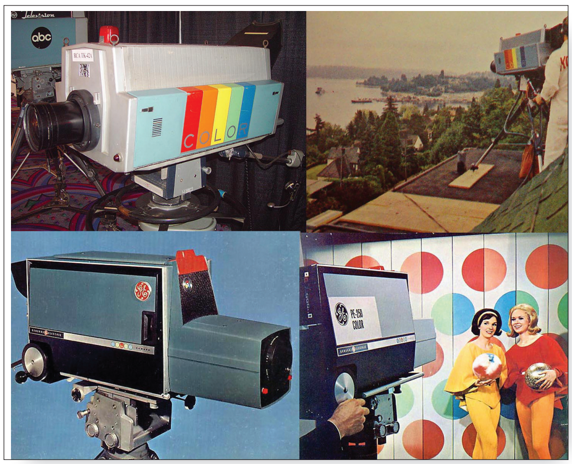

Figure 4.12 *Second generation of color cameras: the top two are RCA TK-42s, and the bottom two are GE-250s. Both used an orthicon image tube for capturing the luminance image, and smaller orthicons for red, green and blue channels of video.*

Cameras Grow Up

Cameras get Reasonable

By the mid-60s, image tube technology had evolved to a point where fairly sensitive cameras with good resolution could be produced with camera heads weighing less than 100 lbs. This was possible because camera manufacturers had settled on the use of three-tube imaging systems using an imager much smaller than the image orthicon. This imager was known as the Plumbicon. These new imagers were quieter, and the preamp circuitry was better at amplifying the tubes' output without adding much noise. Signal-to-noise ratios (S/N), which up to this point were in the low 40dB range, now were in the low 50s. This was a fourfold decrease in noise levels. Today, camera S/N values are into the 60s. Another major development came with the arrival of the integrated circuit (IC). Not often thought of as ICs, but as the operational amplifiers (op amps), these combined a half dozen transistors into one package. This allowed more processing to be packed into smaller spaces. Another plus with the op amp is that it was a much more stable device, as compared to a single transistor, which meant that cameras required less setup than before.

Figure 4.14 *The PC-70 was the first of the third generation of color cameras. These cameras used three Plumbicon tubes, instead of orthicons (as in the case of the TK-41) or a mixture of orthicon/Vidicons tubes (as found in the TK-43). This was the first camera that included an image enhancer as part of the camera. The image enhancer made all changes in picture level more pronounced, which made the video appear sharper. Throughout the late '60s and much of the '70s this was the workhorse of the remote fleet.*

Figure 4.13 *As color cameras were about twice the cost of black-and-white cameras, $70,000 for a TK-42 vs. $35,000 for the TK-60 shown here (in 1960s dollars), black-and-white cameras continued to be sold well into the 1960s for use in studios and on trucks. (Source: Chuck Pharis collection on display/NAB2002)*

Figure 4.15 *A smaller camera, and one that was more stable with better video, the PC-70, could be found everywhere. (Source: Doug Barry, Denali)*

Figure 4.16 *Within a couple of years, RCA responded to the PC-70 with its TK-44. These camera heads were approximately 50 lbs., and they made remotes much easier to accomplish. While both ABC and CBS made extensive use of the PC-70, there were a number of trucks that used TK-44s.*

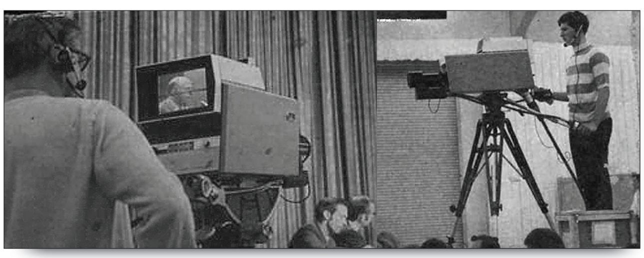

Figure 4.17 *In the late 1960s a number of other manufacturers got into the color camera business. Companies like Zarkes-Tarzan and IVC made cameras that made it onto a few trucks. Whether these cameras were high-end industrial or low-end broadcast was open for debate. Although the IVC-300 shown here used Plumbicon tubes, it was less expensive than the TK-44 or PC-70 mainly due to the fact that it used a discrete set of dichroic mirrors to separate the incoming light into red, green and blue. Higher end cameras used a prism.*

The Prism

Figure 4.18 A prism found in a modern camera. The tabs are where the CCD imagers and their preamps are attached via solder to make a complete image assembly.

