BACK FOCUS

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Contents

The Australian Photographic Collectors' Society of Australia Inc.

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The Australian Photographic Collectors' Society Inc is incorporated in Victoria Australia, and has as its members, people with similar interests in photography. Its Rules of Association contain its aims and purposes as "To foster the collection, restoration and conservation of the apparatus, images and literature of photography from its beginning until recent times, and to encourage the exchange of information about such items."

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Meetings are held at Australian Model Railway Association Hall. 92 Wills Street, Glen Iris, VICTORIA - Details of meetings, markets, auctions and other event may be found on the APCS website: www.apcsociety.com.au

Society membership includes subscription to Back Focus: $30.00 per annum. See the APCS website for details.

EDITORIAL The APCS, like so many photographic societies around the world, is entering a new era as several matters-for-change have all arrived at more or less the same time. We are an aging society with no significant recruitment of younger members, (the membership numbers have nearly halved in the last 3 years), a significant proportion of the committee has passed on or is retiring, the world at large is moving from small groups of people with common interests towards global "membership" relying very heavily on electronic communications, and probably the most significant issue in modern history, the world is learning to live with the COVID pandemic. Who would have thought as little as 6 months ago that there would be virtually no face to face meetings, and probably no auctions or markets run by the APCS in 2020? But there is hope as the lock-downs around the world start to be relaxed. In the background, other elements are at play - there is a movement away from collecting and towards trading as cameras and related items have become valuable trading comodities that are more than competing with traditional financial share-trading etc., a whole new focus is emerging as digital cameras now dominate conventional photography, and the mobile phone has emerged as the most popular tool for photography driving new cameras almost to extinction. Further, conservatism is driving us to be more risk-averse in using photographic chemicals. We are using new image processing and printing/display techniques, and overall image performance can achieve quality/resolution that has never been achieved using classical processes. This may be reducing the global interest in using collectable cameras and equipment to a very small group of people with interests in the history of the subject and with some specific artistic aims. Ultimately the number of people who actually used those systems when they were younger is falling rapidly. This magazine grew from a newsletter in different times, but in the new environment, along with the passing of the long-time editor Ian Carron last year, Back Focus will change. It relies very heavily on contributions from members as well as non-members who wish to do so. We are struggling to find articles, and if they don't come our way then the content of Back Focus will suffer.

Rod Reynolds - President

CONTENTS

Rare Collectible Cameras

Tthe APCS meeting on Sunday 16th February 2020 featured an number of illustrated presentations by members of items from their collections that could be considered as rare - or just interesting. The following are summaries of written notes with some additions from the video that was taken during the presentations.

NIKON M Range Finder *Keith Head*

On 10th June 1991 I went to a house in Montclair Court, South Oakleigh, to look at a "box of old cameras" advertised in the Trading Post. It was a "Steptoe and Son" kind of property. The box was about suitcase size, full of dirty cameras, with an asking price of $100. This camera was near the bottom, it looked awful and I knew nothing about Nikons, so I put little value on it. However, I could identify a working Spotmatic and some interesting movie cameras, so didn't argue with the price. Later, even after reading up about Nikon rangefinders, I didn't think that a camera in such poor condition could be of any value, until I mentioned it at an APCS meeting and another member offered $1,500 for it, sight unseen. But by then I had become too interested in the Nikon Rangefinder story to let it go.

Peter Braczko's book on the Nikon System states that "this camera made Nikon world famous", a reference to its adoption by LIFE photographers in the Korean war. It was produced from August 1949 to December 1950. This one (number M6091727) was made in July 1950; one month after the start of the war. A total of 1643 M's were made. They are all marked "Made in Occupied Japan".

The "M" superseded the rarer Nikon "I", of which only 400 were delivered. The differences are;

- A fixed take-up spool
- A protruding panel on the back for a modified pressure plate
- Picture width increased from 32mm to 34mm
- The sprocket wheel changed to eight-tooth spacing.

One of the most interesting things about this one is its very worn condition. It has been used to the limit and a bit beyond. The leather covering has worn right through where the fingers naturally rest. The shutter curtain has been patched. The pressure plate is very worn. It must have been used professionally to sustain that amount of wear. It has not been mistreated; just worn out. The shutter still works OK on 1/200th and sometimes on some of the other speeds. Focusing is accurate.

Technically, it is very simple but of the highest quality:

- Shutter speeds from 1 second to 1/500th.
- No flash synchronisation.
- Non-standard picture aperture (18mm X 34mm).
- Internal and external bayonet lens mount copied from the Zeiss Contax, with focusing scale and helix on the body (for the 50mm lens only) and a trigger-finger focusing wheel.
- Removable back, numbered to match the body.
- Long-base coupled rangefinder integrated with the viewfinder.

The associated 35mm lens and zoom viewfinder were both from 1954.

The "M" was superseded by the synchronised model "S" which was the first Nikon export camera. For the first few months of its production, Nikon continued to use the "M" prefix to the serial number, but no other Nikon rangefinders have had prefixes (until the millennium models).

Unfortunately, Keith Head was unable to be present on the day for the presentation but had provided the above text in advance.

Fuji 680 III *Peter Lansley*

Hi, I'm Peter. I came to Australia in 1949 with my father, (Ten pound Poms) I was 15 at the time. I started work as a Survey assistant on an open cut coal mine at Ravensworth near Singleton. Part of my job was to assist the NSW Government Surveyor when he came to check our company Surveyor's work. Part of his kit was a Rolleiflex, the first good camera that I was able to handle. Soon after I went to Sydney and purchased a Zeiss Ikoflex IIA with an f3.5 Tessar, I took this camera to the UK in 1954 and took some of my best pictures on a visit to Paris in 1955. It was the start of my love of medium format cameras, Over the years since I have owned and used 7 different brands of 120 roll film cameras.

My last acquisition the Fuji GX680 III kit is potentially the best I have had; It was advertised on eBay. I could see that the kit comprised a number of items in a crate full of foam, I asked the seller for an itemised list, to no avail, so I took a punt and made a silly offer, this he accepted. I received a note to pick up the Fuji kit from a courier company in Dandenong. On pick up the kit was delivered on the front of a fork lift unit in a large Pelican crate with contents that weighed 23k. When I opened the crate and started to pull out components I felt like a kid who's Christmas's had all come together. The GX680 III, 3 Lenses, 3 film magazines, 3 viewing units, 3 power systems & lots of other accessories, and best of all they were all like new, some still in boxes. For less than the price of two film magazines when on the market in the USA ($1000 each) I was the proud owner of a comprehensive kit, and arguably the best of its kind.

The Fuji GX680 III started life in 1987, there were 3 model variants my model III was built 1998-2007 it is the only medium format camera to have front standard movements like large format view camera, it can be moved left, right, up and down for perspective control, also can be tilted on horizontal and vertical axes to control depth of field using the Scheimpflug principle, only limited by the fixed rear standard. Its strength would be in product, portrait, architectural & landscape work. There are 17 lenses ranging from 50mm to 500mm plus one zoom of 100-200mm, most are f5.6 but some are f3.2, their reputation is first class (Fuji builds lenses for Hasselblad). Fuji did produce an in house digital back that was only sold in Japan for 2,380,000 yen=$22,120, however, you can fit other brand digital backs Hasselblad 6x6, Contax 645, & Mamiya 645 with adaptor plates available from China for $200. Formats 6x8-6x7-6x6-6x4.5 can be set with viewing masks, the film magazine adjusts the film spacing automatically. Number of shots in order as above 9-10-12-16, double these for 220 film. Reading from the film surface the camera can check the accuracy of exposure, if under or over by two stops it displays the error with + or – and if using the remote trigger a warning buzzer sounds. Seiko electronic shutters are built in to the lenses + aperture control lever, flash synchronisation is available at all shutter speeds. Eye level & waist level viewfinders with auto exposure were available, (including flash). Bellows for long focus or wide angle lenses. Instant film holder (Polaroid) type. Extension rail set 40mm & 80mm + 1m and 5m Remote release. Film holder adaptors for Hasselblad 6x6, Contax 645 and Mamiya 645 backs, + plenty more accessories, too many to list.

The Edixa Zoomar   Rod Reynolds

The Voigtländer Zoomar lens is well known and held to be the first zoom lens fitted to a consumer camera – and many were fitted to the Voigtländer Bessamatic series. They did not have a good reputation for resolution or distortion, but with a range of 36-86mm and an aperture of f2.8 it was seen as a “universal lens” covering moderate wideangle through to portrait lengths and indeed was pretty innovative at the time.

But the word “Zoomar” actually refers to a US manufacturer that came up with the idea back in 1947 arising from a US military application – and an early use was as a television lens. The manufacturer was called Zoomar - maybe the result of this early development - they went on to design and manufacture surveillance lenses, usually with very long focal lengths, and some very fast lenses (faster than f1) for low light work. Their customers were predominantly Governments but they did occasionally advertise in professional publications. In 1958 Zoomar purchased the German (Munich) manufacturer Kilfitt who in turn made the lens for Voigtländer in 1959 on a dedicated 35mm camera as well as an interchangeable lens on the Bessamatic series. Kilfitt also made a couple of versions for use on other cameras. A version with an Exakta mount is fairly common. But there was another version as well – with a 42mm thread but not too much is known about this one. It is rare and desirable and the reference site Collectiblend prices it at 5 times that of the Bessamatic version.

Back in about 1975 one of those 42mm thread versions was on sale in its original case and box for very few dollars in one of Melbourne more notable camera stores – cheap for a very good reason – one of the internal elements had come loose and was rattling around. Worth having a go? Definitely, and after some hours of getting into this very complicated lens, relocating the errant element and then by trial and error getting the focus helix to line up properly, I had a working lens that performed – well – just like a Voigtländer Zoomar! Now I had not seen another one of these 42mm versions (and have not seen another one since) so the rest of this story might be subject to revision.

Was this a standard Voigtländer Zoomar for a Pentax, Practica or Contax-D? It differed from what was expected as it did not have the “normal” auto aperture control - a pin actuated from the camera. It had a spring loaded preset aperture lever and in the box was a short flexible cable assembly with an odd thread on one end and a conventional shutter release pin on the other. Very curious – and back in 1975 the lens in its box went into storage. A few years later I was playing with an Edixa Reflex-C and realised that the shutter release button had a strange thread around it. Could it be…? Search for a big Blue Voigtländer box and sure enough that flexible cable fitted and worked perfectly. But there was another detail that links this Zoom lens to Edixa. Users of Edixa cameras will know that the alignment of Pentax lenses is not quite right with the centre line and hence the aperture activation pin out by about 10 degrees. But this lens lines up perfectly with the Edixa body.

This display is with a Reflex C - it was readily to hand - and may not have been the actual model that was intended to be associated with the Zoomar. Maybe it was intended to be used with the Edixa Type A which did not have the aperture release mechanism as part of the M42 system.

I have never seen this Edixa-Zoomar combination referred to, and I have not seen any comment on the coupling cable when the 42mm version of the Zoomar turns up. It has to be one of the rarest modern combinations.

Canon Finger Print Camera
Peter Kitchingman

Towards the end of 2006 while doing a search on the internet for items that maybe marked with “Seiki Kogaku” an item popped up on my screen for a camera being auctioned through the auction house called “Auction Team Breker” who is based in Koln, Germany.

The camera was part of two items being sold simultaneously in the same lot #558 but the one I was interested in was the “Fingerprint” camera as I recognised the lens through a book, I owned but not the camera body itself.

I bid on the camera, half expecting many other Canon collectors to outbid me but when the auction finished, I found out I was the only bidder. After a month I duly received the item in the mail and could not wait to open the parcel.

The lens was a Seiki Kogaku 75mm f/4.5 which was described in Hayato Ueyama’s book “Canon” a book written totally in the Japanese language, but the accompanying photographs gave a good idea what the subjects were about.

I have been corresponding with Hayato (an Ex Canon Inc employee) for some time and during that time he has guided me in Canon history before I produced my own book on Canon Rangefinder Lenses in 2008.

I quickly sent an email off to Hayato who replied that he knew about the lens which he had coined the name “The Mystical” lens but had never seen the camera body it was placed in. As far as Hayato was concerned that this maybe the only existing example to date to be found from the Sino-Japanese conflict.

My research indicated that this was one of the first lenses that Canon had produced as predates the use of the lens identification name “SERENAR” which came into use in December 1941.

I have dedicated a chapter in my book on this 75mm lens and how it came about BUT how the camera itself got to Germany and ending up in a German auction house in 2006 got me researching the Fingerprint camera.

The Seiki Kogaku camera itself is a copy of the American Folmer Graflex Finger Print Camera produced between 1917-1929 for the Police laboratories throughout USA.

My theory is that SK Canon made this camera sometime in the middle of 1940 and shipped it to Germany late 1940 via Korea, Manchuria the Russian Trans-Siberian Railway before Germany attacked Russia in June 1941.

I have seen documentation where the Japanese were connecting with Germany via the above method but after June 1941 all contact was made at first by surface ships and later via U and J boat submarines via the Atlantic and Indian Ocean.

Who this item was being delivered to in Germany I cannot say or confirm but in the 1920s Nippon Kogaku along with both Zeiss and Leitz via a cross delegation they visited each other’s factories and checked out production methods and personnel?

The overloaded Contarex
Rod Reynolds

After WW2, the victors collected the remains of the German optical industry. A major name was Zeiss and the West established a camera division in Stuttgart. The Eastern Block did much the same in their area and continued with the pre-war concepts and production, while the West focused on new industrial, medical and related fields pushing quality and performance to the limits. On unification, the East & West Zeiss groups merged, and production is now global.

The West German Carl Zeiss program included cameras from snapshot to professional, with the 35mm range including names like Contax, Contaflex, Contina, and Contessa. An advanced SLR was rumored before 1954, but it was another 5 years until they released the flag-ship camera, the Contarex. In all there were 7 main versions and several variants from a simple film holder to an electronic version (1967) – far ahead of its time. Accessories were produced following whims rather than good business. The result was interchangeable backs, electronic controls, and about 50 lenses from 15 to 1000mm that still lead the world - although modern integration of lens and camera produces results that exceed even the best of stand-alone optics..

There were many “special items” made for the Contarex and some are exceptionally rare. Components of the “Contarex System” found their way into microscopy and similar laboratory applications and even into a quite rare electronic movie camera made for standard 8 film. In a radical development for the era, an “Electronic” version of the 35mm camera had multiple control systems via a data interface. Users of the system included NASA in space in an early Apollo mission, universities and research organisations with big budgets.

Even Kodak used one as a reference camera for testing film. Amateurs seeking the best could afford a basic camera and maybe a couple of lenses.

Shown here is an “Electronic” with most of the support system. The 1967 body is fitted with a 40-120mm f2.8 Vario-Sonnar Zoom lens, a 450 shot back and motor, along with an extended right-angled viewer to get past the back. One power supply is located in the handle, and another in the top of the camera. On the top of the body is an automatic shutter control system, which could close the shutter early or late if the light conditions changed during the exposure, using a system patented by Zeiss in about 1912. Note the data connection on the front of the body below the ZEISS symbol – a bit like USB today - providing functional access to power, exposure and shutter control - but all analogue rather than the modern digital approach. The remote sequence controller has a shutter duration meter mounted on top and permits time lapse photography for up to nearly 10 days unattended. This controller can be triggered by sound waves, trip wires or whatever else you can dream up… There was even a wireless remote control... Ask for it and Zeiss would make you an interface as a special, and it may never appear in a catalogue. (This display does not include the multitude of cables that are necessary to keep all this connected.)

But the Contarex did not last as it was uneconomic for Zeiss. In the frenetic race to be best, the system cost a lot more to design and build than the market would pay, and in any case was so big and heavy that it was virtually unmanageable. The product officially ceased in 1974, replaced in the consumer market by a more sensible family of Contax RTS cameras using economical versions of many of the Contarex lenses from predominantly Japanese sources. Yet back in Germany, an occasional demand by a customer allowed technicians to build another device based on spare parts for some years after 1974 – sometimes without serial numbers!

So how rare is this display? The camera is fairly common, the zoom lens only exists in a few examples, the add-on bits are quite hard to find, and the 450-shot back without a serial number may be a unique assembly made a couple of years after the main production of about 100 ceased around 1970.

Sometimes we wonder why some cameras were produced. This Contarex combination is close to if not totally unworkable. It is very heavy - over 6kg - and the lens mount is not really strong enough to support the camera from the lens support or vice versa. I once observed an American tourist in Europe carrying a Contarex Electronic fitted with the 40-120 Zoom with a bag of other bits over his shoulder in about 1978. It might have been the best that he could find for his trip but I also suspect that he wished that he had chosen a lighter system - he could have used a Contax RTS and been a lot more comfortable with no loss of image quality!

This display item raises an interesting point in the subject of photographic collectables. The first Zeiss Contarex Bull’s Eye was made more than 60 years ago and most of the components of this display were made more than 50 years ago. If we put that into the context of what was considered collectable due to age when the APCS held its first meeting - the Contarex today was equivalent to showing off a camera made during WW1. From another perspective, showing an early digital camera today was equivalent to showing a Contax I back then.

A couple of Exakta 6x6 cameras Geoff Schirmer

Geoff Schirmer brought along a couple of the rarer Exakta cameras - the pre-WW2 roll film model known as the “Exakta 66 and a post-WW2 version of the same format which looks like a scaled-up version of the much more common 35mm Varex series..

Geoff also brought along a modern large format camera and some images produced by it - showing that the old techniques were well and truly alive, and capable of excellent results.

It is to be hoped that a future edition of Back Focus will feature some of the results of the images captured by this modern approach to a classical camera design.

Very desirable Leicas Steven Mills

When Steve Mills shows something off, it will be a pretty good guess that it will be a Leica - or at least Leica related. This was no exception and we were treated to a close-up look at two of the most sensational Leicas of all time - the “Reporter” also known as the “250”, and the “250GG” in America and no less than probably the most notable of all Leicas in the mind of the collecting community - one of the very few original and highly collectable “Gold Leicas”.

Stephen related how he acquired the Reporter and its case - both in exceptional condition following an advertisement in the Melbourne Trading Post. Apparently its original owner was a professional photographer who did not use it because he preferred a "normal" Leica in spite of the fact that it was restricted to conventional cassettes - indeed that camera was also then owned by the owner who placed the advertisement and according to Stephen, it was the most worn Leica he had ever seen!

Stephen then told a story of being asked about authentication of a rare Leica which led to acquiring a Gold Leica made in 1930, and what he had to sacrifice to raise the necessary finance. In his presentation he outlined that there were thought to be 95 Gold Leicas made, and this one is the eleventh of those, although there is written opinion that the first 10 have never turned up so this one is the first - but no - on the serial numbers it is the eleventh. He also noted that there were two Gold Leicas in Melbourne at one stage the other one being a Model 1c that had been factory modified - and he noted that it had since been sold. He observed that there were variations in the Gold series - lenses and finishes for example.

Kodak Autographic Specials
Rod Reynolds

Kodak autographic cameras are among the most common cameras of all time. Aimed at the amateur, the autographic idea was a German patent that Kodak purchased - the idea was that you could write a note or a date directly on the film through the backing paper via a flap on the back of the camera using a metal stylus effectively exposing the film by pressure. They made cameras and film from about 1914 to about 1932 - although different references quote different dates. The cameras were so common that a few years ago one of the antique camera data books quoted the value of the most common Kodak Autographic cameras as "$3.50 per hundredweight". The common basic ones are still not valued highly and commonly sell for only a few dollars.

The largest was the Autographic 3A which produced pictures 3.25 x 5.5 inches on A-122 film. But there were specials that Kodak made for amateurs with very deep pockets, and even a military version. These are scarce and even very rare. The "Autographic Special" was also a platform for product experimentation and from about 1917 even included a coupled rangefinder. Lenses varied from a simple Kodak Rapid Rectilinear to a couple of Zeiss lenses made by Bausch and Lomb under license and the shutters ranged from Ilex through Compur to Wollensak Optima shutters.

