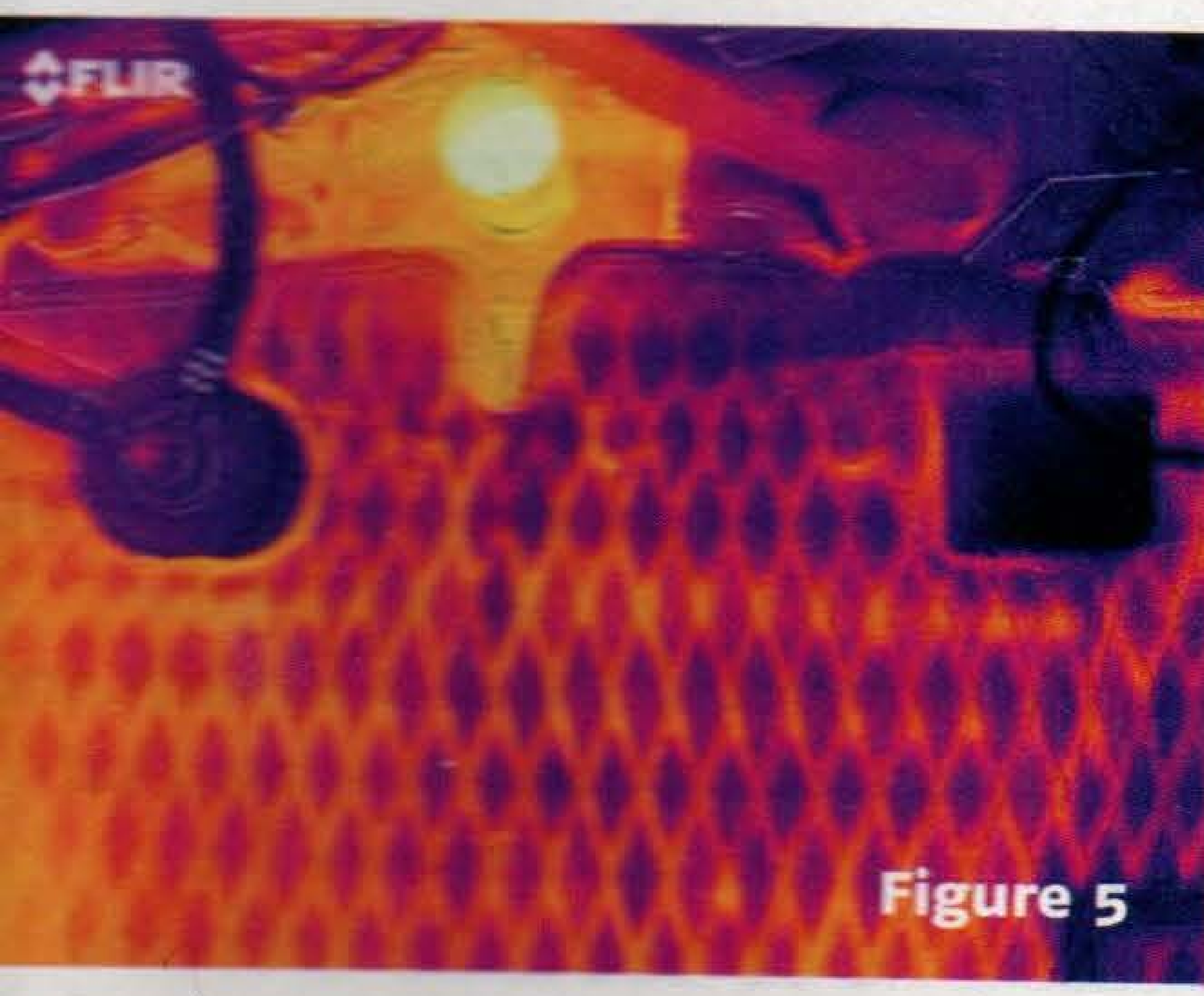

Figure 5

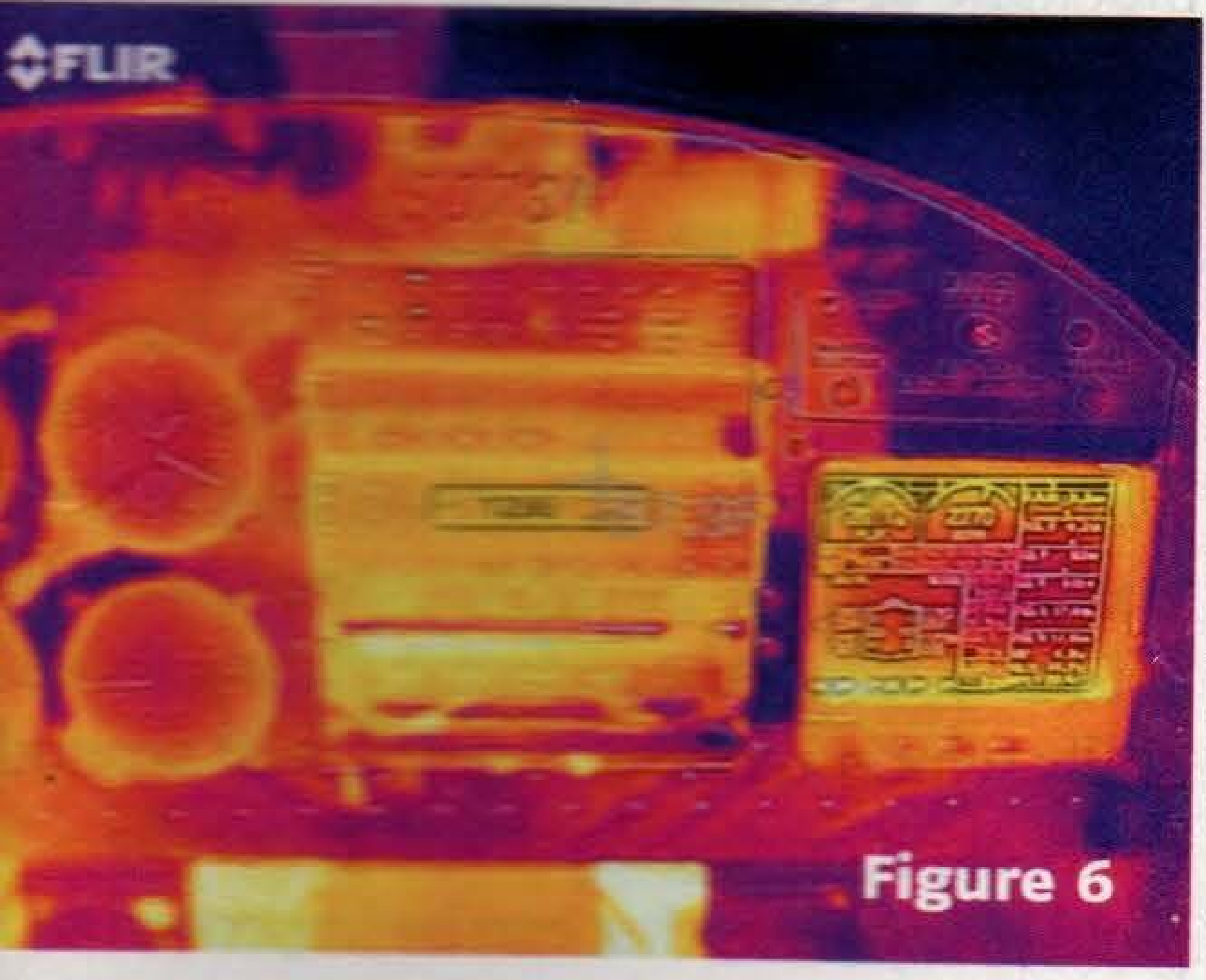

Figure 6

solate the entire electrical circuit by imply turning on the circuit (applying load), and then use the FLIR to see he individual wire or circuitry that is eated from the load. You can even see ght through upholstery. A quick lance at the circuit breaker panel and ou can identify hot spots. Wire sizes hat are too small for the load will how up brightly in comparison to a rger wire with a small load. Butt con- ectors and ring terminals attached ith screws that have high-resistance onnections as a result of corrosion can asily be identified as hot spots. We ave used the FLIR camera to trouble- hoot cooling issues for generators and ternators. The voltage regulators on otax 9 series engines are notorious r failing when overloaded and, in rticular, when inadequate cooling pply is available. Instrument panel d avionics overheating due to inade- uate cooling is commonplace. Being le to identify, make modifications, d evaluate the cooling results is par- mount to the longevity of that gold ine installed in the instrument panel.

Firewall forward: Checking cooling and baffling is probably gle biggest purpose for the FLIR If the cowling is removed shortl landing, the residual heat withir engine will give a good represen the heat distribution throughou engine. Hot spots are easy to ide subsequent maintenance to rela fling can significantly improve t engine's cooling system. Radiato oil coolers will instantly show a blockage or contamination inter Following engine hoses will give consistent color throughout the length of the hose, making it pos watch where the coolant or oil i

Airframe: Not only is it possibl where the heat is getting through wall, but also it is possible to see w cold is entering the airframe durir chilly winter months. A quick scan the cockpit during flight will gene yield many areas that can be impr retain heat within the cockpit. Do canopy seals, missing insulation, a to the exterior are common culpri

Wheels and brakes: Overuse can be identified by following th the brake line, brake calipers, wh and even into the bead of the tire bearings with improper lubricat the process of failing can be iden

In all fairness, we are the epit gadget junkies. Any excuse to try new technology is considered a g enough excuse. As a result, over we have had our share of gadget simply were not worth the effort The FLIR smartphone adapter, h is one of those gadgets that has g us over time. The more we use it more that we find it to be a usefu And, although the FLIR adapter meet the definition of a must-hav for the average aviator, even at th price tag, we are happy to have it in one for our toolbox. EAA

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