A prism uses dichroic mirrors that are epoxied together into a single item. That is a very expensive process. Early prisms and imagers could account for one-third to one-half the overall cost of the camera. The drawback to using separate dichroic mirrors as a prism, as some cameras did, is that they tended to move, ever so slightly, when the camera was jarred or its temperature changed. Thus, the camera would have to be adjusted often. The second drawback was that this approach lost more light between lenses and Plumbicons, so these cameras were less sensitive than ones using prisms. Many of the older venues around the country, namely some of the old civic auditoriums, had light levels as low as 35-foot candles. These cameras needed 200-foot candles to operate comfortably.

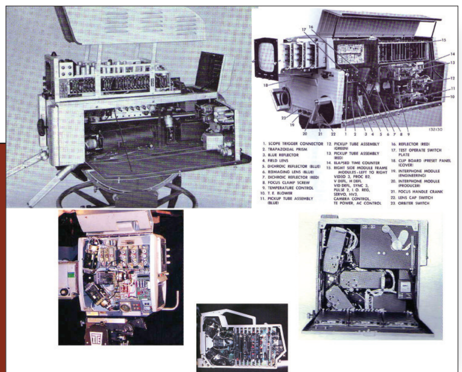

Figure 4.19 The inner workings of four generations of color cameras. The top left is RCA's TK-41. Very little processing of video took place in the camera head. Top right is the second generation TK-42. While the camera head didn't get any smaller, much more processing power was located there. Second row are two predominant third-generation color cameras: Norelco's PC-70 (left) and RCA's TK-46 (right). Both used Plumbicons, so the imaging tubes and the electronics were smaller, making for a smaller head. Bottom is the next generation, RCA's TK-76, which heralded the introduction of the handheld broadcast camera. Although physically much smaller than the cameras before it, the TK-76 was able to fit all the necessary electronics into a single case. No external CCU was needed. Simply feed 12V in, and composite video came out the back. All these cameras had very high voltages, often 1500V or more, running through them to drive the imaging tubes and deflection circuitry. An opened, powered camera was to be dealt with carefully. The introduction of CCD imaging finally eliminated those very high potentials.

Smaller - Both the Camera and its Tether

The continual miniaturization of electronics — mainly as ICs evolved from small-scale integration with a few transistors incorporated into a package, to medium-scale integration with dozens of transistors per package — made possible smaller assemblies. One assembly that continued to get smaller was the camera head. By the mid-70s, RCA was able to fit the required camera head electronics into a package that could sit on a person's shoulder, and that weighed about 40 lbs. It was known as the TKP-46 (P for portable). It worked with the same CCU as the TK-46. This camera, along with a competitive entry from Bosch, was the first production-line "handheld" broadcast camera.

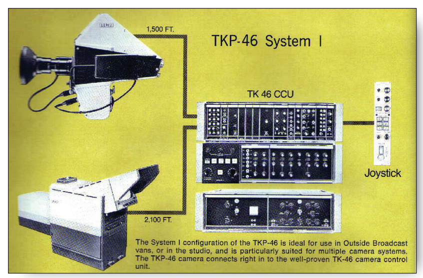

Figure 4.20 *Before a television camera could stand on its own, with no external CCU, a couple of evolutionary steps occurred. Most studio cameras were re-engineered so that a shoulder-mounted version could work with the same CCU.*

Once camera head and then CCU circuitry had become small enough, the next logical step was to combine these two subsystems into one box. The RCA TK-76, introduced in the late 1970s, made that evolutionary leap. This camera was truly portable: The complete camera, with viewfinder and lens, weighed less than 25 lbs. Supplied with 12V, it would provide composite color video out the back. Power consumed was remarkably low for the time, 50W. If you wanted to use the camera in conjunction with other sources, it had a genlock input. Feeding a reference video signal into that spigot locked the camera to the reference.