None of the Autographics were cheap with the base models costing about the equivalent of $150 in today's terms but the top models cost the equivalent of $3,000. Even a base Kodak Box Camera in 1925 cost $50 in today's terms.

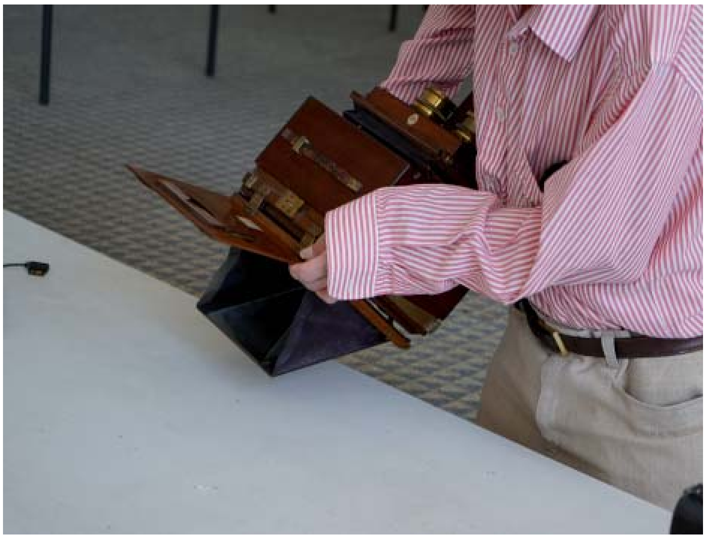
A result of this cost structure is that today - 100 years later, and with the special autographic film (A122) for the 3A going out of production at the beginning of WW2 and the 122 size ceasing half a century ago, very few of the exotic models have survived and good examples can command very high prices. Find a US armed forces version of a 3A from 1917 in good order and you will be paying several thousand dollars for it. But good examples of the exotic models do turn up and the displayed Special Autographic 3A Model-B fitted with the Wollensak Optima shutter and a Zeiss Anastigmat lens made by Bausch and Lomb, and the more common (but still rare) Model 2c Special from about 1924, this one having the base Kodak lens and shutter, both turned up in a recent APCS auction. Here they are... The original 1917 3A only needed a bit of internal resynchronisation to get the shutter to work. Other than the cosmetic finish this unit is nearly identical to the military version. It is of interest that the equivalent price today for these exotic Kodaks did not vary whereas the simplest box cameras fell in price by about 70% between the end of WW1 and the mid 1920s.

The whole subject of the Kodak Autographics is a very interesting one as it encompasses the development of popular photography between the two world wars. There were maybe 60 or more models in many negative sizes from Vest Pocket to the large postcard size 3A. Each basic model was available in up to 4 lens types and 3 or 4 shutters. Bodies were in wood and metal with coverings in leatherette, various hides and even seal skin. Bellows were usually black but some were red. Optional backs supported film pack and roll film. Even the range of film is large coming in rolls commonly to take 8 photographs but also in rolls limited to lower numbers down to 2 photographs. Kodak was exploiting the amateur art of photography in the era of contact prints.

There were many models with some variations depending on country of sale, and every now and again a surprise camera will turn up that is not obvious from the literature. For example a few years ago I was looking at the tables at an APCS Market day and picked up a very ordinary looking VP Autographic from about 1914 in fairly scruffy condition. I noticed that the lens was rather larger than usual and the front element was "different", including an engraved bezel.. Close inspection with a loupe showed that it was fitted with a Zeiss Tessar, and that it might even be a prototype before Bausch and Lomb made them under license. At the time, such an item was no more than a curiosity - today it is a very desirable item - another special version of the autographic family. My interest was with Zeiss lenses so that VP is in the collection. It is now emerging that Zeiss promoted several lens makers and their Anastigmats and Tessars, and even their Planars can be found everywhere. Sometimes it is worth checking everything!

A "no-name" SLR stereo plate camera Chi Chan

120 or so years ago it was fairly common for a photographer to get a carpenter to make a camera based on the expensive cameras that were commercially available. Specialist lens makers would sell you whatever you wanted and in the era of faster plates, makers like Thornton Pickard made "universal shutters" that could be used on just about any new plate camera or for upgrading of the older wet plate cameras that did not have more than a lens cap as a shutter. At that time cameras were quite simple devices - little more than an exotic light-tight box that included a focussing mechanism and a means of holding plates. Home builders could also get plate holders from the main manufacturers at reasonable prices and all the extra bits from general suppliers.



Occasionally, something emerged that included features that would become very standard in years to come - a great many of these bespoke cameras were inventions...

Such a camera was shown to us by Chi Chan... A fairly standard looking field camera but fitted with a stereo front, and many of the features of comparable commercial cameras - a spirit level on top, a swing back typical of the reversible back Rochesters from the USA, and of course the almost obligatory Thornton Pickard shutter - in the standard stereo format.

Other than that, there was no maker's name on the camera, and searches for similar items have not resulted in finding a name for the maker. But one feature stands out for comment. On the back was a device that included a 45 degree mirror allowing waist-level viewing - a real "SLR" - or maybe it should be called a "Double lens reflex" - being stereo - to differentiate it from the more common twin lens reflexes that were to come.

A Gowland SLR Paul Ewins

Paul brought along a Gowland 5x4 SLR. This is one of those cameras that just looking at it pretty much sums it up... Its maker - Peter Gowland - worked in the film industry as an extra in several feature films over a 30-year period (including the block-buster "Citizen Kane") and in the late 1950s turned to glamour photography - producing magazine covers etc, and publishing nearly 30 books on photographic subjects. He found he had special needs for large cameras and adapted ideas and was even an inventer, manufacturing small runs quite successfully. They do turn up on eBay but most seem to be sold privately in the USA. The 5x4 (standard Graflex back) that Paul showed was a true SLR using an ingenious mirror system close to the lens and incorporated a single speed shutter designed for flash control of the exposure, quite adequate in the low ambient light that would be normal in a studio.

Of course - being Paul - there had to be a Pentax on show as well - this one a relatively recent and common K20 DSLR but a rare variant that will be part of history.

This camera is marked as a K20D-W which uses a WORM memory card (Write Once Read Many) and was apparently produced for Law Enforcement where it was important that photographs taken as evidence could not be edited. The camera is essentially the same as the normal K20D but was loaded with special firmware supporting the WORM cards. When sold originally it was listed at the same price as a standard K20D. Total production of the K20D-W was probably very small compared with the huge numbers of the standard model that were made for public consumption.

That brought us to the close of what was a very interesting day and the chance to see and hear about a lot of cameras that are relatively unknown. In retrospect, it was the last meeting of the APCS for some time as a result of the COVID Pandemic.

Richlet 35

A very uncommon Japanese Camera — *Geoff Harrisson*

I first noticed this little camera that was for sale online because of its smart 1950s styling and it looked like no other camera that I had seen. Although the seller's picture showed it was a bit grubby and tarnished I thought it was worth obtaining and that I could possibly improve on its appearance.

The Richlet 35 was made in Japan by Rich-Ray c.1954. While it has '35' in its name and '24x36' printed on the front it does not use a cassette of 35mm film. A red window on the back indicates that it uses a small rollfilm. That film is called Bolta-size and is a paper-backed unperforated 35mm B&W

film on a special spool; it makes 24×36mm negatives. The hinged back opens downwards and the film is loaded over a curved film plane. The camera has a f5.6 focusing lens with two apertures and a blade shutter with three speeds plus B.

When the camera arrived it was smaller than I expected and certainly in need of some cleaning. A solid little camera, it has a bakelite body with a metal front and a metal top plate showing the maker's name and logo. There is a flash terminal on the front and a space to store a spare film in the back behind a cover marked "spare film pocket".

After removing some of the grime with solvent I worked on the lens mount and front knobs. They are made from cast aluminium alloy, so I had just the tool for the job. My eraser pencil (left over from years ago when I used a typewriter!) has a small point of hard rubber that was abrasive enough to carefully polish off those spots of tarnish and leave the metal clean and shiny.

I quite like the stylish look of this little camera. The designers have managed to take a brick-shaped camera and dress it up to look attractive. They were quite liberal in having its name displayed, including the little zippered pouch that has Richlet gold-stamped on its front.

The camera is pictured in McKeown, and the only other example I have seen anywhere is a picture on Holger Schult's website, so it seems to be a scarce camera.

The dawn of photography

Photographs and mountings at the beginning — *Richard Berbiar*

The Daguerreotype

The early 19th century saw the birth of a new art form known as the daguerreotype. Named after its inventor Louis Daguerre in 1839, the daguerreotype would remain the premier art form for the next 20 years.

The daguerreotype was made with a brightly polished silver coated copper plate, which exhibited a mirror-like quality. The plate was made light sensitive by exposing it to iodine crystal vapours, exposing the plate to light, developing it by exposing it to mercury vapours, then fixing the plate by immersing it in hyposulphite of soda (hypo). The image was then dried and colour tinted if so desired.

There were six standard sizes, from the extremely small 1/16th plate which measured 1.375” x 1.625” to the whole plate which measured 6½” x 8½”. The most popular size was the 1/6th plate which measured 2¾” x 3¼”.

Since the plate was easily scratched, it was protected by placing a brass mat around the perimeter of the image. A protective piece of glass was placed on top, secured with a paper seal held in place by the use of a thin brass retainer referred to as a preserver. The image was then placed inside a leather or thermoplastic case, many of which were ornate. The early leather cases had a silk pad opposite the image, while the later cases had a velvet pad depicting floral or other ornate designs with varying shades of red being the colour of choice. Occasionally the mat would be stamped or the pad would be embossed with the photographers name and address. On occasion, the case makers label would be noted behind the image.

The daguerreotype exhibited a wide range of tonal value with rich blacks and bright whites as compared to the later ambrotypes and tintypes which typically reflected a flat, drab appearance.

The daguerreotype was very popular, but had some drawbacks. The mirror-like quality was difficult to see from every angle, and had to be viewed at the correct angle of light the image was subjected to. In addition, viewing the image at certain angles would reflect a negative image, so the viewer had to change his angle of view.

Since there was no negative from which to make multiple copies, the daguerreotype was a one-of-a-kind image. If a duplicate was required, a second photograph was taken. The image was reversed and could only be corrected by the use of a prism or mirror, but this was a complicated procedure and was generally not used. The sitting process was quite lengthy due to long exposure times and often required a headrest to be placed behind the sitter. Perhaps that is the reason why most people’s expressions were somber. In spite of these drawbacks, the daguerreotype remained very popular until around 1860, when it was replaced by the ambrotype and tintype, lower quality, but less expensive methods of photography.

Most images depict people dressed in their Sunday best. Occasionally, an image is found with the sitter dressed in work clothes or clothes depicting that person’s interest or vocation. Books, flowers and other studio props were utilized, as well as an occasional scenic background depicting mountains, trees, lakes, etc. Daguerreotypes of pets, statues, paintings and outdoor scenes are rare and sought after.

Unfortunately, most of the images are not identified. Who are these people that lived 150 years to 200 years ago? What secrets do they hold? What stories could they tell? One such image was discovered by this writer and the story will be told in a future article.

Today, prices vary considerably depending on the subject, condition and size. If the identity of the photographer is known, that would also increase the value of the image. Anyone interested in photography would certainly find collecting daguerreotypes, and of course the later Ambrotypes and Tintypes etc, an interesting addition to their vintage camera collection.

Image cases

Leather (1839 - 1860) Image cases used to house daguerreotypes, ambrotypes and in some cases tintypes were made with a wood frame and covered primarily with leather. The early wood frame cases, generally those made prior to 1849 were made with a one piece backing, usually pine and four side rails glued together to enclose the back part of the case. The same construction was done for the front portion of the case. The design was inherently defective, and it was soon determined that the one piece backing caused warping. The problem was solved by making the backing shorter and adding a separate piece of wood to the top and bottom with the grain running perpendicular to the centre piece. This gave extra support which made the case more stable.

Leather case - Castle design

Improved wooden backing

The wooden frame was covered by gluing extremely thin pieces of leather which had been previously dyed and embossed. Typical colours used were black, various shades of brown, and cordovan. Some cases were enhanced by adding gilding. Closure was maintained by use of a single or double hook with eye fasteners.

The two halves were attached by the use of a leather strip (the spine), which now allowed for the opening and closing of the case. On the inside of the front cover was placed a plain red silk pad, and by 1850 the silk pad was replaced with a velvet pad of various shades of red, and to a lesser extent, tan, purple and green. Designs consisted primarily of geometric or floral patterns.

Open case - Cupid & Stag

Less seen were images of birds & butterflies. On the inside behind the image, a thin piece of paper was glued covering the wood backing. Unlike the later thermoplastic case, rarely did the case maker's label appear on the inside back of the leather case. A unique style case to appear in 1855 was the Eichmeyer case, named for Henry Eichmeyer. His cases consisted of rounded corners, ornate latches and band style design.

Eichmeyer case

Thermoplastic (Union) (1853-1867) Besides leather, a variety of materials were used to make image cases. Ornate cases were made utilizing other materials such as paper mache, cloth, mother of pearl, metal and thermoplastic, the latter being by far was the most popular of the later cases.

Thermoplastic cases, otherwise known as Union cases were made from wood fibre and shellac and should not be confused with Gutta-percha, a rubber based material which comes from a Malaysian tree. Gutta-Percha is pliable when heated and hardens when cooled but is not very durable. It becomes discoloured and brittle relatively quickly. The word "Union" has nothing to do with the Civil War, but was derived from the combination or "union" of the components when mixed together.

Union case - Lady & Falcon

Detailed molded images adorned Union cases in a variety of styles and themes - geometric, historic, patriotic, mythology, animals, people and flowers. They were mostly black or brown, but rare example in red or green are known but were seldom used.

Union case - 1/4 plate Cupid & Stag

Several firms made Union cases, and it is not uncommon to find the case makers label behind the image. Some of the more well known makers were Littlefield, Parsons & Co., A.P. Critchlow & Co., S. Peck & Co., Holmes, Booth & Haydens, and Scovill Mfg. Co. Although more than one case maker claimed to have devised the Union case, it was Samuel Peck who opened his gallery in 1844 and is generally given credit for inventing it. In 1850, a partnership was formed between Peck and Scovill, and in 1857 Peck was bought out by the Scovill Co. which became one of the largest photographic dealers in the world for the remainder of the 19th century. Scovill merged with Edward Anthony and became Anthony and Scovill and eventually the Ansco Co.

Union case - 1/4 plate Lyre in wide portal

Union case- Rebecca at the Well

Images and cases are a rewarding subject in historical photographic memorabilia from the 19th century. They run from common to extremely rare, and afford the collector an almost countless number of variations from which to choose. They are usually well made and many (including quality images) have survived from the era.

The Purma Plus

The lesser-known Purma — *Geoff Harrisson*

In 1937 Purma Cameras Ltd. of London introduced their Purma Special camera. The name PURMA is derived from the surnames of the company founders PURvis and MAyo. The Special has a very distinctive shape, is made of moulded black Bakelite and takes sixteen 31mm (1¼inch) square exposures on 127 rollfilm. Its most notable feature is the innovative gravity-controlled shutter. They must have sold many Purmas as they are a fairly common camera amongst collectors and sellers today. I remember them being sold here by Kodak in the 1950s.

Then in 1951 a completely re-designed Purma was marketed – the less commonly seen Purma "Plus". "Photographs Without Fuss" it said on the cover of a sales booklet. This camera has quite a different appearance to the first model and the body is made from aluminium. The film size and format are the same and it also has that unique shutter. Added features are an accessory shoe and a two-pin socket for flash sync. There is also a pin in the lens mount that prevents the shutter from firing when the lens cap is screwed on. It has been suggested that the Purma was the first camera to have plastic optics, but only the viewfinder is plastic. The Plus has a retractable, fixed focus/fixed aperture, three-element Purma Anastigmat 55mm f6.3 lens. It is spring loaded to pop out when the lens cap is unscrewed. Depth of field was given as 12 feet to infinity.

The unique gravity shutter runs under the curved film plane and is actually a more clever design than is obvious. A very detailed explanation of its design and operation can be read at http://licm.org.uk/livingImage/Purma_Special.html The shutter has three speeds marked: Slow 1/25, Medium 1/150, Fast 1/500 and is cocked by winding on the film. Holding the camera in a different orientation – as shown on the label – gives the different speeds. After taking your picture you cannot see an image in the very small viewfinder as a metal blind inside pops up and blocks your view, a reminder to wind the film on. There are two red windows on the back so each frame number is set twice to give the sixteen exposures.

As the lens aperture was fixed, and with the speed of the 1950s films, you would expose with the fast speed for sunlight, the medium for cloudy bright and the slow for overcast. The different shutter speeds were achieved with an adjustable gap in the blades and a varying speed of travel governed by a weighted brass cam. There is a secondary shutter, or cap, that covers the lens while the shutter is being cocked. Longer exposures were possible by rotating the shutter release button to the B position, there is also a cable release socket. Both are positioned in an unusual location - on the user's left.

Accessories such as a flashgun, filters and a lens hood were also offered by Purma. The Purma Plus was made at the Purma factory in Aberdare, Wales. Camera manufacture had ceased by 1959 and the company became Purma Precision Engineers in 1962.

There were a couple of versions of the Purma Plus during its development. The first version without exposure prevention and with simplified graphics is shown below:

Innovative Designs (Part 2)

Trend setters - or just oddities?

Herb Parker

One of the problems which plagued early photographers and camera designers was focusing. In the very early days of plate cameras this was not so much of an issue, but as cameras became smaller, focus aids were needed. Coupled rangefinders date from the early days and were included in special versions of the Kodak Autographic at the end of WW1. Part 1 of this article (Back Focus #114) I described the way in which Voigtländer addressed this issue with range finder in the 1933 Perkeo, and in their twin lens reflex, and here are some other unusual approaches. As told in part 1 (Back Focus #114 in Richard Berbiar's article) Corfield came up with a focusing viewer in their "Periflex".

A real curiosity is the ***Hanimex "Electra II"***, which was a 're-badged' Dacora-Matic 4D from the German Dacora Kamerawerk, (1961 and 1966). The unusual feature is again the method of zone focusing. Instead of the usual one shutter release this camera has four shutter releases, arranged one above the other on one side of the lens, marked both in feet and by pictorial symbols. The button one presses depends on subject distance – for close-ups one used the lowest button, and for distant scenes the top button, with other buttons for small and large group shots in between. The lens turns and moves forward when the appropriate shutter release is pressed, and the photo is taken, hopefully in adequately sharp focus.

Some unusual American designs.

We don't normally think of American designs when we speak of quality cameras, because American companies are generally better known for their 'popular' designs aimed at the mass market. But it would be surprising if a nation with the industrial capacity and the advanced technologies of the USA was unable to produce a quality camera, which indeed they can do and have done.

The Argus C3 is one of the better known American designs in the Argus C series of cameras, affectionately known as 'The Brick' on account of its unusual shape. This was perhaps the most serious attempt by an American company to produce a reasonably priced but quality 35mm camera for the serious amateur market. Its shape alone makes the design unique, but it has other unusual features as well.

The C3 has a CRF, and focusing is done by means of the rotating dial marked RANGE FINDER in the photo. This dial is surrounded by gear teeth (shades of the Voigtländer 'Brilliant' and 'Superb' designs?) which intermesh with similar teeth on a second wheel, which in turn drives the lens barrel. The conventional blade shutter has to be separately cocked by pushing down the black lever under the rangefinder dial, and double exposure prevention is achieved by pushing a small knob on top of the camera (just behind the frame counter to the left of the accessory shoe) before the film can be wound on. Compared to a Leica or a Contax the C3 is relatively crude and basic, but it was durable and reliable, and much loved by thousands of American photographers for many years.