Now the logistical, philosophical and operational aspects of two different types of cameras arose. The handheld camera was great for getting close to the action and being mobile along the sidelines or in other production environments. The handheld could also be placed on a tripod and used

Figure 4.21 *By the mid-70s, cameras were portable enough to sit on a person's shoulder and to fit in small diving bells (still with a tether to the CCU), as seen in these two photos. On the left, a Norelco PCP-90 is disassembled and checked after the diving bell sprung a leak. On the right, a cameraman with a TKP-46 on his shoulder points to a PCP-90. (Source: Jerry Hughes)*

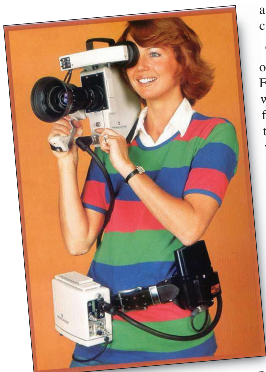

Figure 4.22 The scaling down of the camera head was just the first step. Next the CCU was downsized. Soon the camera had reached a point where a rack-mounted CCU and associated power supply were no longer required. What wasn't packaged in the camera head on the shoulder required only a small belt pack.

as a fixed place camera. So why not only have handheld cameras?

The handheld is ideal for a lot of situations. But the good old hard, or studio, camera is still good at a number of things. First, it is heaver, so the pan/tilt heads it sits on have more weight on them, which leads to smoother pans. Zoom and focus handles are available on pan handles on the back of the camera so the camera operator doesn't have to directly work the controls on the lens, again leading to generally smoother camera work. The large lenses in use today are more easily integrated on a studio camera. A studio camera with a large lens has a center of gravity such that the camera is not mounted as far back on the pan/tilt head, which makes some camera operations (like extreme tilting) easier.

These studio-configured cameras also have some infrastructure that the handheld camera doesn't. Studio cameras have return video feeds, helpful in complex production environments where the cameraman needs to see the on-air signal, or a composite effect that their camera is a part of. Via the camera's CCU, additional video from the truck is usually available at the head to feed talent prompter monitors, as is power to drive that monitor. Although generally not as true today as when the handheld first came out, studio cameras also tend to give the video operator more control over camera setup and operating parameters. On many shoots, the client may need this extra control. The advantages that a hard camera brings to fixed camera locations are so great that even trucks that carry only handheld cameras on tripods have some sort of buildup kit to turn them into "semi-studio" configured cameras.

RCA soon had competition from Ikegami and Sony. Ikegami launched a series of cameras (HL-77/78/79 — HL actually stood for Handy Looky) that were slightly lighter and more comfortable and had better ergonomics for the user. Sony was right behind with their BVP-300/330. Both Ikegami and Sony engineered their offerings to be slightly less rugged, but still up to the tasks and demands of a handheld camera.

Triax

Along with miniaturization of components, another technical breakthrough made remotes easier. That was the advent of triax cable. Before triax, bulky, heavy and expensive camera cable connected the camera head with the truck. Often cameras from different manufacturers used different cable. In addition, total cable length was limited by the most vulnerable signal traversing the camera cable's many conductors. This limited camera cable runs to less than 3000 feet in this latest generation of cameras. The introduction of triax changed all that.

Figure 4.23 With the arrival of the TK-76, the handheld evolution was complete. The handheld would continue to get lighter and smaller, but the basic genesis was complete.

Figure 4.25 Right: Modern handheld cameras built up into hard cameras.

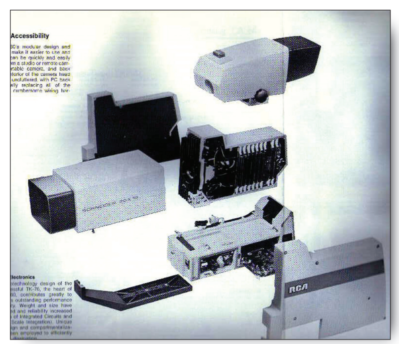

Figure 4.24 Studio buildup kit that turns a handheld TK-76 into a studio camera (TK-760).