The 'Mercury.'

Another very unusual design by the American Universal Camera Corporation of New York was the Mercury. The first model, designated the 'CC' appeared in 1938, and the 'CX' (Mercury II) appeared in 1945. The main difference between them is that the first model used special cassettes, whilst the post war model used standard 35mm cassettes.

The Mercury shutter is a rotating focal plane variable-gap shutter covering 1/20 to 1/1,000 sec plus T & B, and which accounts for the unusual rounded protrusion on top of the camera. Many references state that the Mercury was a half frame (18x24 mm) camera, but the actual size was 1"x3/4" ie 19x25mm and an annoying feature was that when the film wound on the spacing was uneven (wide at the end) so instead of getting 72 shots on a normal cassette you only got about 68, but that feature was part of the simplicity of the design which rotated the takeup spool by a set amount for each shot without counting sprocket holes..

The Mercury also had other unusual features. Film winding and shutter cocking is done by turning the knob to the left above the lens. The camera had a 'hot shoe' to accommodate a Mercury flashgun and another accessory shoe for the optional Mercury extinction exposure meter and the special viewfinders that came with the longer lenses - yes, this camera took interchangeable lenses!.

The 'Vest Pocket Autographic' Kodak (or VPK) first appeared in 1912, and claimed to "take up no more room in your pocket than three fat cigars".

From 1915 to 1926 it incorporated the patented Kodak Autographic feature, which is what makes the design unusual. On the rear of the camera there was a hinged flap which could be opened, and then by means of the metal stylus supplied (on the right of the flap) information about subject, date etc. could be written on the edge of the negative.

The VPK was not a sophisticated camera, but it was much loved by soldiers in World War I, who could carry it either in their pocket or on their webbing belt by means of the leather pouch that came with it, and many famous World War I photographs were taken with a VPK. It was also the camera used by Frank Hurley to take some of his incredible images of the ill-fated 1914-16 Shackleton Antarctic Expedition after his ship Endurance was crushed by the Pack Ice. There were a few variants of the VPK including a costly "Special" which was fitted with no less than a Zeiss "Tessar" lens in 1914 and then by a Tessar made under license by Bausch and Lomb.

Some interesting Chinese designs.

It may surprise some readers to learn that the Chinese have been making good cameras for quite a long time, perhaps the best-known example being the 'Shanghai' Leica copies of the 1950s. But the Chinese have made and are still making many other cameras, both under their own brands and in more recent years under license to Japanese makers such as Asahi/Pentax. Some of their designs are interesting.

The Great Wall DF-2.

This camera was made by the Beijing Camera factory around 1981, and is a waist level SLR for size 120 film. It is similar in design to the 1930s Pilot Super, which was in itself innovative. What makes the design unusual is the guillotine shutter. I am not going to pretend that I understand exactly how it works (but if a reader would like to tell me I would much appreciate it). It seems that the mirror opens the shutter as it flips up, and a following second metal blind closes it. Chinese lenses seem to be generally well thought of, and the Great Wall DF-2 is no exception. It features a very good Leica screw thread f3.5/90mm lens (I have used it on a Spotmatic, with bellows and adaptor, and found it very sharp).

The Hongmei-5.

This is a fairly conventional TLR, about which very little has been published in the various reference books I have been able to find. It appears to date from the early 1980s, and what makes it unusual is the depth of field scale, which can be seen under the lens. The camera is focused by moving what is in fact the depth of field scale, so focusing it is the depth of field scale that moves, and not the focusing scale as is the case with every other camera I have ever seen.

What makes these Chinese cameras interesting, to my mind, is not only that their design is unusual, but that the cameras themselves are not often seen, at least not in this country.

But I managed to find them, and that's one of the things that make photographic collecting so much fun!

Some interesting Japanese designs.

So far I have not described a single Japanese camera, and yet we all know that Japanese manufacturers have been at the forefront of camera design and manufacture since at least the 1950s, and so I thought I would have a look at some unusual Japanese designs.

The 'Asahiflex'.

For my 21st birthday in 1958 I was asked by my family what kind of present I wanted, and I asked for a good camera. I knew very little about cameras at the time, and when we visited Paxtons in George Street Sydney the salesman there tried very hard to sell us an Asahiflex, pointing out all the advantages of an SLR. I eventually settled for a Voigtländer Vito B, but my interest in the Asahiflex had been aroused.

The Asahiflex was of course the forerunner of the famous Pentax range of SLRs. The first model, the Asahiflex I, appeared on the market in 1952. It was the first Japanese SLR, and was soon followed by the Ia in 1953, the IIb in 1954 and the IIa in 1955 (yes, the IIa came after the IIb). The one I have, and which is pictured here is the IIb.

The Asahiflex IIb was a waist level SLR, not unlike the early Prakticas, except that it had an instant return mirror (Asahi were not the first maker to design an instant return mirror, contemporary claims to the contrary notwithstanding). What was unusual about it? The fact that it incorporated a conventional optical viewfinder, seen to the right of the waist level viewfinder hood. (This feature was also found on the Practina of the same era.) It meant that the photographer had all the potential advantages of an SLR, but it was slow and fiddly because such improvements as automatic diaphragm and pentaprism were still in the future.

So, if you wanted to do some quick shooting you could use the Asahiflex IIb just like a normal viewfinder camera, which I thought was clever.

The 'Konica IIIM'.

By the late 1950s there was a large selection of competitively priced high quality Japanese CRF cameras on the market. One of these, which appeared in 1959, was the Konica IIIM shown here. It was a very well-made camera with an excellent Hexanon f1.8/50 lens, and it had some unusual features.

The hinged selenium exposure meter cell was attached to the top of the camera in such a way that when the camera was not in use it folded down over the viewfinder window. Turning it up switched it on, at the same time allowing the viewfinder/rangefinder to be used. The meter needle was visible on the top of the meter itself, just under the shutter release button. Unfortunately, these meters were prone to early failure (note the small crack top right), and to find one still in working order would be most unusual, but it was a clever idea just the same.

The other unusual feature is the unusual film winding and shutter cocking lever, which will be seen to the right of the lens barrel. Just as was the case with the Voigtländer Vitessa it was possible to wind the film and cock the shutter with your left index finger while firing the shutter with the right, making rapid sequence photography possible without a motor drive.

Others with innovative features.

The 'Robot'.

It is often said that "there is nothing new under the sun". One of the features many photographers demand today is a motor drive, and this feature was already available as early as 1934 in the now famous German 'Robot' series of cameras, which featured a spring motor automatic film advance. One loaded the film (initially by loading special cassettes – later models accept standard 35mm cassettes), wound the large knob on top of the camera and fired away by simply pressing the shutter release. About a dozen exposures could be made before the clockwork motor needed to be wound again. The one I have is a Robot II, made from 1939 to 1951. The Robot IIa featured an elongated winding knob, which could be operated with gloved hands, which made it ideally suited for use by Luftwaffe pilots. Special models with Luftwaffe markings are eagerly sought after by collectors.

But there was another interesting feature. By pushing a small knob on top of the camera above the viewfinder the latter turned 90 degrees, so that one could seem to be looking straight ahead whilst in fact taking a photograph at right angles, thus making candid or spy photography possible.

The Zeiss 'Werra.'

The Werra range of cameras were made by Carl Zeiss Jena from about 1955 to 1960. There were several different models, some with coupled rangefinder and/ or meter, but they all had the same unusual features in common.

Winding of the film and cocking of the shutter were achieved by turning the ring around the lens barrel clockwise, with the top of the camera entirely uncluttered except for the shutter release. Another unusual feature was the lens cap (pictured) which could be reversed and doubled as a lens hood. These cameras were well made and had a Tessar lens, so were capable of very good results.

The Agfa 'Flexilette.'

I have always thought that Agfa (and also Yashica) was a manufacturer much under-rated by collectors. They made some well-engineered cameras with fine optics, yet not many of their cameras are keenly sought after. One of the exceptions is the Flexilette of 1960/61.

The Flexilette was a 35mm twin lens reflex. Now TLR's are common for 120 and even 127 roll film, but 35mm TLR designs are rare, which is what makes the Flexilette (and the more sophisticated Optima Reflex which followed it) unusual. I know of only three other 35mm TLR designs, the famous original pre-war Zeiss Contaflex, the American Bolsey C and the rare Bislent which was made in Argentina. The Flexilette has a very bright waist level viewfinder and a conventional shutter, with a filter ring covering both lenses. It was very well made and is a delight to use.

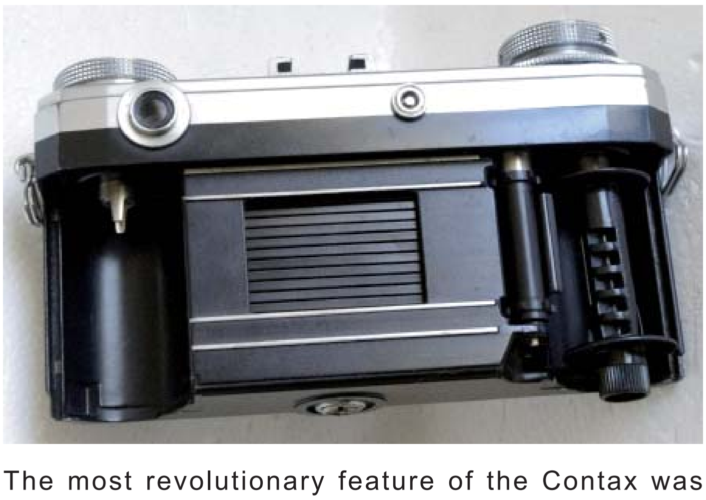
The Agfa 'Optima.'

The original Agfa Optima appeared in 1959, and is claimed to be the world's first fully automatic 35mm camera. Shutter speed, between 1/30 and 1/500 was selected automatically depending on the film speed set (10 – 200 ASA) and the meter selected only the aperture. This was done by depressing and holding down the large knob to the left of the lens barrel with the index finger of the left hand, and pressing the shutter release at the same time. For flash photography there was a small wheel to the right of the lens. When this was turned from "A" (for automatic) to flash the Compur flash socket above it was exposed at the same time, and the aperture could be selected manually.

The famous 'Contax'.

After the first Leica appeared in 1925, to be rapidly succeeded by more sophisticated models with new features, 35mm photography rapidly became more generally accepted. Soon the Leica swept all before it, and soon enough other manufacturers vied for a slice of the action. The most successful camera to challenge the Leica was the Zeiss Contax, which appeared in 1932. There were a number of different models, all with the same basic features, and the one I have is the Contax IIa, which appeared in 1950 and continued in production until 1961.

The first Contax introduced a range of innovations which were later to become standard, including interchangeable bayonet lenses, removable back, vertically travelling metal FP shutter, coupled rangefinder and combined shutter cocking/film transport. The later Contax II featured a combined viewfinder and rangefinder window.



The most revolutionary feature of the Contax was without doubt the shutter, with the then unheard-of top speed of 1/1250 sec. It was brilliant, but sometimes troublesome and difficult to repair. The standard lenses for the Contax were the famous f2/50mm and the rather more expensive f1.5/50mm Sonnars, which are still regarded among the world's great lenses, and which took a team of seven mathematicians two years to design in the days before computers. It is little wonder that the Contax, like the Leica, was expensive. The camera was supported by lots of accessories and a host of other lenses from extreme wide angle to nearly astronomically long telephotos.

The Zeiss Contarex 'Bullseye'.

Last but by no means least in this series is what many regard as the ultimate SLR of them all, the famous Zeiss Contarex (often called the 'Bullseye' on account of its Cyclops like meter cell above the lens) of 1958 although it did not come to market until a year later. Naming the Contarex models is problematic as different names were used by different marketers and commentators, including "EE", "I" and "Standard" but the official model number for the Bullseye was 10.2400 865/24. The Contarex was eventually made in seven basic models if we include the prototype of a fully automatic one in 1968, but even the Bullseye was produced in 5 distinct versions with the last running at the same time as the Super and Super Electronic in 1968. About 36,000 "Bullseyes" were produced along with 3,000 "Specials", 1,500 "Professionals", 9,600 "Supers", and 3,600 "Super Electronics". For the collectors there were very small quantities in a Black finish and very short productions runs of a couple of sub-variants - especially right at the end on the line. The basic cameras were extended for special purposes and became known as the "Contarex System" which takes volumes to describe.

The basic Contarex hardware was to become a very important part of a great many research areas and even made it into space where quality was essential. It was arguably the most opulently designed SLR ever. An exceptionally fine range of lenses was available with it, and it was the first (West-German) Zeiss Ikon SLR with an FP shutter. Zeiss also owned the Compur shutter works, which is why they persevered with their blade shutter Contaflex series for so long. Apart from a conventional cloth FP shutter the Contarex had several unusual features and innovations.

The meter looked distinctive and unusual (later models had TTL metering and looked quite different). It surveyed an 'average' angle of view, and was coupled to shutter, film speed and aperture.

The camera had the capacity to use interchangeable backs, with the ability to change films in mid roll without losing a frame and with complete security, although admittedly this necessitated a fiddly and complex sequence of operations. Most of those backs were never actually used! Mainly in research areas, data could be manually added to each frame by means of a plastic strip that the user could write on and insert into the optical path via a slot in the back. Most models included that slot, but examples of the Bullseye and the Special do exist without that feature.

Most of the shorter lenses automatically compensated for increased exposure needed for close up work, i.e, the aperture opened by up to half a stop at the closest focusing distance, and maybe a feature of many lenses is that the focus helix had a greater range than most other makers provided.

The series (1958-1973) was very much a platform for innovation and experiment, and by the end of the series there were remote controls (including wireless), timers, a data port, vibration absorption, distance controlled flash compensation, and supporting hardware of almost every imaginable kind.

Certainly, the Contarex was heavy, expensive and complex, but it was also a superbly engineered camera with legendary optics. Unfortunately for Zeiss the equally revolutionary Nikon F appeared around the same time, and within a few years succeeded in capturing the lion's share of the professional and serious amateur markets. Likewise the rest of the Japanese makers were producing cameras and lenses that were more than adequate for most users - they were very significantly lighter and cheaper - and they won the commercial war. However for Zeiss probably the most competitive threat came from Leitz with their corresponding SLR cameras and similarly high performance lenses. That competition can be appreciated when it is observed that the total production of the Bullseye was about the same as the first model of the corresponding Leitz SLR - over nearly a decade for Zeiss but only 4-5 years for Leitz.

Innovation continues.

But we should look to another innovation which opens a whole new line of examples - the innovation of Digital Photography which has totally revolutionised the recording of images - from devices that were no more than digital versions of film cameras to totally new concepts inside computers, phones and virtually every application you can dream up. The history of digital cameras and how the digital camera came to be present in nearly everyone's pocket is a whole story of its own, and that story is far from over.

Some of the cameras I have described in this and in part 1 printed in Back Focus No 114 are fairly readily available at affordable prices, whilst others are scarce and relatively expensive. But that's what collecting is all about. Why do I collect? Let me quote from R.L. Stevenson's essay "El Dorado": "To travel hopefully is better than to arrive", or as some great lover once said: "The search is half the pleasure".

Using Collectable Cameras (Part 2)

The results of the competition *The Judges*

The last edition of Back Focus included a competition to judge the best of a series of photographs taken by a couple of heritage cameras in an article by Jim Morraitis. You, the readers, were asked to judge as well from the included voting card, and a few of you did just that - without knowing who took what.

The results are now in and the voting was close no matter how we manipulated the weighting for first and second. But there was a clear winner with that result being the same as was nominated by Ian Carron last year. So congratulations to Jim for the No 1 spot, or maybe it is congratulations to those who voted for coming to the same conclusion as did Ian.

The Winner - Photograph by Jim

The equal runner-up - Photograph by Jim

The equal runner-up - Photograph by Violetta

AUSTRALIAN PHOTOGRAPHIC COLLECTORS' SOCIETY Inc

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(Founded 1976)

45th ANNUAL REPORT

Included with Back Focus No. 115 – June 2020

And to be presented at the

ANNUAL GENERAL MEETING

To be held at

The AMRA Hall
92 Wills Street, Glen Iris

on

a date to be determined

President's Report

This last year will be recorded as the most extraordinary period in the 44-year history of the APCS, and is likely to mark a dramatic change in how the APCS functions. Over the last few years, we have struggled to maintain membership numbers, and that is now lower than at any time since the first few years. There are a few fairly obvious reasons for that which stem from finding the type of person who wants to collect camera equipment, and indeed the general popularity of that hobby – if that is the right word for what we do.

The 1970s saw the beginning of photographic technology – even film and chemistry – which relied heavily on electronics for their ease of use and performance. Many of the early members of the society were those who yearned for the old ways of photography before this new technology became a significant part of the art of taking photographs. Coming together as the APCS was a natural way of sharing the historical experience and indeed collecting cameras and equipment that was beyond their financial resources when they were younger. 20 years later witnessed the transition to digital photography and there were more candidates yearning to remember the older film technology.

This was a gradual process as digital photography took a few years to achieve the required resolution and capability in a digital camera and the associated processing that went with it. But by about 2010 and maybe specifically the emergence of the mirrorless DSLR, digital photography overtook the capability of film in the minds of all but maybe a few film diehards. Putting it simply in that context, there are now very few people in the new generation who are dedicated long term adherents to collecting, and at the same time, those who were in the first 20 years of the APCS have now aged to the point that their involvement has dimmed.

It is observed that the length of membership or maybe interest in collecting seems to have reduced over recent times… Many members who joined before say 2000 are still with us but many of those who joined since then lapsed after only a couple of years. Currently we have 169 members of whom 9 are life members – a net loss of 40 members over the last 12 months.

A new trend has emerged for a fairly high proportion of the membership. There has been a significant change in the behaviour of members who have migrated from "collecting cameras and equipment" to "trading cameras and equipment". This seems to be a global trend and there is now a lot of attention around what a camera is worth as an investment and often as a vehicle for quick financial gain. There is of course a lot of evidence for that as some cameras have increased in value so much that the gains have outstripped any other investment type, and individual examples have caught public attention. Various trading platforms – auction houses – on-line trading – our own APCS markets and auctions have capitalised on that realisation and have to some extent become the publicity centres for our behaviour. Further, where once trading cameras was a local affair, it is now global, and many of the big transactions are international.

At the same time as exotic and perceived valuable cameras are costing more, some of the cameras that were simply collectable have actually reduced in value – or at least the prices at auction have reduced – particularly when inflation is taken into account. That may be one of the consequences of the increase in the number of collections on the market from deceased estates and those wishing to liquidate their collections.

New challenges are emerging that are changing the whole photographic industry. In spite of new technology that is producing exceptional digital cameras, the total production of precision cameras has been overtaken by the capability of the cameras in everyone's mobile phone to do a good job. Today the production of dedicated cameras is only about 20% of what it was 20 years ago, but the production of cameras in phones is such that more such cameras are made every 15 or so days than all the film cameras that were ever made. Could this be any more evident than in the number of cameras made for the tourism industry? Not only are phone cameras easy to use but they are connected to communications systems that allow near instant transfer and viewing, and in a great many cases produce better results than any film camera that the user might carry around – and those phones can also store thousands of photos, and tens of thousands more if the Cloud is included as storage. Maybe one day these will be collected but they will probably be collected as phones rather than as cameras.

Further, as this is being written, the beta models of the latest premium phones that are part of the 5G revolution are being equipped with cameras that seriously out-perform even the most elaborate stand-alone cameras. Those high-performance phones are aimed at the professional photography market, and will almost certainly make serious inroads in the market for advance prosumer photography.

As is the case for aging societies, death is a relentless event for the APCS, and we notice it critically when those pass on who were the stalwarts of running the Society. This year we lost two who were long serving members of committee – Brian Hatfield and Ian Carron, both leaving vacuums that will be very hard to fill or emulate. Our condolences are extended to their families and all who held them as friends. With Ian's passing, the APCS will not be the same as the central product "Back Focus", previously controlled by Ian, will change quickly into a new format as we are now forced to reinvent it in a new digital world.

But the event that is on every member's mind at present is the COVID-19 pandemic. It has brought the traditional events of the APCS to a standstill and who knows what the eventual result will be with everything that we do being now clouded with uncertainty? After a normal 2019, we have had only one event in 2020 – the February meeting, and who knows if there will be any more APCS events for the rest of the year?

Many organisations with similar aims to those of the APCS were struggling around the world for much the same social reasons prior to the pandemic, and with events being cancelled everywhere there is a high probability that more such organisations will cease to exist when this is all over. The APCS has one very important feature in its makeup that should make its continuance far more certain. We have substantial financial assets that will allow communications like newsletters and the production of a quality Back Focus to continue for several years without the financial support of our auctions and markets. In fact, the APCS is in a position to invest in the future – making innovation in communications and promoting the hobby of collecting cameras even more accessible to the public through the Internet than has been the past practice of restriction to paying members. New technology is becoming more accessible – websites – email communications – social media like FaceBook – and these are now universally facilitated by new and simpler home computers and the ubiquitous mobile phone. This is becoming the "new normal", and even that is likely to change in ways that we currently can't predict over the next year or two as the effects of the pandemic become less evident.

As far as APCS events go, the APCS financial year ran normally up until the Box Hill market scheduled for March 2020. It was only a few days before that scheduled date that the pandemic essentially demanded that the event should be cancelled. That was a few days before the rest of the community shut down and retrospectively it was the right decision for us as by the end of that week the whole population had changed its behaviour and the attendance would have been so low to be very disappointing. Since then there was absolutely no question that APCS events should continue, and at the time of preparing this report it is certain that it will be several months before we contemplate any resumption and even then we can expect very low attendances, because both the rules imposed by Government and our own personal risk-averse nature will be to avoid infection at all costs. And we have to note that we will be more conservative than the rest of the community as we are predominantly an aging group that is more likely to be in critical danger if infection does occur.

For us it does mean that there is a significant quantity of photographic equipment banking up that is not being sold – in the two markets – Melbourne and Adelaide, and in the April auction, and it seems likely that the situation is not going to improve any time soon. Not only are the selling opportunities absent but it also seems that the membership has suddenly become reluctant to go out and purchase items of interest. This is not just evident in the APCS but is also reported all around the world.

The electronic newsletter is now well established as the main communications channel to members, reaching about 95% of all members via an email link on the second Sunday of each month that includes an APCS event – and in this

COVID year that continues keeping members up to date. Such are the on-line communications from other Societies, that some of their publications are also linked to APCS members in the same way.

Four new life memberships were awarded this year:- John Fleming, Stefan Sztromajer, Andrew Korlaki, and Steven Mills for their contributions to the life of the APCS and photographic collecting in general.

Thanks to Leigh Harris and Katherine Blyth for their management of the last dozen Box Hill markets. They now step back and we are looking for someone else to take over. To help that process, Leigh has developed a working standard procedure for running the markets. With the passing of Ian Carron and the management vacuum in a couple of other areas, it is becoming normal for the functions of the other key APCS events like the auctions and meetings to be managed by groups of people – maybe only a couple – rather than having an individual taking the whole load. If you check the last page of this report you will see that a few of the traditional functions are marked "Vacant", but the work is continuing as the committee and non-committee take over the roles. Inevitably, there will be individuals who appear to be leading each group but others are taking increasing proportions of the load.

The APCS strong financial resources – made possible by the profitable events like the markets and auctions, means that the continuance of the APCS is not at risk for many years – and we will weather the COVID emergency and expect to generate a new people resource for whatever the APCS becomes when the crisis is over.

As President, I thank all who have rolled up their sleeves and contributed to the good of the APCS, and I am particularly thankful to those who have contacted me to express opinions and ideas. Those inputs are valuable as they are the basis upon which we can evaluate changes and move forward.

Rod Reynolds, President

Treasurer's Report

Financials: The 2019-2020 financial year ended with an operating surplus of $1,934.62 compared to the previous year of $22,562.60. The income for the year, was down by $20,627.98. This significant decrease was due to two factors. The larger retained profit from last year is attributed mostly to the sale of Margaret Mason's camera estate, the bulk of which was gifted to the society. The other significant issue was the virus lockdown during the first two quarters of this calendar year. This effectively curtailed our income earning activities which included the auctions, the March market and the Adelaide market.

Operating expenses were $1,133.71 higher than last year. This is partly due to higher auction vendor payments, compared to the retained profit from Margaret Mason's estate. Other expenses were in line with previous years except for Back Focus, there being two issues less that previously following the passing of our Editor, Ian Carron and pending the reorganization of the future of our magazine.

Fixed Investments: Our fixed investments continue to be managed by UCA Funds Management. They are placed in the UCA Enhanced Cash Trust fund. The interest rate of 2.25% was effective until 23rd September 2019, however, from then to the present time, the interest rate was reduced to 1.90%. This follows a reduction of the cash rate by the reserve bank. In July 2019 we transferred an amount of $32,769.11 from our current account to our fixed investments. The fixed investments stand at $49,979.86 for the year ending 31st May 2020.

Subscriptions: Subscriptions remain at $30 for the current year. Payments should be made to the Treasurer by cash or cheque, or by direct deposit to BSB 083-166 Account number 51-531-5423 indicating both surname and membership number in the reference. It would assist if members wrote their membership number on the back of cheque payments.

I would like to thank Kevin Saunders for his assistance in reviewing the accuracy of the reports.

John T Young, Honorary Treasurer

FINANCIAL STATEMENTS FOR THE YEAR ENDED 31 MAY 2019

Profit and Loss statement

2019		Notes	2020
	Income		
4,590.00	Subscriptions	3	3,790.00
427.35	Interest Income		715.28
38,856.00	Auction Bid Payments	4	30,435.95
6,290.00	Market Door Entry Fees	5	1,947.00
6,205.00	Market Table Fees and Sundry Sales	5	5,450.00
3,806.15	Transfer from PPS, South Australia		0.00
1,793.00	Adelaide Market		0.00
0.00	Web Hosting refund Netsys		135.00
61,967.50	**Total Income**		42,473.23
	Expenses		
20,510.80	Auction Seller Payments	4	28,994.28
60.00	Auction Expenses	4	0.00
4,906.75	Market Expenses	5	2,577.00
0.00	Table refunds March Market	5	650.00
5,249.99	Back Focus	6	3,419.00
527.27	Social and refreshments		967.87
573.60	ADSL Editor and Netsys		135.00
75.00	Depreciation		70.00
986.64	Insurance		986.57
57.80	Meetings		0.00
1,139.00	Office Expenses, Stationary & Software		312.44
145.25	Other expenses		0.00
4,072.80	Postage		1,216.45
1,100.00	Rental		1,210.00
0.00	Bank fees		0.00
39,404.90	**Total Expenses**		40,538.61
22,562.60	**Operating Surplus for Year**		1,934.62

Balance Sheet As At 31 May 2019

2019		Notes	2020
	Assets		
	Current Assets		
71,653.58	Cash and Bank Accounts	7	73,748.20
71,653.58			73,748.20
	Non Current Assets		
7,882.00	Library at Cost		7,882.00
1,681.00	Equipment at Cost	8	1,681.00
1,611.00	Less Depreciation	8	1,681.00
70.00	Depreciated equipment		-
7,952.00	**Total Non Current Assets at WDV**		7,882.00
79,605.58	**Total Assets**		81,630.20
	Liabilities		
	Current Liabilities		
210.00	Subscriptions in Advance		300.00
210.00			300.00
210.00	**Total Liabilities**		300.00
79,395.58	**Net Assets**		81,330.20
	Equity		
56,832.98	Retained Earnings		79,395.58
22,562.80	Operating Surplus for Year		1,934.62
79,395.58			81,330.20

Statement of Cash Flows

2019		2020
	Cash flows from operating activities	
3,806.15	PPS South Australia Transfer	0.00
4,440.00	Total Subscriptions Received	3,880.00
427.35	Interest Income Received	715.28
38,856.00	Proceeds from Auctions	30,435.95
14,288.00	Proceeds from Markets	7,397.00
0.00	Other income	135.00
-39,329.90	Payments to All Suppliers	-40,468.61
22,427.60	**Net cash inflow from operating activities**	2,094.62
22,487.60	**Net increase in cash held**	2,094.62
49,165.98	Cash at the Beginning of the Financial Year	71,653.58
71,653.58	**Cash at the end of the financial year**	73,748.20
	Reconciliation of operating surplus to net cash	
22,562.60	Operating Surplus	1,934.62
75.00	Depreciation	70.00
-150.00	Change in Subscriptions in Advance	90.00
22,487.60	**Net cash inflow from operating activities**	2,094.62

Notes To and Forming Part of the 2019 Financial Statements

Note 1 Statement of Significant Accounting Policies

This special purpose financial report was prepared for distribution to the members to fulfill the committee's financial reporting requirements under the Australian Photographic Collectors Society's constitution and the *Association Incorporation Reform Act 2012* (Vic). The accounting policies used in preparation of this report, as described below, are in the opinion of the committee appropriate to meet the needs of the members:

(a) The financial report was prepared on a modified cash basis of accounting, including the historical cost convention and the going concern assumption.

(b) The requirements of accounting standards and other professional reporting requirements in Australia do not have mandatory application to Australian Photographic Collectors Society because it is not a 'reporting entity'. The committee has, however, prepared the financial report in accordance with all applicable Australian accounting standards.

(c) Property, Plant and Equipment is carried in the accounts at cost less, where applicable, any accumulated depreciation. The depreciable amount of Property, Plant and Equipment is depreciated over the useful life of the assets of the Society commencing from the date the assets are first held ready to use.

(d) Cash and Cash Equivalents. This includes cash on hand and deposits held with banks including trading accounts and term deposits. Interest earned is brought to account as it is received and credited to the account.

(e) Goods and Services Tax. Australian Photographic Collectors Society is not registered for GST. All amounts are recognised inclusive of the amount of GST where it applies.

Note 2 Trade Receivables

The Society trades on the cash basis of accounting. It does not bring sales to account when the sale is recorded but only when payment is received.

Note 3 Subscriptions

2019		2020
360.00	Prior Subscriptions in Advance	210.00
4,440.00	Subscriptions Received	3,880.00
-210.00	Subscriptions in Advance	-300.00
4,590.00		3,790.00

	2019		2020
Note 4 Auctions			
	10,912.10	July Bid Payments	11,509.10
	-3,359.14	July Seller Payments	-11,352.07
	-60.00	July Expenses	0.00
	847.00	April 2018 receipts	0.00
	-8.75	April 2018 payment	0.00
	8,331.21	Profit	157.03
	20,362.65	October Bid receipts	17,502.20
	-11,907.01	October Seller payments	-15,436.63
	0.00	October expenses	0.00
	8,455.64	Profit	2,065.57
	6,734.25	April Bid receipts 2019	1,424.65
	-5,235.90	April Seller payments 2019	-1,707.13
	0.00	April Expenses	0.00
	1,498.35	Profit / Loss (-)	-283.48
Note 5 Markets			
	2,410.00	September Door Entry Fees	1,947.00
	3,255.00	September Table Fees and Sundry Sales	3,000.00
	-2,367.90	September Expenses	-2,389.00
	3,007.15	Profit	2,558.00
	3,880.00	March Door Entry Fees	0.00
	2,950.00	March Table Fees and Sundry Sales	2,450.00
	-2,488.85	March Expenses	-650.00
	4,341.15	Profit	1,800.00
	1,793.00	Adelaide market - net result	0.00
	-50.00	Other market miscellaneous expenses	-188.00
	1,743.00	Total Adelaide market	-188.00
	14,288.00	Total Market proceeds	7,397.00
	-4,906.75	Total Market expenses/table refunds	-2,577.00
	9,381.25	Total Market Profit	4,820.00
Note 6 Back Focus			
	930.00	Articles	1,140.00
	4,319.99	Production	2,279.00
	5,249.99		3,419.00
Note 7 Cash and Bank Accounts			
	54,442.83	NAB Trading Account/Quicken balance	23,768.34
	17,210.75	UCA Cash Management Account	49,979.86
	71,653.58		73,748.20
Note 8 Equipment at Cost			
	798.00	Library Cabinets	798.00
	475.00	Furniture	475.00
	408.00	IC LCD Flat Screen	408.00
	1,681.00		1,681.00
		Depreciation	
	728.00	Library Cabinets	798.00
	475.00	Furniture	475.00
	408.00	IC LCD Flat Screen	408.00
	1,611.00		1,681.00

Officials and Contacts

Office Bearers 2019-2020

PRESIDENT	Rodney Reynolds – president@apcsociety.com.au
VICE PRESIDENT	Ken Anderson
SECRETARY	Stephen Chung – secretary@apcsociety.com.au
TREASURER	John Young – treasurer@apcsociety.com.au
COMMITTEE	Ian Carron (Died August 2019) Leigh Harris Matt Makinson Kevin Saunders John Millar
NEWSLETTER EDITOR	Vacant – email to web@apcsociety.com.au
BACK FOCUS EDITOR	Vacant – email to backfocus@apcsociety.com.au
AUCTION MANAGER	Vacant – email to auctions@apcsociety.com.au
MARKET MANAGER	Vacant – email to market@apcsociety.com.au
WEBMASTER	Rod Reynolds – web@apcsociety.com.au

Clubrooms

MEETINGS	AMRA Hall 92 Wills Street, GLEN IRIS

Contacting the APCS

MAIL	THE APCS C/o The Secretary (See the web, newsletter & Back Focus for current details)
PHONE	(See the web, newsletter & Back Focus for current details)
WEBSITE	http://www.apcsociety.com.au

There is more to testing a lens than meets the eye

A new approach

Rod Reynolds

Part 1: Testing Methods - Resolution

About a decade ago, photographers welcomed the first of the mirrorless digital single lens reflex cameras (M-DSLR) and the ability to mount nearly every interchangeable lens via a range of adapters that became available, and a few more if you made your own adapter – facilitated by a reduced space between the camera mounting flange and the image plane which allowed space for those adapters. A few conversions needed aperture and focus controls to be included within the adapter. The formats at the time were the less-than-full-frame APS-C and micro-4/3 and the sensor resolution was typically 14MP. The practical side has been presented on many internet sites and in publications: eg Back Focus in issue 79 (December 2010) which looked at the fundamental details, and issue 90 (September 2013) which addressed optical converters to allow lenses designed for full frame to be used more effectively with APS-C sensors. The camera limitations of the day dominated any design and performance shortfall of virtually any lens, and users could expect near "perfect" performance no matter which old lens they used.

Today full frame M-DSLR cameras have sensors achieving 36MP, and up to 61MP for more dollars, and there are a few tricks in the latest models that will allow even better than that. New dedicated lenses are integrated with in-camera software that compensates for design and performance errors, achieving image results that exceed anything that we have seen previously. Very few of the heritage lenses are good enough to exploit the new camera resolutions and it is time again to look at the whole matter.

This is the first of three parts, essentially covering how to test a lens and a precis of the results of testing a lot of lenses, concentrating on the resolution that can be achieved. The second part deals with the next stage of complexity, and compare the various aberrations that occur in the tested lenses, and the third part deals with the whole matter of integrating lens, interface and camera, and optimisation to achieve new precision in image quality. There may be a common theme throughout the series – "don't bother trying to use legacy lenses on a modern quality digital camera – even a cheap dedicated lens is likely to do a better job".

This is not a treatise on the design of lenses and how they should or could be compared based on their geometric form. To cover the breadth of lens design and practice, this would be a very large work indeed, would need to rely on some highly mathematical approaches and would also need to address quality control in manufacture. While such approaches are important to manufacturers and designers, they are not of much practical use to those who are primarily interested in how an existing lens performs.

The science of lenses used in image forming goes back hundreds of years, and even the work of Newton (1643-1727) is still a useful albeit simplistic approach to fundamental lens analysis. Since then, many have contributed to the technology, usually with the aim of creating perfect lenses and as that has progressed, so has the complexity of the design and analysis methods. For most people, the multiplicity of parameters that describe the ability of a lens to resolve an image has resulted in confusion. But maybe more importantly, summaries that might have been sufficient once are now misleading as lens and system design have progressed and early ideals of perfection have changed.

Common measures of lens performance have been resolving power, chromatic and spherical aberration, "MTF" diagrams (Modulation Transfer Function) etc. Most are beyond the ability of an individual to test and maybe even to understand. Even though modern highly quantitative approaches to lens design only date from about 80 or so years ago, those considerations were restricted to the optical laboratories and did not become generally known until the 1960s. As photographers, we may even ask different questions… "Is it sharp?" "Are straight lines straight?" "Is there colour fringing in the corners?" and the importance of the answers may also depend on the subject matter. Some of the parameters that are thought of as lens parameters are also short-comings in the recording medium – the film – and today not only the digital imaging sensor but the software that is used to make corrections. The most modern digital cameras are an integrated combination of lens, sensor and software, and as much of the correction is achieved in the software, the design of the lens itself is no longer such a challenge. More of that in part 3. There are other characteristics of real lenses that are mentioned from time to time – coma – flare – refinements on aberration types etc. For practical purposes they are probably not particularly relevant to lens comparisons, but there are times when reference to them is the easiest way to describe problems. Sometimes, various lens characteristics go hand in hand and it is really only necessary to look at a restricted list of issues.

Almost inevitably, photographers or maybe more particularly photographic collectors will ask questions like "What is the best lens?" The theoreticians will rely on published and tested data and proclaim that certain lenses can have that title. Some practical photographers will disagree, often for very good reasons, quoting parameters like star patterns, bokeh and other characteristics that are seen as having artistic value that might even be abhorred by the lens designers. However in comparing lenses we will find occasions when we have to resort to such terms, as those effects dominate what we see.

But there is more to it than this… What we are about to do is to test a lot of lenses to get some understanding of what lenses are good, and in a very few cases we will be looking at the actual performance in an environment where we are close to the theoretical limits. And we probably recall texts on diffraction limitations, dependence on wavelength, and other theoretical approaches that ultimately remind us that there are real limits to what is even possible. In practice we are unlikely to see those limits for a whole host of reasons, and the effect will be that we will end up looking at total degradations to an image with a strong factor being that manufacturers can't make perfect lenses – and if they really tried we would not be able to afford them. So we will leave the theoretical approaches to the theorists – and that is all well written up elsewhere for those who want to go down that path. We will consider real lenses that we have, or might consider getting, and look at the degradations that we might have no control over.

For the moment let us ignore the corrections that can be performed using digital software, and without too much comment, avoid the image modification that comes with image encoding (eg JPG) and in the film context ignore the complications of film chemistry and manufacturing processes. We will come back to those issues later. If we ignore really bad lenses, then the difference in performance between the world's top lenses is not very much at all. We will shortly see that all lenses designed and made to work with panchromatic and colour film, and now for digital imaging in the visible spectrum perform similarly. Let us also accept for the moment that there are some lens-digital-sensor issues that are known to cause problems, particularly in wide-angle lenses, that probably should be considered temporary – until new sensor technologies arrive.

The limits for the systems that we use for different purposes – snapshots – studio shots – surveillance – and some technical applications – all have parameters that pretty much define what lens is going to be useful. Back in the film era, photographers had – maybe without realising it – adopted working imaging standards, essentially based on the film that was available. As the formats decreased in size, higher resolution films were demanded and "standards" like "Panatomic-X" and "Kodachrome 25" were adopted as design ideals for many cameras and of course the lenses that they employed for full-frame 35mm usage, mostly because those films were the most common limiting factor, and even quality lenses did not have to be any better than that. It was only in the laboratories that films like Technical Pan etc stretched the performance of most lenses and could exploit the precision of laboratory grade imaging systems. Further, some lenses were the product of marketing philosophies and commercial issues around patents etc – all of which led to a huge range of lens performances.