Canon
SONY
UPER

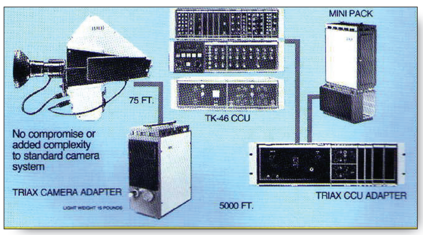

Figure 4.26 Along with reducing the size of the camera head was the parallel task of eliminating the bulky cable between the camera head and the CCU in the truck. Here a triax adapter is connected near the camera, and a triax cable is run back to a second triax adapter in the truck.

Triax heralded a common cable format for connecting cameras to the truck. It also greatly decreased the connectoritis that had plagued camera cables up to this point. Even when the source of poor connections in a camera cable were found, it often took many hours to get the connector of a TV-81 cable apart and repair the problem. Inadvertently cut cables could take a day to repair. Triax connectors can be replaced, or in the case of a cut cable, installed at the break in under 10 minutes. Triax has made it possible for a truck to carry 10 to 12 miles of cable for camera head dispersal at large or complex venues.

Triax cable is essentially coax with an extra shield. Instead of multiple conductors between camera head and CCU, all video, audio, intercom and control signals are frequency multiplexed down the center conductor. Also, just as some microphones are phantom-powered, power is also sent down the center conductor from the CCU to the camera head. Triax connectors easily snap together and a collar on the connector allows for easy release.

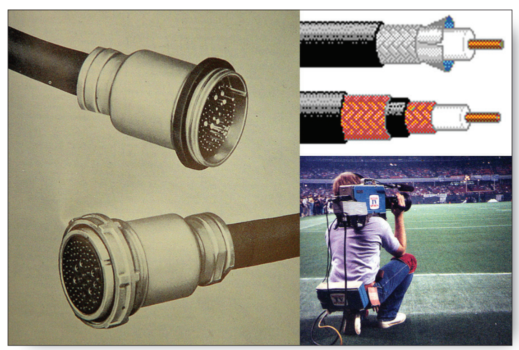

Figure 4.27 Left is how cameras used to be connected to the truck. That thick cable was known as TV-81 (number of conductors in the cable). Top right is an exposed coax, below it is triax. The "tri" in triax means three conductors. The center conductor in triax is surrounded by two shields as opposed to a single shield, as in coax. The camera is an '80s vintage (RCA TK-86) triax camera. While it was a stand-alone camera, it required an awkward belt pack. Subsequent triax cameras either incorporated the triax adapter, or offered a module that plugged into the rear of the camera.

Several philosophies as to camera architecture now sprang up. From the mid-70s on, it was possible to build stand-alone cameras. But since levels and other operating parameters had to be controlled by video operators in the truck, there had to be some sort of control unit for the camera. This control unit would send video operator commands back to the control head. But if an operations subsystem is required anyway, and the camera is not ever intended to be a stand-alone system, why not do some processing in the truck? In the case of an NTSC camera, shipping the three color channels back to the head separately for monitoring made sense. A camera designer had to decide what type of camera they wanted to build. Would the camera be a studio camera? By that, the classic camera head and CCU would connect via triax. In this way, the only systems in the head would be the ones that had to be there. Or were they going to build a stand-alone camera? And if that were the case, would that stand-

Figure 4.28 *Today's cameras, tethered to the truck via triax or RF link, can get anywhere the cameraman can.*

alone camera also be expected to operate as a studio camera? The fourth generation of color camera manufacturers made these decisions, from one end of the spectrum to the other.

As technology improved and cameras became smaller and more reliable, innovative producers such as ABC's Roone Arledge saw the opportunity to not just document the sport but to bring the television viewer into the whole event. Roving minicameras immersed the viewer in the experience, just like sitting in the stands, capturing the look, feel and sounds of the experience. With the advent of *Monday Night Football* in 1970, ABC pushed the envelope by using upwards of 10 cameras to cover a single NFL football game, while the others were still using five or six. Today *Monday Night Football* often uses as many as two dozen cameras for each game.

In this section we looked at how manufacturers were able to shrink the camera enough for it to sit on a shoulder, and to make the cable that connects the camera back to the truck much smaller and simpler. The number of cameras at a venue was now poised to explode in number, as trucks could carry more of them and the introduction of triax allowed cameras in far-flung locations that weren't possible before. As we will see next, cameras have become extremely stable, and optics have come to dominate the camera's profile. ■