Before we start considering the performance of specific lenses, we need to have some understanding of how to make judgements and even how to put some quantitative numbers around what we see. The analysis of lens systems can be performed on an optical bench of some kind, often set up to examine specific lens parameters, and as the design limits are often tiny then the extremes of optical microscopes etc are needed to help with the analysis. This inevitably leads to some uncertainty, especially with the best lenses, where those lenses can be better than the testing environment. When a lens is considered part of a camera system, some of those historical measurements were made on exposed films and again there was uncertainty as films change their dimensions as they dry etc. Today it is much easier as the digital images that are recorded allow exceptionally accurate results – even from commonly available cameras.

As sensor resolutions increased so did the demands on lenses and it was not long before virtually any compact camera could produce images that exceeded the best film in a 35mm equivalent environment. The original Sony A7R for example produces images with pixel spacing that allows an image to be produced and examined down to a measurement of 0.005mm in a 24x36mm full frame, and there is no ambiguity in such measurements as they can be seen and measured directly with the aid of a computer program like Photoshop. Lens design improved to match the new sensors but it turns out that only a few lenses have total degradations small enough to exploit the sensor capability. The resolution limits of the sensor set the measurement limits that we can achieve this way. Programs like Photoshop include tools that allow exact measurements within a frame, so features like pincushion and chromatic distortion evident as colour fringing can be measured right down to the pixel limit (see part 2). For pixel level measurements to be meaningful, the essential test image must be accurate enough for the purpose. Fortunately, modern graphic systems and printers allow such a chart to be produced very easily – a far cry from the days when we relied on photographic reproduction to produce them, or if we had resources, we used mechanically produced test charts.

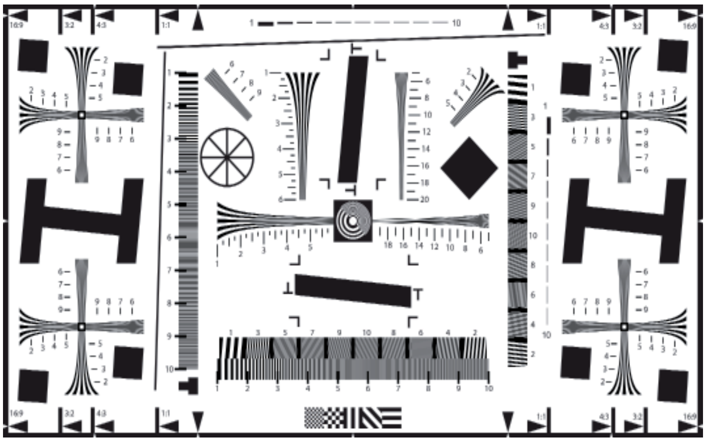

Fig A1 - ISO-12233 test chart

Many test charts have been produced over the years. Photocopies exist and are useful but are not particularly accurate due to the inadequacy of the lenses used in those processes. In a digital world however, it becomes much easier and all you need is a high quality printer and a data source for the image. For our purposes a reasonable standard image is contained in the international standard for lens testing: ISO-12233, shown here as figure A1. The whole standard contained in ISO-12233 is aimed at an agreed process to determine the performance of a lens. For the purpose of comparing lenses in a given test environment, a small subsection of that standard is useful, and in this series of articles a practical qualitative rather than quantitative approach is used. The chart used for this series is not even the latest version, and we won't be using the associated computer analysis tools to determine MTF etc. We will concentrate on a small number of details:

- The resolution in the centre and the corner of the image – key issues for sharp photographs.
- The straightness of the framing lines as a measure of pincushion or barrel distortion – key issues when image shape is important.
- Colour fringing in the corners as a measure of total chromatic aberration – a key issue when the image is in colour.
- Comparison of brightness in the dark and light areas as a measure of contrast – a key issue when looking at the mood of a photograph, and in some cases when vignetting is evident in the image corners.

A PDF of this image is readily available from several sources and there is a copy on the APCS website: http://www.apcsociety.com.au/images/ISO-12233-chart.pdf - download it and print it using your best printer. If printed as a PDF, the edges of the details will have the resolution native to the printer. For a typical A4 Laser printer with 300dpi performance an image on the paper will be of the order of 40MP. 600dpi on A3 will be more like 200MP – more than adequate for lens testing using the full frame for the image. When printing out maybe select Black Toner only if the alignment of the other colours in your printer is not perfect. Of course this is not an issue in a Black and White printer! And a practical note – in this PDF version, the details are not subject to degradation as they are in raster versions such as JPG, PNG etc. We are indebted to Steven Westin at Cornell University for the derivation of this chart from the original specification. It may be that your particular computer/printer combination does not allow that PDF to print directly and in the worst case has an intermediate stage of raster graphics that is not fine enough to resolve details. There is not much you can do about that other than to ask someone else with a better system to print it for you, or take a copy of the PDF file to a commercial printing service and get them to print it out on an A3 or A2 sheet using a suitable printer. Even the quality of the printer paper becomes important. When printed out check that the straight lines are indeed straight and that all the edges are very sharp with no grey or fuzzy transitions. Note that this chart does not include a grey-scale component. We will be able to measure extreme contrast using this chart but another chart will be needed to measure sensor linearity (not really a lens issue for decent lenses) and that will come up in part 2.

In the digital world, is there an equivalent of Kodachrome 25 when it comes to judging performance with a perfect lens? Not only is resolution an issue but contrast depth, linearity etc will also be evident, and different digital sensors have different sensitivity curves with spectrum. However, relying on the published resolution for Kodachrome 25, the full frame equivalent is about 35MP when the lens is perfect. So for practical purposes a full-frame digital camera with a sensor that achieves about 35MP meets that ideal – but with a couple of warnings… Firstly, this really only holds if the image is stored in RAW mode and if there is NO image processing involved. Many cameras don't allow the user to do that, and there are indications that in the near future even RAW mode will automatically incorporate lens corrections when used with lenses dedicated to the camera concerned. But secondly, the newest cameras can enhance an image using in-camera correction of lens faults and a processed image should be better than the unprocessed RAW image. This flies in the face of opinion in the past that held that RAW was the best way of recording digital images – now not always the case.

The use of this chart is as complex as you want to make it. In a simplistic approach, resolutions etc can be judged from the numbers on the chart. These are in 100x per picture height, and a bit of arithmetic is needed to convert what you see on an image to the lines per mm of the sensor etc. Digital post-processing can sharpen edges and unless you are aware of that effect you may be misled into thinking that your lenses are sharper than they actually are. In a later part of this series, the matter of in-camera enhancement will arise, and we will see that many of the lens errors can be fixed through post-processing, and in fact are now part of modern photography when using dedicated system lenses.

Probably the easiest approach when testing a lens is to use a digital camera and examine what happens at the pixel level, and with the aid of a computer and a program that allows it, you can judge what happens at black-white transitions. A little bit of arithmetic will determine what resolution can be judged and the key element is the physical size of a pixel. Cameras will be marginally different and as the years pass, the trend is to make those pixels smaller. Right at the moment, using a Sony A7R as the test-bed, the pixel spacing is 0.005mm, and logically if you can see a detail at that level then the local resolution is equivalent to the camera limit of about 35MP. That same pixel observation in the corners (where most aberrations are observed) corresponds to a vector radial measurement of about 0.025% of the picture. Exact measurements are another matter and need a much finer resolution sensor, and some way of determining error when what is seen is hard to estimate, and may have quite different features for different lenses. We will be using that percentage measure in part 2 of this series. Looking at coarser resolutions, double the number of pixels to resolve a detail and the resolution in MP terms is divided by 4 for example. Intermediate values are by personal analysis and don't need to be too accurate.

When testing lenses there are a few other tricks that might be observed: A resolution limit might be held to be when a sharp line is exposed on one pixel but not on the adjacent pixel, but in practice that has to be modified. There are optical limitations, diffraction, the existence of Airey Discs, and even the ability (or otherwise) of a pixel in a sensor to record without leakage to its adjacent pixel. And there is another distortion that rarely gets a mention – atmospheric distortion. At these imaging limits the atmosphere that we breathe becomes a limiting factor. Heat and wind make changes to the refractive index of the air at a resolution level that can be noticed, and if you are taking a photo of an image that is about 400 meters away, then the curvature of the earth – and thus its atmosphere – is enough to degrade the resolution to a level that you can see on a 35MP camera – very obviously with a long focal length lens. This is one of the reasons why most of the World's great telescopes are located on the top of mountains – so that there is less atmosphere to look through – and the best images are when the telescope is looking straight up – the atmosphere can be treated as a simple lens that can be at least partly allowed for relatively easily. So what is the maximum distance in air that you can make meaningful measurements of the performance of a lens that exceeds the image resolution of a good digital camera? Testing vertically up to a couple of metres there is no "air-problem" but testing horizontally there is evidence of effect at 50 metres and by 400 metres the "air-problem" dominates. If it is a hot sunny day and the wind is blowing then those distances have to be reduced due to air turbulence. (As an aside, the "air-problem" in the lenses used for photolithography in the manufacture of integrated circuits is measured in millimetres.) These matters are not trivial and we will meet them again in Parts 2 & 3.

The test rigs needed to test a lens to determine its limits are also not trivial, and need a whole book just to discuss the pros and cons of every method used, and indeed to discuss what can be done to make design corrections based on what is measured. Testing and analysing centre performance is almost trivially easy compared with off-axis, ie corner, performance. The most you need is a test chart, and for infinity measurements, a conventional collimator most commonly consisting of the test chart placed at the focal point of a positive lens, and it is well established that a high precision achromatic doublet with a focal length of about a metre in the collimator is more than accurate enough for most measurements on lenses intended for photographic cameras. There are some practical tricks for testing APO lenses to do with illumination of the target – another story entirely. For off-axis measurements the whole matter becomes much more complicated, as the distortions due to the achromatic doublet cannot be easily accounted for, especially when chromatic and spherical aberrations are to be measured. The "Voigtländer Collimator" which includes a correction plate might have been OK in the middle of the 20th Century but is not up to the user demands on the best modern lenses, but is still used today by at least one manufacturer during lens assembly. This unit (shown here as figure A2), and the much larger unit by Wray (UK) also in the writer's test-kit are difficult to use. Again matters for Parts 2 & 3.

Fig A2 - Voigtländer Collimator - circa 1955

We can make off-axis measurements in macro ranges up to about 2 metres object distance using a modern high resolution digital camera and do the analysis on the resulting image using a computer, but when trying to measure distortions at long distances, the problems of realising even a laboratory equivalent make that task virtually impossible. The conventional laboratory way is to use a Collimator to "create" an infinity image, but such lenses have to be perfect if you are testing a lens that itself is near perfect. There is an argument against seeking perfect lenses for work at infinity as the atmosphere is likely to be the dominant degradation, and such a "perfect" infinity lens will never have the opportunity to be used. Thus the performance in the range from moderate macro to portrait is probably the most exacting. Testing a "normal" lens at 1:1 macro is normally fairly pointless as for that sort of work a dedicated optic should be used. If you have enough money then the analysis of a single lens may be possible but followers of the story of the Hubble Space Telescope will recall how they got that wrong doing atmospheric analysis of a lens designed to be used for infinity work in a quasi-vacuum! OK, your camera lens does not have to be as good as the Hubble but we are talking about diffraction limited resolution at the full aperture for our best lenses. (Note: The writer was testing a 1,000mm f5.6 mirror objective recently and discovered that even centre measurements over a distance of 400 metres horizontally was dominated by atmospheric effects – a bit of an insight into the Hubble error story.)

A comparison test was done on a Contax RTS f1.7 50mm Zeiss Planar at an object distance of a metre and again including a precision 75mm diameter Achromatic Doublet which was designed as a Collimator for laboratory work, with the lens under test then set to a distance of 15 metres – probably the most common distance for a general camera. The performance of the two "systems" were then compared – arriving at virtually identical results for resolution and both chromatic and spherical aberrations. The achromatic doublet introduces another four lens surfaces and while that has the ability to degrade the total lens contrast performance, the effect was not noticed. Thus for the purposes of this testing exercise, all measurements were performed without a collimator at roughly 1 meter object distance – a little longer for the 60mm lenses and a couple of the lenses that did not have focussing helixes that were quite long enough. However it does not rule out the possibility that some lenses might be better performers at infinity than they are at a metre or so. The newest 50-60mm "super lenses" with compensation designed for macro work only apply that compensation at very close distances – less than about 300mm.

An important part of lens testing is the illumination of the object and how that relates to the sensor in the camera and the ability of the lens to deal with non-visible images. In an extreme example, consider imaging an object illuminated by light from a Mercury discharge source which contains a lot of ultraviolet light, and a camera-lens combination that was designed only for visible light, or another arrangement where infrared images are simply out of focus. Photographers with long memories will remember that orthochromatic film (not sensitive to red) was used on most cheap cameras up until the mid-1950s very successfully but when the film manufacturers switched to panchromatic film for nearly all domestic B&W products, the results were less than acceptable. There are several ways that this can be dealt with, like filters of various kinds, inside a digital camera, as a skylight or UV filter on the front of a lens, and even choosing glass in a lens that blocks the IR and UV components. On a test bench however, a choice of the illuminating light is also effective, or conversely, when chosen poorly can make for analysis problems. Obviously, incandescent lamps with a lot of IR and Mercury discharge with a lot of UV might cause problems, and might lead to wrong conclusions when general photography is sought. Thus when testing for visible performance, choosing a light source that is restricted to the visible spectrum is logical ie 760-380 nm, and it might be that we should use individual illuminators at the three RGB colours for digital sensors at 600, 550 and 450nm. Some modern LED lighting has excellent spectra for visible light testing but a spectroscope is necessary to make those decisions. As a matter of interest, when ultra-resolution is needed, essentially monochromatic illumination from an Excimer Laser is used in the UV spectrum at wavelengths like 248nm. Manufacturers are cagey about quoting bandwidths but numbers like 0.1nm are suggested. The result is exceptional resolution far exceeding anything that a conventional camera could achieve. For those wishing to experiment with images out of the visible spectrum, the bandpass filter in a digital camera can be removed – a common modification for astronomical observations. This provides a camera that can see both the IR and UV components. (There are variations on this.) Put an ordinary camera lens on that unit and take a photo outside on a sunny day and you will see severe colour fringing etc suggesting very poor performance outside the visible spectrum. Exchange the lens for a mirror telephoto without dispersive correction elements, which normally has no chromatic aberration, and those fringes will go away!

So what is the practical platform for testing lenses? Film can certainly be used but with some reservations. Ultrafine B&W film has resolution limits that exceed Kodachrome 25, but can be exposed by IR and UV light which are usually not within design parameters for most lenses. The analysis is then done using a decent microscope on the processed negative. But that is only part of the story… In today's photographic world, colour performance is important and testing an APO lens to determine chromatic aberration and hence colour accuracy using B&W film is possible but very complex demanding narrow band illumination. The fact that film changes shape between exposure in the camera and ultimate dimension changes after processing will demonstrate that for many lenses, the lens errors are in the same ballpark as the changes to the film dimensions. A lot of work is needed to establish actual measurements. The digital alternative is much easier – Use a camera like a Sony A7R, a 36MP unit which does not have an anti-aliasing filter, and does include a filter that blocks IR and UV (unless removed for astronomical work). Further, the RAW mode is unprocessed. Choose the object distance that you use most of the time, but noting that long distances are problematic, and as suggested above, testing at about a metre is probably good enough. We might guess that there are two areas of an image that more or less define how good a lens resolution is – the centre performance and the corner performance, and a practical feature of lenses is that they are not always focussed across the whole plane. Focus in the centre and the corners are out… Focus in the corners and the centre is out… In practice, depth of field is a factor and it is common to stop a lens down to achieve resolution over the whole image. However that does not always work, and there are lenses that have to be refocussed when they are shut down. (See the comments on the Xenar from 1936 below.)

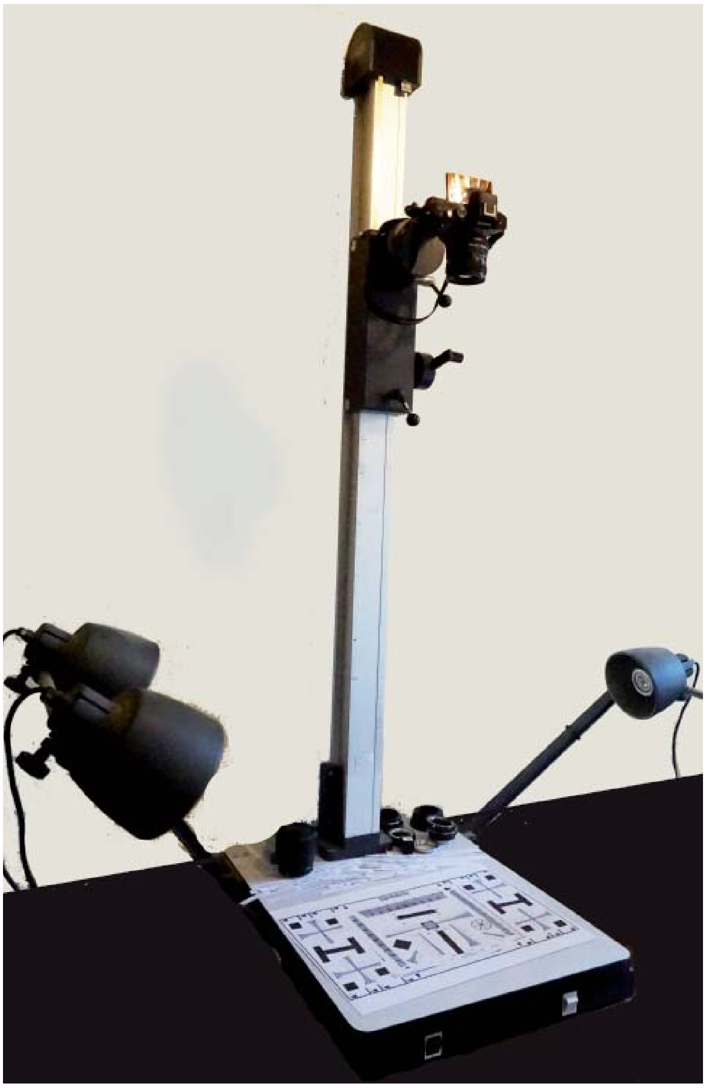

Fig A3 - Polaroid MP4 copying stand

An unexpected result was that there were lenses that had good resolution in the centre and the extreme corners but not in the area about 12 mm from the centre of the image!

Judging resolution is a personal matter, and while there are practices for judging "adjacent pixel extinction" "the 10%-90% rule" and other quasi-standards, the numbers that are produced are fairly equivalent. For practical purposes we can quote the equivalent MP resolution in the centre and corners for a lens and use those parameters as a measure of lens performance – especially for comparison purposes. So let's have some fun and test a few lenses using the above ideas – a Sony A7R, a studio distance of about a metre viewing a ISO-12233 test chart – test everything at full aperture, then stop down to f8 to see if that improves things – and in the following chart we are limited to "standard" ~50mm lenses that are in the writer's collection and where we have adaptors that allow them to be fitted to the E-Mount camera. For this testing, I used a Polaroid MP4 stand fitted with LED lamps. (figure A3)

At least, that is how the testing started… Very quickly a few problems became evident, and after a few hours of taking photos, processing the resulting digital images, and trying to make sense of what was seen, a list of problems and solutions emerged. The following points are very shortened versions of what actually happened and we will visit some of them more in the second and third parts of this series.

Note: The Polaroid MP4 is a rugged multi-purpose vertical stand. There are two main versions with short and long columns. The longer one – about 1.5 metres is needed for this work. Both support various cameras, lighting solutions and even a 5x4 enlarger head.

- Set the lighting so that specular reflection does not reach the camera. Illumination over the object plane must be uniform if measurement are to be meaningful.
- Ensure that the object plane and the image plane are parallel and that the centre of both are aligned. A good spirit level is essential.
- At the limits of lens resolution, camera vibration is not desired and a remote control is a good idea.
- Most of the lenses tested required the use of adapters. To avoid internal reflections, some adapters may need to be "re-blackened". It helps if the area around the test object is also mat-black.
- Any testing that relies on JPG images will be compromised by the encoding and correction so real lens testing must be done with RAW images. Photoshop, Lightroom and a few others, don't always have the ability to see those files directly, and some that work in a viewing mode do so in a way that does not extend to the fine detail. At present (2020) even the latest versions of the popular programs do not cover all the cameras that you might use. For these articles Photoshop was used requiring two stages of processing. Photoshop uses an intermediate standard DNG (Digital Negative) and a utility called DNG Converter will convert your RAW files to DNG for most cameras. Photoshop CS6 and later import these via a plug-in called CameraRaw. You may need to find other solutions for other photographic editing tools.
- In analysing your images your image detail cannot be

Lens	Focal Length	Native system (year)	Aperture	Centre MP wide open	Corner MP wide open	Centre MP at f8	Corner MP at f8
Biotar	58	Exakta 1952	2	30	12	30	30
Biotar	58	Contax D M42 1954	2	30	20	30	25
B-Planar	50	Contarex 1969	2	20	20	35	35
Canon	50	EOS 1988	1.4	35	10	>35	35
Canon	50	EOS 2015	1.8	35	30	>35	35
Centaur	50	Waterworth 1948	3.5	15	10	15	15
Elmar	50	Leica-screw 1938	3.5	20	10	20	20
Focotar I	50	Leitz Reprovit 2a 1962	4.5	20	15	25	20
Focotar LFE	50	Leitz Focomat 1c 1970	4.5	30	30	35	35
Heliar	50	Voigtlander L39 2018	3.5	30	30	25	25
Macro Planar ZF	50	Zeiss 2010	2	35	35	>35	>35
Macro-Elmarit-R	60	Leica R 1975	2.8	35	17	35	35
Makro-Planar	60	Contax RTS 1977	2.8	25	25	35	30
MicroNikkor AF-D	60	Nikon 1989	2.8	30	25	30	30
Nikkor	50	Nikon F 1975	1.4	35	20	35	35
Nikkor	50	E-series 1980s	1.8	25	12	25	25
Nikkor	50	Nikon AF-D 2010	1.4	25	15	30	25
Pentax-M	50	SMC Pentax - K-1980	1.4	30	18	35	20
Pentax-M	50	SMC Pentax - K-1980	2	30	20	35	25
Planar	55	Contarex 1970	1.4	10	10	20	20
Planar	50	Contarex 1963	2	20	20	35	35
Planar	50	Zeiss type 3 RMS 1902	4.5	15	15	25	20
Planar	50	Contax RTS 1977	1.4	30	20	35	30
Planar	50	Contax RTS 1977	1.7	30	25	30	30
Serenar	50	Canon M39 1949	1.9	25	20	30	30
Sonnar	55	Sony Zeiss FE (RAW)	1.8	35	35	35	35
Sonnar	55	Sony Zeiss FE (JPG)	1.8	35	35	>35	>35
Sonnar	50	Contax RF 1936	2	25	20	30	30
Sonnar	50	Contax RF Bloomed 1936	2	30	20	30	25
Sonnar	50	Contax RF 1936	1.5	30	25	35	30
Sonnar	50	Contax RF 1955	1.5	25	15	35	30
Sonnar	50	Contax RF 1955	2	30	20	35	35
Sony (Zoom)	28-70	Sony FE (50 RAW)	3-5-5.6(4.5)	35	35	35	35
Sony (Zoom)	28-70	Sony FE (50 JPG)	3-5-5.6(4.5)	35	35	35	35
S-Planar	50	Contarex 1966	4	20	20	>35	>35
Summicron	50	Leica M 1958	2	25	20	30	30
Summicron-R	50	Leica R 1975	2	35	15	>35	35
Summilux	50	Leica M 1964	1.4	20	10	20	20
SuperTakumar	50	Pentax M42	1.4	30	18	35	20
Tessar	50	Contarex 1966	2.8	20	25	35	30
Tessar	45	Contax RTS 1977	2.8	30	20	35	30
Tessar	50	Contax-D M42 1953	3.5	20	15	25	20
Tessar	50	Practica FX3 M42 1956	2.8	25	15	25	25
Tessar	50	Icarex M42 1968	2.8	25	15	15	25
Travenar	50	Edixa M42 1958	2.8	15	15	25	25
Xenar	50	Exakta Kine 1937	2.8	25	10	15	15

CHART 1 – Resolution Data in Megapixels for standard ~50mm lenses made over the last Century when used in a full frame format better than the sensor and processing in your camera – unfortunately not all camera manufacturers are completely honest and what you measure can be misleading.

- Considering that we are looking at images at the limits of technology, we need to use the best professional software in the computer which probably needs to have a Workstation Grade video system. The computer analysis here was done using an NVIDIA Quadro 5000 – a long way from the 'entry point' and has some internal features tailored to Photoshop. Before anyone asks the obvious question "how good is the computer screen that I used" – it is a high-end 30-inch unit and more relevantly, displays the full resolution via the Quadro 5000 when used with Photoshop. This screen is also programmed for colour and linearity. Your computer screen may not be as good, and your photo-viewer may not honestly allow the full resolution to be observed.

The table shows the measured results for a lot of different lenses at their full aperture and at f8 in the centre of the image and in the corners (Full Frame 24 by 36mm). With only a few exceptions all had centre resolutions that were close to what the A7R sensor could detect and corner resolutions that were about half as good. A couple of modern expensive units were "perfect" everywhere. Not shown in the table, all lenses improved significantly in the corners when stopped down by a couple of full stops but beyond f8, all lenses started to deteriorate again. The numbers shown are the equivalent Megapixel resolutions. A couple of lenses stood out for special comment – and typically, when tested at f8, the Xenar 2.8/50 from a 1936 Exakta had much worse central resolution but better corner resolution than when wide open. That would seem illogical but there are several possible reasons, the most likely being an inappropriate placement of the iris in the lens and something wrong with the curvature of one or more elements in the central region. A little further testing showed that the central focus for f2.8 and f8 were at different points on the scale – a matter that does get talked about in textbooks but does not feature much in practical photography. While very obvious in the case of the 1936 Xenar, other lenses also exhibited some strange behaviours.

With only a couple of exceptions, all lenses showed aberrations of various kinds in the corners and that will be the central subject of part 2 of this series. An instant message comes from this table that will be repeated in part 2 – the dedicated FE lenses that are specific to the Sony E-mount cameras produce near-perfect images when corrected by the camera, and are certainly better than those produced by any other consumer-grade lens without correction. It is worth noting that in-camera correction is so effective that the low cost kit zoom from Sony – the 28-70 – is exceptional value, and should probably be preferred for all work except where higher speed or low depth of field is demanded.

As I conducted these tests I found that I spent a lot of time on a few lenses that seemed to have features that were not common – or were not what I was expecting. In a few cases, it would take pages of text to describe and explain the results – indicating just how complex the issues are. Why for example is there so much difference between examples of similar lenses? And even between lens examples from maybe the same manufacturing batches? Those oddities are not included in the above table (nor the table in the later part of this series). I have included the results of the best of the examples as tested. Of course, there is a practical issue to be considered in these results… Part of conducting the tests involves manual focusing, which is not as easy as you might expect. The Sony A7R (I used a Mk.1 unit) has a "focus peaking" feature that helps greatly to find the right spot – but it also raises an issue… Some lenses did not "peak well" and they turned out to be lenses with lower resolution figures – in those cases I estimated the mid-point.

In presenting these results, I am loathe to offer opinions as to the "best" classic lenses but rather leave it to the reader to draw conclusions. On resolution alone, all lenses tested are good, a couple of modern lenses are outstanding, but readers should continue reading and consider other aberrations which may be far more relevant and highlight shortcomings in many of the older lens designs. As we will observe in Part 3, we may be able to address some problems.

Special note on mounting Macro-lenses: Many classical Macro-lenses achieve close focus by moving the whole lens as an assembly, and the addition of extension tubes etc to achieve very close focus is appropriate. Emerging designs like the Zeiss 50mm Macro Planar ZF achieve focus in a complex way which makes element spacing adjustments. The distance between the image plane and the rear mounting plane of the lens MUST be correct for the mechanism to work correctly. Should such a lens be required to focus even closer than the internal control allows then maybe add a rear spacing tube but keeping the focus control at the minimum distance. An alternative might be to add a high quality positive element on the front of the unit to extend the range. A limited experiment during this investigation shows that the latter approach seems to work well for a small change in magnification. However a test using specialised lenses designed for microscopy, specifically lenses designed for a rear flange to image plane of 160mm such as Zeiss Luminars and equivalents from other manufacturers, produced results that could not be faulted.

Part 2: Aberrations

When I started to write this series, I expected that the data output would be a list of centre and corner resolutions for a lot of lenses. After looking at the preliminary results other issues became obvious. With a couple of exceptions, all centre resolutions were near enough to the limit of the camera, and with a couple of exceptions the corner resolutions were no worse than half that performance. What stood out dramatically was that the spherical and chromatic aberration in the corners of all but a couple of lenses were at least measurable and at worst objectionable. Nearly all uncoated lenses, and a few coated lenses, stood out visually with poor contrast, and a couple had some quite weird oddities about them that looked like local focus problems. For every lens in the "standard 50mm class" that I looked at, the Spherical Aberration was evident as pincushion (barrel) distortion, and the Chromatic Aberration was evident as colour fringing on sharp edges that were Black-White transitions in the test object. These can be measured fairly easily on a computer screen these days now that CRT computer screens are no longer with us. (If you still use one of those it is definitely time to change if you want to do image analysis!) The method you adopt to make these measurements is not really important as you are probably only comparing lenses. Thus absolute numbers don't have to match what the manufacturers say. For Spherical Distortion measure the percentage pincushion along a straight line at the top of the image and for Chromatic Distortion add the pixels of colour on each side of a White-Black-White transition. Technically you can make some estimates of the absolute numbers from those measurements using a bit of geometry. Recall from resolution calculations that the pixel spacing in the Sony A7R that was used for testing these lenses is 0.005mm and when converted to a radial measurement at a full-frame corner, that is equivalent to 0.025% of the image height.

All these aberrations prompt enquiry around what can be done to correct them, recognising that most if not all camera manufacturers seem to be producing perfect or near perfect images from lenses that are cheap and fairly simple compared with high performance legacy lenses, using software engines inside the camera. That is the central subject for part 3 of this series.

Of course there are many other forms of image degradation that cannot be easily quantified from resolution and distortion tests. Spherochromatism (fringing on out-of-focus areas), Fall-off (or any variation of illumination over the image frame), Contrast (or any modification of the illumination brightness due to the lens – reflections inside the lens, coating inadequacies, number of elements etc) and other degradation features that are eventually important to the lens users, can also be measured. This leads to a lot of parameters that might be used to compare lenses, and in some cases may actually determine the quality of a lens rather than the commonly observed resolution. Often, the measurements of these errors and effects are far from trivial. In some cases, degradation of an image by the camera sensor or film or even the way that the lens is mounted will dominate the performance and hence the measurement result that we might consider. Measurements can be done using simple setups, but they take a lot of time and effort and need some understanding of how they arise in each lens that is being considered. Some such measurements are restricted to specific families of lenses. I leave it to readers to ponder this…

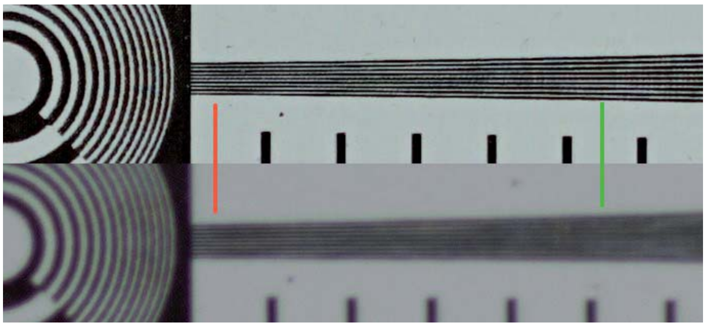

Fig B1 Top - Zeiss Sonnar FE 1.8/55

Bottom - Zeiss Planar (Contarex) 1.4/55

Let us step back a bit and look at just how measurements can be made and turned into performance figures – and at the same time look at some associated issues. One would assume that judging resolution might be straight forward, but we are looking at real images and maybe multiple sources of error so that complicates things a bit. To demonstrate, consider what can be seen in the centre of the image – figure B1 compares a small sample to the right side of centre of two lenses – the top one is a new Zeiss Sonnar FE 1.8/55, and the bottom one is a Zeiss Planar (Contarex) 1.4/55 from about 1963. By film standards both exceed the capabilities of Kodachrome 25, but in the digital world there are significant differences. Inspect the areas just above and below the red mark. Under the testing conditions, this area corresponds to about 30MP when the lines are evident and black and white lines – and the 1963 lens meets that. But obviously the top area is a lot sharper and further magnification (not shown here) shows that the resolution is good enough to see black and white on adjacent pixels – enough the establish that the resolution of the new Sonnar is better than 35MP. But now look at the areas above and below the green mark. The Sonnar is just as clearly good, but the definition is lost for the 1963 lens, suggesting that the resolution has dropped to something worse than about 10MP. In practical terms the effect is probably a result of a couple of issues… The area is a few mm from the centre and may not actually be exactly in focus, but at that level of detail there is a possibility of wave interference causing the white and black areas to cancel. Quite a lot of further testing is needed to solve that question.

Measuring Chromatic Aberration in terms of fringing is relatively easy (but note comments later regarding Spherochromatism). All we need to do is to enlarge one of the corners and inspect a white-black-white region and count the pixels on both transitions that show colour. That will take a bit of interpretation as those pixels are unlikely to be sharp. Figure B2 shows such an area expanded in Photoshop which also shows the actual pixels. The blue and yellow appearance are actual and have not been enhanced. Counting horizontally, the sum of the two is about 5 pixels and as these are 0.005mm each then the total aberration at that point is 0.125%. Incidentally that is still a good lens and that level of error won't show up on a film camera nor a digital camera with 12MP resolution.

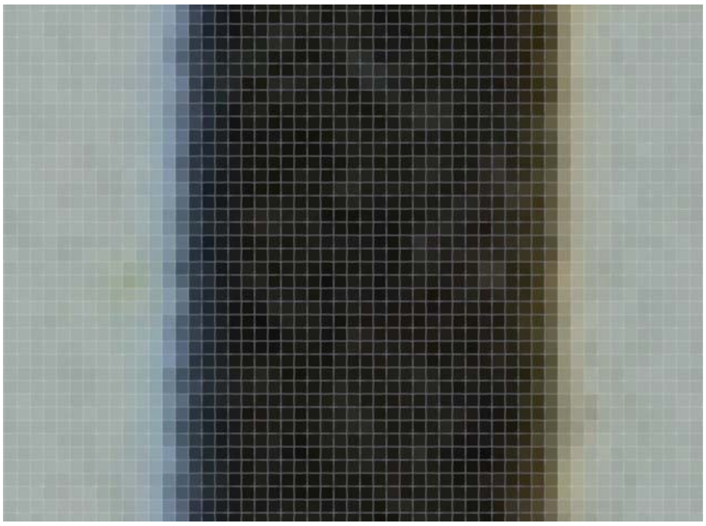

Fig B2 Corner colour fringing - pixel level

Pincushion and Barrel distortion are looked at in much the same way, and in describing this test, I am adding the matter of in-camera correction. Figure B3 shows two images of a few mm of the top of the full image from the Sony Zoom kit lens 28-70mm set at close to 50mm. The pincushion distortion of this arrangement in RAW (bottom image below the red line) was the worst of all lenses tested, but such is the nature of the in-camera correction, that when saved as a JPG (top image above the red line) all that distortion was removed without any loss of resolution, provided that the JPG image is saved at a high enough resolution. Note that many if not most of the older digital cameras lose definition when images are saved in JPG mode. Assuming that the printer that produced this article is accurate, put a straight-edge against these two lines to see just how good

Lens	FL	Native system (year)	Aperture	Pincushion (Barrel) Distortion	Corner chromatic Distortion	20*log(W/B) ie Contrast wide open	20*log(W/B) ie Contrast at f8
Biotar	58	Exakta 1952	2	0.08%	0.25%	15.6	18.1
Biotar	58	Contax D M42 1954	2	0.08%	0.25%	20.8	20.3
B-Planar	50	Contarex 1969	2	-0.40%	0.10%	21	22
Canon	50	EOS 1988	1.4	-0.87%	0.25%	18.5	16.3
Canon	50	EOS 2015	1.8	-0.38%	0.10%	17.6	18.1
Centaur	50	Waterworth 1948	3.5	0.08%	0.10%	5.5	8.9
Elmar	50	Leica-screw 1938	3.5	0.08%	0.10%	5.8	5.8
Focotar I (R)	50	Leitz Reprovit 2a 1962	4.5	-0.08%	0.05%	17.2	17.9
Focotar LFE	50	Leitz Focomat 1c 1970	4.5	-0.08%	0.05%	18.1	19.2
Heliar	50	Voigtlander L39 2018	3.5	-0.15%	0.15%	22.4	20.4
Luminar (ID=160)	63	Zeiss standard RMS 1985	4.5			14.5	
Macro Planar	50	Zeiss ZF 2010	2	-0.08%	<0.025%	22.7	22
Macro-Elmarit-R	60	Leica R 1975	2.8	<0.025%	0.10%	22.3	23.9
Makro-Planar	60	Contax RTS 1977	2.8	0.20%	0.05%	26.8	30
MicroNikkor	60	Nikon AF-D 1989	2.8	0.15%	0.10%	30.1	29.8
Nikkor	50	Nikon F 1975	1.4	-0.75%	0.10%	18.5	17.9
Nikkor	50	E-series 1980s	1.8	-0.18%	0.15%	18.5	19.1
Pentax-M	50	SMC Pentax-M - K-1980	1.4	-0.38%	0.15%	19.6	21.9
Pentax-M	50	SMC Pentax-M - K-1980	2	-0.38%	0.15%	19.6	20.3
Planar	55	Contarex 1970	1.4	-0.80%	0.18%	19.5	21.9
Planar	50	Contarex 1963	2	-0.40%	0.10%	21.1	22.1
Planar	50	Zeiss type 3 RMS 1902	4.5	0.20%	0.05%	10.7	12
Planar (ID=160)	50	Zeiss type 3 RMS 1902	4.5			7.6	
Planar	50	Contax RTS 1977	1.4	-0.20%	0.13%	18.3	20.4
Planar	50	Contax RTS 1977	1.7	-0.38%	0.15%	21	23.9
Serenar	50	Canon M39 1949	1.9	0.15%	0.15%	12	18.5
Sonnar	50	Contax RF 1936	2	0.20%	0.08%	11.6	11
Sonnar	50	Contax RF Bloomed 1936	2	0.20%	0.10%	22.4	20.7
Sonnar	50	Contax RF 1936	1.5	0.15%	0.08%	19.6	18.1
Sonnar	50	Contax RF 1955	1.5	0.20%	0.15%	20.8	22.3
Sonnar	50	Contax RF 1955	2	0.20%	0.10%	24.3	26.7
Sonnar (Zeiss)	55	Sony FE (RAW Mode)	1.8	0.80%	0.10%	23.6	21.7
Sonnar (Zeiss)	55	Sony FE (JPG Mode)	1.8	<0.025%	0.10%	23.8	23.4
Sony (Zoom)	28-70	Sony FE (50 RAW Mode)	3-5-5.6(4.5)	1.75%	<0.025%	23.2	25.1
Sony (Zoom)	28-70	Sony FE (50 JPG Mode)	3-5-5.6(4.5)	<0.025%	<0.025%	20.5	21.3
S-Planar	50	Contarex 1966	4	<0.025%	<0.025%	16.4	18.1
Summicron	50	Leica M 1958	2	0.75%	0.03%	19.9	19.5
Summicron-R	50	Leica R 1975	2	-0.15%	0.15%	30.4	26.4
Summilux	50	Leica M 1964	1.4	-0.15%	0.15%	19	19.5
SuperTakumar	50	Pentax M42	1.4	-0.38%	0.15%	16.5	17.8
Tessar	50	Contarex 1966	2.8	-0.08%	0.08%	20.8	20.4
Tessar	45	Contax RTS 1977	2.8	-0.20%	0.10%	21	23.9
Tessar	50	Contax-D M42 1953	3.5	-0.15%	0.08%	6.2	6.9
Tessar	50	Practica FX3 M42	2.8	-0.08%	0.15%	15.4	17.8
Tessar	50	Icarex M42 1968	2.8	-0.20%	0.15%	22.5	23.8
Travenar	50	Edixa M42 1958	2.8	-0.20%	0.15%	8.3	9
Xenar	50	Exakta Cine 1937	2.8	0.38%	0.75%	12.9	14.3

CHART 2 – Aberration & contrast data for standard ~50mm lenses made over the last Century when used in a full frame format the correction is. For the record, the pincushion distortion of that lens was 1.75%, and rather than count pixels the actual measurement provided by Photoshop was a quicker way of analysing it.

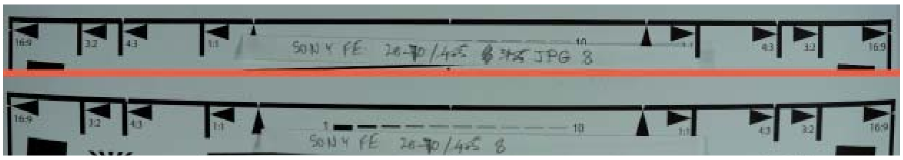

Fig B3 Sony kit lens 28-70 at 50mm.

Top - JPG - automatically corrected, Bottom - RAW

But let us look specifically at some of the more obvious distortions.

Spherochromatism is very obvious in only a few lenses – and sometimes only then because the in-focus Chromatic Aberration is very small. In an image plane these two aberrations look very much the same in the corners, and a reasonable way to differentiate between them is to take a photo with the exact focus in the corner of the image, and then repeat the process a little out of focus in a corner. When the image is focussed on the corner, any colour fringing will be conventional Chromatic Aberration. However when the image is out of focus in the corner, the fringing that you will see in the corner will be a combination of both Spherochromatism and Chromatic Aberration. For a lens that has no Chromatic Aberration then a slight defocus in the corner that suddenly starts fringing indicates Spherochromatism. This effect is quite obvious in the relatively new Zeiss Macro-Planar ZF 2/50 since conventional Chromatic Aberration and indeed Spherical Aberration are both zero, and it comes as a surprise when colour fringing is evident in the corners due to focus errors.

Nearly all lenses exhibit some level of pincushion or barrel distortion and it is conventional to show pincushion as positive percentage and barrel as negative percentage. For virtually all consumer grade standard lenses the level is less than 1%. However zoom lenses can be far worse than that. Fortunately, if such distortion is a problem for a photographer, this type of distortion is easily corrected in Photoshop or automatically in the camera when that feature is provided – more on this and correction of some other distortions in part 3.

Less than perfect contrast in a lens system arises from several sources. Uncoated surfaces, too many surfaces, inadequate blacking around the elements, reflections from the lens tube, reflections from the sides of adapters, reflections in the camera itself, and unwanted bright light sources in the image can all cause contrast degradation. A way of measuring the contrast is to use the computer to analyse the luminance in a black area and a white area of the test image – and when comparing lenses, the same white luminance in the test image should be set. Most modern lenses have good contrast and in the testing for this series of articles only the uncoated lenses came up poorly. But there were a few lenses that have reputations for excellent contrast but did not perform all that well. A bit of inspection quickly showed why…. With the lens under test connected to the adapter, one can view what is happening by simply looking through the system from the camera end and looking for bright reflections from the edges of the lens elements and from the adapter tube – that then is a problem for that lens/adapter combination. More about this in part 3 when we look at mechanical developments in camera design. Measurement of contrast poses a few problems, particularly when the loss of contrast is very small. I leave it to the reader to work out why this is so – but think about the ability of a sensor to detect dynamic range, sometimes called the “noise floor” of the sensor, and also think about the ratio of white to black areas in typical test charts.

Brightness fall-off towards the corners (vignetting) is very obvious when it occurs and can be quantified by measuring the luminance of white areas in the centre of the image and the corners using Photoshop etc. Such fall-off is often measured in equivalent f-stops, so a fall-off of 50% is said to be 1 f-stop.

Before you question just how I have made those contrast measurements, let me observe that there is more to this than meets the eye too. When relying on a printed image to be the reference points for white contamination of a black area, all sorts of problems arise. The original PDF of the test chart can be converted to JPG and the contrast on that chart can be measured in Photoshop (and the tested implication is that PDF “black” may not be absolutely black). But when the PDF is printed out to the eventual test sheet using a laser printer, the “black” on that will be different, and absorption, density and reflectance of transferred toner may vary across the page and will not be the same for all printers. Then the illumination of the test sheet will result in a different “black” depending on how reflective the toner/paper combination is. But the lens under test WILL degrade what contrast is there, and analysis of that is a measure of contrast degradation. It is tempting to establish a “reference perfect black” as some sort of calibration, but there are too many problems in the way and the best that might be possible is to test a lot of systems, observe the “best” and use that as the “best black” – until such time as another “best black” comes along.

The writer has a calibrated contrast test plate from a Macbeth analyser, and the “black” on that is significantly lighter than the dense “black” from the laser printer that was used to create the test image for these tests.

(Technical note: It is possible to make a “contrast testing box” being a white box with a hole in the middle of one side where the inside of the box is painted with a good matt-black. The target contrast ratio is much better than a simple black area in the middle of a white sheet by a very large margin – typically by nearly 3 orders of magnitude – or at least 8 f-stops. That creates a black-white testing environment with a total of maybe 14 f-stops which is greater than any lens is capable of.)

Another comparison possibility is to calculate the illumination difference between white and black at a specific point in the image – say the centre. The response of the sensor in the camera is unlikely to be entirely linear with illumination and without a lot of testing we are unlikely to discover why, mostly because the sensor is part of a smart system that tries to be perfect, and probably “overshoots” perfection, but is more useful that way as it automatically corrects for lack of contrast in typical lens/camera combinations, and tries to avoid black noise due to temperature etc in the output image. The apparent practical effect is that provided that the printed test sheet is good, and only a few laser printers can be considered “good”, then average quality lenses with average quality contrast will test well, but very good lenses with known very high contrast test only marginally better than average lenses. We will meet this all again in part 3 when we look at how a typically average image with moderate contrast can be post-processed to create an image with excellent contrast, effectively correcting contrast inadequacy in any lens.

Years ago, this writer did some extensive testing on consumer grade lenses using an optical bench and a detector probe with high sensitivity, and found very high contrast in a couple of lenses – way better than the rest that were tested – with the lenses being supported without any adapters or camera bodies to muddy the image. A test image designed to highlight contrast was also used – produced in those days by hand with Indian-ink on drafting paper. Repeating those tests using the test image in part 1 and the computer under Photoshop showed much less difference between lenses. This suggests that there is more at play. The black level recorded in the sensor is possibly elevated as part of some anti-noise algorithm, but without knowing exactly what the camera manufacturer is doing about that, measurements are not going to tell us much about the lens in isolation. Specifically, those historic tests for contrast on an optical bench were comparing a Zeiss Planar 2/50 from a 1963 Contarex with a Super-Takumar (amongst others) from a Pentax from the same era, and the black level difference was a factor of about 30:1. Using the A7R camera in this new setup, the difference was only about 2:1 based on measurements of Luminance made using Photoshop. Working against accurate measurements was a readout precision of about 1% of white level in Photoshop which corresponds to 50% at the lowest detectable black level. However, other than a couple of those Zeiss lenses, all other lenses did demonstrate measurable contrast degradation as shown in the table.

So what were the results from the testing here? The best of all the lenses tested was the Zeiss Makro-Planar f2 in every respect that I could measure. Other commentators have reported ZERO chromatic aberration – and I have to agree with that – right out to probably 100Mpixel using a couple of tricks to estimate pixel sensitivity. There was also no pincushion distortion – at least I could not measure it as it was less than a single pixel of the A7R image. Some commentators have suggested that other Macro lenses are as good and much cheaper but I cannot agree with that on performance alone, and an inspection of the above chart will show that there were several macro lenses in the list. Images formed with the Zeiss 50mm ZF lens will get better as the camera sensors get better.

Testing at this level drew a number of confirmations, conclusions and a couple of real surprises, but in considering these remember that there were a few optimisations in the testing method – most notably the illumination spectrum, and the care taken to ensure the best image analysis. It does not take much to degrade an image.

- Compared with the best, f1.4 lenses did not perform well across the frame, and even when shut down they still exhibited distortions in the corners.
- Modern economy lenses – usually around f1.8 are exceptionally good value – right out to close to the limits of the Sony A7R.
- There have been many commentaries praising the quality of the Zeiss 2/50 Planars used in the Contarex family – justified! – but they are not perfect. However they are close to the new Makro-Planar ZF from Zeiss.
- A lens group that performed surprisingly well was the older 4-element lenses like the Leitz 3.5/50 Elmar from 1936. However, their contrast was well down as they are not coated lenses.
- A surprise performer was the Tessar 2.8/45 pancake lens made for the Contax RTS – sharp everywhere, virtually no Chromatic distortion and only a tiny bit of pincushion.
- Disappointing performances were hard to find, but are covered in the following comments on oddities.
- Multiples of a few lenses were tested and there were variations between them. In particular there were significant variations between examples made in the early 1950s, suggesting manufacturing quality issues.
- If a lens is not coated it does not mean that the contrast is poor. Zeiss f2 Sonnars from the 1930s were not too bad in this respect. One of these (1936) had rather different geometry from the rest and was coated on some surfaces. Whether this example was originally coated or a retro modification is not known but the contrast on that one was exceptional. The average f2 Sonnar is a collapsible from that era and the exceptional version was rigid nickel/black – and its other parameters were also much more like the excellent post-WW2 versions.

The chart of aberrations for all lenses is very large and what is reproduced here is a precis of what was discovered. Only the important or rather indicative results are included and only for about half the lenses, since so many with similar descriptions had very similar performance. It is evident that Chromatic and Spherical aberration does not change much when a lens is stopped down, but in nearly all cases the contrast improved a fraction – probably because internal reflections from the walls of the lens and camera were less evident. In quoting the contrast in a way that makes comparison meaningful I calculated the contamination of black areas by scattered white in a black/white image. Mathematically the contrast is stated here as:

Contrast = 20*log(W/B) where W and B are the actual luminance values in white and black areas, and the expression is 20 times the logarithm to base 10 of the White to Black ratio.

This equation has a parallel in noise theory and is the same as Signal to Noise in a communications circuit expressed in dB. The larger the number the better the lens in terms of contrast. Traditional dimensionless measures of contrast (CR and Michelson contrast) are not particularly convenient for this purpose where all lenses are fairly good. The luminance values measured using Photoshop do not have more than 2-digit resolution so the calculated contrasts are approximate only. When considering individual lenses, any contrast value over 10 (using the above formula) is fairly good while those lenses with contrast up around 30 are exceptional. In part 3 it will be implied that the contrast can be improved through attention to internal reflections in lens barrels etc., and for a digital image the contrast can be improved by manipulating the digital values either in the camera or in Photoshop.

At this point in the story, we should mention some image oddities that are characteristic of many lenses, and while there are often highly theoretical approaches to them, a qualitative rather than quantitative discussion is maybe more useful to a photographer. The mathematicians amongst us can chase down the books on lens design! A feature of most lenses is that when an image is focussed and the object is a flat surface at a distance, the image plane is generally not exactly flat. A simple meniscus lens produces an image that is roughly spherical and focus on the centre and the corners will be out of focus – focus on the corners and the centre will be out of focus. Have a look inside a Purma Special camera and you will observe that the film lies on a curved path as a way of improving the focus in the corners – not perfect everywhere, but it helps. The baby brownie and a few other simple cameras did the same. Corrected lenses addressed this issue – and similar image degradation issues, often getting good image detail in the corners at the same time as the centre. When using the term “corners” we really mean an image circle that includes the corners or maybe a bit inside the corner dimension. Thus a 50mm lens that is well designed for half-frame work, may not be optimised for full frame work and vice versa (and highlights why some full frame lenses perform so well on the reduced APS-C cameras as the corner degradations are avoided). Generations of lens designers have addressed these issues and the genius of Dr P Rudolph back in 1897 produced the “Planar” lens which corrected image flatness nearly everywhere, and is still the basic design for virtually every premium lens. A lot of simpler lenses out there don’t have this “flat image field” and they show up as poor performers. Sometimes even lenses that are supposed to be good show such oddities. On test the Pentax-M 1.4/50 is out of focus in a 12mm radius circle but is in focus in the centre and in the corners – this shows up as chroma errors, probably in the form of Spherochromatism. Usually, shutting down a poor lens improves definition but a Tessar 2.8/50 for an Icarex (one up from their economy Pantar lens but probably not made by Zeiss) degrades rather badly in the centre when shut down to f8 – a fair indication that there is something wrong with at least one of the lens surfaces. A 1937 Schneider 2.8/50 Xenar designed for an Exakta showed the same defect along with poor chroma in a 12mm diameter circle – a lot wrong with that lens! Another oddity was an apparent presence of two images in focus but with effectively two slightly different focal lengths. This is only evident at the corners and might be classed as Coma but looks rather different. One lens demonstrating this was a Travenar 2.8/50 made by Schacht for a mid-1950s Edixa – maybe an incorrect grind on one of the lens surfaces as well? Some of these lenses are simply odd and maybe should be avoided.

But there is another way of considering these oddities and in fact most images that depart from being perfect. Using the test system outlined here, a perfect lens can be said to achieve 35MP everywhere on a camera that can resolve at that level. A lens that performs poorly can be less than that – and virtually all lenses can resolve well at about 15MP – and that is certainly good enough for most photography – and indeed was the digital standard for perfection a decade ago. If we jump forward a few years maybe the standard for full frame 24x36 will be 100MP and no classical or heritage lenses will meet that level of perfection. So is a future lens likely to achieve 100MP? The answer is a qualified yes… If perfection is sought in the lens itself then you will need very deep pockets and there will probably be different error types to consider, but integrate the lens design with some very smart software inside the camera and you will have a product that can produce photographs with 100MP resolution – and fix a few other issues as well.

But is the idea and/or availability of a super-lens relevant? At this time (2020) the best digital sensors that a photographer might use for full frame working is commonly 36MB and 61MB for more money. Such a sensor matches the best lenses that we saw during the testing, but we became aware that there were better images to be had. There were lenses that promised better performance and the technology of new cameras was also improving – although there may not be too much further to go for general photography. Some specialised photography techniques allow much higher resolution pictures to be taken with some often-considerable inconvenience. Assuming that the target image is a “standard” 50mm lens on full frame, then using a tele-lens to scan the object on a 4x4 matrix allows 16 times the MP rating using the same sensor, and as in the case of the new Sony A7R Mk IV, simply vibrating the sensor in an ordered way allows 4 times the MP rating – assuming that the lens in use is good enough to resolve those displaced pixels. Both those techniques demand that the object does not move and that the camera is also absolutely stable in reference to the object.

A few lenses produced images with issues that are not described above – or anywhere else in this series, marking them as being different from other mechanically similar lenses. A few oddities might be described as departing from APO classification (an APO lens is supposed to produce good images across the wavelength spectrum), variability across the frame in some parameter, evidence of decentralised elements, production control (and there was evidence of performance difference between lenses that should have been the same) and while looking at the images and data I did not rule out a possibility that some lenses are not suited to working with digital sensors. That latter point suggests that a different type of sensor might produce different results with a lot of lenses – it is known for example that some sensors do not work well when the angle subtended to the lens back element is large. A full analysis to take all this into account would be a lot of work for a single lens – let alone the pile of 100 or so lenses that I considered! Having gone through this exercise, I am now very wary of reviews of lenses that appear on web pages etc. I saw details in some test images that seem never to be mentioned, calling into suspicion nearly all of those reviews.

This treatise addresses resolution, distortion and to some extent spectrum. But there are many features of lenses that were not covered – convenience of use, contrast beyond the obvious, the details of APO performance, star patterns due to diaphragm arrangement, corrections when integrated with camera software, and probably a few more. Some readers will want test results from other lenses – unfortunately, some lenses are hard to couple to the test body, and in any case the collection resource is not infinite here. Amongst photographers and collectors there is bound to be some tribalism – ie the highlighting and support of a particular maker for example – it can be hard to be objective sometimes. And there is one major issue to be considered – a while back it was generally assumed that prime lenses were the only way to get high resolution. The use of aspheric elements and modern design has changed that to the point that for most photography even a moderately priced zoom lens does just as a good job when incorporated into the dedicated camera software.

Readers will observe that there are special lenses made for special purposes. They turn up from time to time and photographers try to use them for general photography – often with mixed results. In this series of articles there is almost no consideration of these special lenses. Often they are designed for restricted wavelength illumination, specific object distances and hence magnification ratios, or are high cost items made for organisations with deep pockets who need specials for surveillance or data-gathering. When they do turn up in general photography, their performance and applicability probably need to be determined on a lens by lens basis, and that may take a lot of effort. A couple of the lenses tested for this article are close to such classifications – for example the Contarex f4 50mm S-Planar only exists in a few examples… Its reputation is very high but on testing it is no better than the standard f2/50 Contarex Planar from the same era. Really all that can be said for it is that its focussing helix is designed for 1:1 work!

Sometimes we have to consider exactly what a lens was designed for rather than its markings. A good example is the 1902 type-3 4.5/50 Planar by Zeiss. For this exercise it was mounted and used as a full frame 35mm equivalent. It was not the best lens when used that way but it was not the worst either, and was near enough to digitally perfect in a 15MP world. I then tested it in an application that it was designed for, that of a lens that might be used on a microscope in conjunction with a camera – ie with an image distance of 160mm and effectively a magnification of 10:1. In that mode its performance was exceptional to the point where I reached into my “precision lens box” and pulled out a late model Zeiss 4.5/63mm Luminar and repeated the test. There was little to separate the performance – (Both lenses were tested wide open.) Indeed, both lenses were good enough to highlight resolution errors due to the laser printer in the test chart – verifying that the ultimate resolution of the test chart was no better than 400MP equivalent on a full –frame image due to the printing resolution limit.

Part 3: Optimisation

So far we have dealt with the testing of lenses, the results as far as resolution were concerned and the Chromatic and Spherical Aberration – appearing as edge fringing and pincushion (barrel) distortions, and fringing that can arise when an object is out of focus, and the loss of contrast. We also looked at the results from some specific lenses that had degradations peculiar to those designs. We now consider how we might optimise the performance of a lens.

We attributed image errors as problems associated with lenses and summarised those errors in recognisable terms. What we did not do was analyse the actual source of those errors in terms of the geometry of the lenses, manufacturing quality, or the characteristics of the dispersive media – ie the glass etc. Unless you are actually going to make a lens, understanding those factors is not particularly important, but the image characteristics in terms of distortion etc are important and if we are going to make external corrections to a lens then they need to be understood. That largely is what the first two parts of this series are – an introduction to what we can do to correct a faulty image.

Throughout the history of photography and indeed before that as the human race was making telescopes and microscopes, almost countless people were devising ways to improve optically generated images and understanding what the theoretical limits were. There were many breakthroughs which are incorporated in virtually any modern lens system – from precision research items to a common box camera and today the camera in your phone. Historically, all camera lens surfaces were spherical – that was the only way that they could be made accurately. Telescope makers were using special grinding techniques to create slightly aspheric mirrors Centuries ago, and now precision moulding techniques are making aspheric elements for common camera lenses in a high enough quality and for an acceptable price to be expected in just about all lenses. Compounding elements to achieve various corrections happened in the 19th Century, coatings to improve internal reflections and transmission belonged to the mid-20th Century and there were refinements all along. Most of the early work was by logic and experiment, and what calculations there were relied on manual methods and mechanical calculating machines until about half a century ago. When computers arrived, they replaced the manual calculation methods – then they started being used interactively to produce designs, and today they are an essential part of virtually every photograph taken as they allow data processing to provide those corrections to images that are not economically or practically possible using a lens alone.

Let us consider a few image problems one at a time and how we might deal with them. As lens complexity increased, lens elements became thicker and had significant edges and they had to be mounted in tubes etc – all of which had the ability to cause internal reflections. It was obvious that in a multi-element lens there were lots of unwanted reflections from the surfaces indicating loss of light through the lens and sources of unwanted light that damaged the contrast in the image, and occasionally caused false images to be formed in the image plane. Lens edges and tubes could be dealt with easily – paint them with black light-absorbing paint and mount them, sometimes with baffles, so that reflections don’t find their way to the image area. That approach is still being developed, and the bodies of most modern lenses and cameras are fitted with baffles, often rectangular and often with sharp edges to remove the possibility of shiny bits. Even the very latest cameras from some manufacturers are still being enhanced that way and new models have baffles that were not present in the equivalent model a few years ago. This is not new – if you can find a Rollei 35 from the original 1968 release you will find that there is a strip of metal in the bottom of the body that the extending lens runs on. That surface became very shiny quite quickly and reflected sky caused a major flare in the middle top of the image. At first Rollei produced a special rectangular hood to address the issue but in the later versions of the Rollei 35 they replaced that metal strip with a U-shaped section to minimise the problem. Early E-mount lenses from Sony had some baffling at the back of the lenses – later Sony designs have smaller, more exact, baffles that align with the sensor. This is a work in progress. When we are dealing with legacy lenses we use adapters. Those lenses usually don’t have baffles and the adapters are commonly not as black as they could be. Maybe try making a baffle and maybe find some black matt paint and “fix” the adaptors. A few adapters do have such baffles but they tend to be the more expensive ones – like Metabones. I looked through my collection of E-mount adapters – there are lots of shiny bits!

Fig C1 shows how a baffle can help optimise contrast by eliminating at least some of the scattered light in adapters and lens barrels. Those baffles need to be large enough not to interfere with the wanted image and what works with one lens may not be satisfactory with another with a larger exit pupil as viewed at the image.

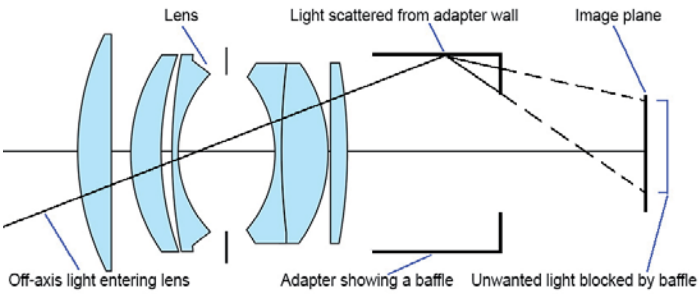

Fig C1 - Use of a baffle to minimise scattered light

A very major issue in lens contrast is the coatings on the lens surfaces. They work by cancelling out a specific reflection wavelength (single coating) and several wavelengths (multi-coating), and enhancing the transmission of light across the RI boundaries between elements and air. The cement used between elements in groups also plays a part in matching the optical transmission properties. Since WW2 virtually all lenses of quality were coated and in the early 1950s it was not uncommon to get a pre-war lens “bloomed” with a vacuum deposited coating – often on both the front and back elements while the lens was still assembled. A few lenses were improved significantly this way. Multi-coating is a way of improving transmission and minimising reflection even further, but some specialised lenses designed for use at a specific wavelength will only be single coated at the operating wavelength. When reflections from coatings appear as colours then that is the design wavelength, or some combination of them in the case of multi-coatings.

Some lenses do not work well with light outside the visible spectrum, and some films are sensitive to the low performance wavelengths – particularly UV light. Thus it was almost standard to include a UV or Skylight filter permanently on your lens, blocking the error part of the spectrum and assisting to correct some colour issues at the same time. Various coloured filters were used for Black and White not only to generate artificial contrast when the subject is coloured – for example enhancing clouds against a blue sky – but they can also improve performance when B&W images are required by blocking non-visible wavelengths. Some digital cameras will improve using similar filtering, and it is normal on most digital cameras to include internal filters to block UV and IR.

As an aside to lens correction some digital cameras include “anti-aliasing” filters to address issues associated with the digital nature of the sensors and the way that they react to fine repetitive features in images. This is a very complex area and there are several approaches to dealing with the problem. A non-filtering approach is to vibrate the sensor slightly to reduce its bandwidth. The effect of anti-aliasing lowers the effective resolution of the sensor – in practice the image is blurred slightly but no more than is necessary. However if you try to test lenses using a camera fitted with such a device, then the detected resolution will be lower than you might expect. On the positive side, pictures will be “smoother” without too much in the way of moiré patterns etc that might even become more obvious when the taking lens is very good!

Lenses with image planes that are not completely flat may produce better overall images when focussed part way towards the edge of the frame at the expense of centre focus – this is not commonly done but can be a useful approach. Lenses that exhibit chromatic and spherical aberration need more significant correction and that brings us to the world of post processing.

When we are dealing with a photograph in the form of a digital file from a digital camera (assume narrow multi-wavelength sensors) software can be used to correct spherical and chromatic aberrations. If the lens parameters are stored in the camera and the camera is designed to account for them, those corrections will be applied automatically when the output format is JPG. One day, such corrections will also be applied to RAW images but for the moment that is on the wish list. The effectiveness of such correction is a measure of the precision and quality of the camera and logically, the best cameras should have the best correction.

So how is that correction achieved? When a photograph is taken in a digital camera, the sensor records the image pixel by pixel, usually across the three primary colours. That creates a lot of data and most commonly, software in the camera will condense that to create a JPG image. The software that does the JPG conversion in modern cameras is also able to correct the individual colour record to remove chromatic aberration and where detail is recorded to correct pincushion and barrel distortion and even to fix some diffusion errors that appear as being out of focus.

The general principle for achieving this is to remap the pixels at each of the sensor wavelengths, usually with some smoothing – ie interpolation to avoid unwanted granulation. Different manufacturers have their own processes for achieving this but in general, the JPG image that is produced is significantly better than the original image on the sensor. The use of JPG was decried as a backward step a few years ago when the quality of the JPG image was significantly worse than the original RAW image.

Most of the effort in producing the JPG was towards minimising the file size. Today, with the cost of storage falling quite dramatically, the size of the JPG image is not seen as so much of an issue and the effort is going into correcting the images – very successfully. Further, the speed of the processing software has been increasing, although at the cost of battery life, allowing the better cameras to perform significantly better than a simple unit in terms of image quality.

There are, however, compromises everywhere. As new lenses are produced, their parameters may need to be updated in the camera. That is done as part of the BIOS or firmware update that can be done from time to time. Users should check every now and again that their digital cameras are up to date – especially after getting a new dedicated lens. For example, the very common decade-old Sony NEX-5 camera is now up to version 5 in its software, and even the very first version of that camera can be updated to the latest performance.

A search of the internet suggests that there are several approaches by camera and lens manufacturers to the correction processes. The amount of processing can be very significant and an idea of it can be gained from the size of the BIOS upgrade which can be hundreds of Megabytes. There may be a few limits – for example a Canon camera (or maybe one model) has space for correction data for up to 40 lenses, so there may be a time when a choice has to be made on what lenses you want to use. This writer suspects that we can expect some changes in the future and envisages a possibility that dedicated lenses will include correction data as part of the electronics inside the lens itself – even if the correction is done in the camera – indeed there are some lens and converter items that have their own BIOS already. Maybe a future lens will include correction data that is determined as the lens is made and becomes an "electronic element" that is specific to that actual lens as part of the manufacturing tests.

But what can we do for a lens for which no correction data is held in the camera? Record it as RAW and open it in Photoshop or some similar editor, but you may need to go through the conversion processes outlined in the first part of this series.

Alternatively, you could work with compressed JPG images but that will actually degrade the image a bit. Photoshop etc have manipulation tools in them that can correct for various classes of distortion and both Spherical and Chromatic distortions of a radial kind can be removed entirely. There are some lens makers that produce standardised data for the necessary corrections in the more common lenses that can be entered as fixed corrections in Photoshop – excellent for bulk work.

If you are using a zoom lens as many do, then getting the exact conversions for a given focal length is rather more difficult and the best option is to do the correction manually. In those cases you really need to make the corrections interactively and that requires a computer, graphics card and screen that are fast enough to work in real time. When it is all done, then you can manipulate and crop etc, but note that those lens corrections should be done with the full frame as they generally rely on knowing where the centre of the optical image is. Experts can do more and include manipulation for other photographic issues like perspective, vignetting and localised changes in brightness and contrast. Of course, some of the ordinary faults in photography like wrong exposure can be fixed very easily in Photoshop and are one of the first things that a user learns to do.

The proof of the pudding is in the eating and with a little bit of trial and error and experience, quite faulty photographs can be brought to a condition that a casual user would assume has involved the very best lenses – even if the original was taken with a junk lens out of the scrap bin. But a caveat – every now and again a lens will turn up with serious assembly problems – most commonly the elements being out of alignment or the grinds being not in the same centre lines. Such lens images can be corrected to some extent but off-centre edits take a lot of work.

These comments on manual corrections of course apply to lenses of all focal lengths. There are plenty of examples where cheap wide-angle lenses can be corrected manually to produce excellent photos with aberrations removed entirely. Even extreme examples like images taken with fish-eye lenses can be corrected fully to produce excellent rectilinear images. A very notable conversion is possible with the naturally fisheye "GoPro" cameras and a computer-based utility will convert such video to a rectangular image with very good results.

What can we do if the image is simply out of focus or just not sharp enough? Photoshop again can come to the rescue and increase sharpness artificially by treating slow changes in detail to sharper ones. That is unlikely to fix everything but superficially does provide some improvement.

All of these tricks and probably a few more are built into the in-camera processes that correct dedicated lenses, and it is not simply fixing evident problems. The software engines can behave like actual correcting elements and as they don't have to be uniform across the whole image then they can deal with very complex deviations from the ideal. A conventional lens element can correct a first order error, an aspheric element can correct a second or maybe a third order error but software is only limited by the power of the processor and Spherical Aberration for example which is typically a 6th order aberration is easily dealt with – exactly! Take the matter further and new processes utilising concepts like transversal equalisers will be able to deal with lens errors in ways that break the fundamental rules of optical limits that are the controlling elements of real lenses by a very large factor.

We should spend a moment talking about hacking digital cameras. There is no doubt that manufacturers' updates can enhance the performance of a digital camera and there is temptation to make a camera special by modifying its form – including changing the software in ways not originally intended by the makers. In a few cases, a camera can be one of a series using common parts with cameras that are more expensive and better performers, and it is logical that a software change may do the job of "upgrading".

Such conversions should probably be left to those who are experts, and in any case, a camera modified in such a way is most unlikely to be covered by warrantee if it goes wrong. More particularly, changing the software in a camera may well prevent any further changes including reverting back to the original software if something is not the way you want it. You may even end up with a dead camera that is only a shelf display item. Some hacks are becoming common. A few cameras can be physically modified to remove spectrum restriction filters, anti-aliasing filters and some can even have sensor cooling devices fitted to reduce sensor noise. Those hacks work and there are people who make the changes accepting the responsibility for problems.

The usual result is a camera that is specialised – for example for astronomical work where Infra-red and Ultra-violet spectra are recorded. In most cases of hacking, the results are to do with spectrum and the format of video etc, and not the way in which lenses are dealt with – which is the general subject of this series of articles. Let's leave hacking to the specialists… (OK, the writer has a couple of hacked cameras for astronomical work – another story entirely….)

One of the degradation issues to emerge was that of contrast reduction and some of the simpler lenses from the 1930s produce excellent images with good chromatic and spherical aberrations and quite good resolution. But the contrast is poor. Photoshop to the rescue – the overall contrast can be enhanced or for a little more work the high and medium tones can be left as they are and the deep shadows affected by extraneous light – recognised as poor contrast – can be modified to produce images of much higher quality. Digital photographs taken using pre-war uncoated Elmars and Tessars can be very satisfying when treated this way. Logically some lenses and adapters could be fitted with custom-made baffles, and there are some lenses that have untreated element edges that might be disassembled and blackened. Coating a pre-war lens might be an interesting exercise but it is hardly worth the effort financially. Many pre-war lenses continued manufacture in the 1950s when they were coated as a matter of course. Buying one of those is likely to be a much cheaper path than coating maybe a dozen surfaces in a pre-war version.

Just how does in-camera lens correction work? At its simplest, a colour digital image in a camera is the combination of three images, R, G, and B – each having their own internal file structure, and in most cases the degradations are not so much the actual focus but the spherical and chromatic aberration that occurs in the lens. If those parameters are known for the lens and taken into account in the camera then they can be corrected – and a simple way of thinking about that is to observe that each of the R, G, and B images are spectrally narrow, and thus there is some freedom in the lens design to get those focus points just right. The camera software has to do a conversion anyway – to produce a JPG file and an extension of that can also process the corrections.

That processing is NOT available on the RAW image as that is straight off the sensor with only minor processing to create the storage file. However the industry is fixing that by correcting to high resolution JPG first and then converting back to RAW. We may not like that but that is the way that it is – however it might be a temporary step until in-camera processing gets faster.

A consequence of correcting the chromatic aberration in the corners is that the resolution also improves visibly in those areas. A result of all this is that the camera JPG versions are likely to be the best that the camera can produce. For professionals however and those of us who are prepared to take the time, post processing with programs like Photoshop can also do those corrections but we have to do it manually or rely on data that takes specific lenses into account.

However there is a new reality: Cameras like the Sony A7 series correct the images to maybe the best correction possible when the lens is dedicated to the camera and its parameters are stored in the camera. We may not like that fact but it means that when we take a photo and store it as a high resolution JPG then the greatest error is typically no more than one pixel. Further still, software in the camera can remove a very large amount of sensor noise and for some photography can even dynamically enhance contrast in shadows – a sort of dodging process. Add to that some special features like the ability to remove wrinkles from people's faces (Canon's "Ten years younger" button) and photography takes on a whole new form.

Virtually the whole of the subject of this series on lens performance has dealt with conventional nominally 50mm lenses used with full frame cameras. Other lens types present different problems. When extended beyond standard lenses – telephoto – wide angle – mirror – zoom – there are so many variables that comparisons are not very relevant unless the items under consideration are otherwise very similar. In the case of a zoom lens, the performance can vary very significantly over its focal range.

At the highest resolutions, taking photographs over long distances using long tele-lenses present some further complexities. Any photographs over a distance of more than about 400 metres will suffer from the effects of the curvature of the atmosphere due to the fact that the earth is a sphere and the atmosphere is subject to gravity. Atmospheric turbulence due to wind and thermal rises etc, atmospheric contamination leading to loss of contrast as well as all the issues that have already been mentioned, all add to damage the performance that is due to the lens alone. Some of those issues will be very evident when telephoto lenses are longer than about 100mm and by about 1,000mm many of those effects dominate on even a relatively poor lens. This is well known by lens designers and many telephoto lenses on the market are relatively simple as they are rarely required to produce accurate images.

Many demonstrate significant chromatic aberration in the corners. As for other cases, when a lens is corrected by the software in the camera that lens is likely to be a significantly better performer than even a high quality lens from yesteryear. Wide-angle lenses have different problems – commonly fall-off towards the corners where the cosine angle effectively lowering the sensitivity of the sensor in the corners can be very noticeable – sometimes favouring a particular colour. Different sensors have different performances in this area. As for many other issues, the eventual photograph can be very significantly improved by the software in the camera, and again those dedicated lenses – including zooms – are probably the best performers.

After all of the above discussion there has to be some sort of conclusion about the lenses we use for photography, and in many respects it comes down to the technology involved and how the adoption of new technology has improved what we can achieve. Collectively we did not really understand how lenses worked until 170 years ago and it took us 50 years to make the first lenses that were capable of what we think of as nearly perfect images. It took a further 50 years to come to grips with making those lenses optically efficient, and another 50 years to sort out a few manufacturing details that allowed the lens performance that we have today. That leaves the last 20 years to push the performance limits of digital imaging and a few refinements in computer processing of digital images to achieve virtually perfect images.

It turns out that the overall performance using a miniature camera today is much the same as we could always get with a large-format camera. Or have we gone further than that? Technology has made exceptional imaging possible in the tiny cameras that are built into our mobile phones at a cost that is accessible to everyone. And those lenses are a far cry from nearly any lens that existed even a decade ago. For practical purposes, the new lenses and their associated digital software correction systems out-perform all classical lenses that we are likely to have. A few classical lenses go close but are always just a bit behind. But the technology changes continue and every new generation brings with it some improvement – whether we need it or not. Do we need better than 35MP? It is better than we could ever do with film, and in fact when compared with a high-end camera at the end of the film era, the practical digital equivalent is only about 12MP – and that is reflected in the performance of some cameras that are designed for the professional market – like the Fuji X100 and the Sony A7S.

And a special note on those professional 12MP cameras. If you genuinely need better than that to avoid the pixilation that can occur in high enlargement, then interpolate the 12MP image up to maybe 48MP or more using one of the smoothing algorithms and it will produce a very acceptable image.

Just as our photographic needs are satisfied in the new tiny cameras, there are also cameras and their lenses that out-perform everything else by a large margin. They vary from the costly items that might be purchased by enthusiasts to the imaging systems used in industry and research – many orders of magnitude higher resolution that is ever needed in photography, but necessary to manufacture the computer chips that we use and to answer some of the questions we have about the creation of the Universe.

Most of the above testing and analysis is to do with what is usually called a "standard lens', ie a lens with about a diagonal 47-degree field of view. Of course, there are many other lens angles and whole families of consumer grade cameras that provide wide angle shots. Are the results with those lenses in parallel with the "standard lens"? It turns out that the situation is much more problematic for a couple of fundamental reasons, and the issues that arise govern just what lenses have been made in the past and how they work with modern cameras. It may be that some of those issues are temporary and may be resolved in the future. For short to very short focal length lenses the thickness of a modern colour digital sensor is large enough to cause significant image errors which do not occur if the sensor is very thin – and those effects can vary from lens design to lens design.

At the other end of the scale – telephoto to super-telephoto, there are many compromises in lens design and just how a given lens will perform is likely to be determined by what the designer and manufacturer intended the lens to be used for – and of course the cost of the lens. A portrait to tele lens used for candid photography in low light conditions in a night club is likely to be fast, and far from diffraction limited. Similarly, a long telephoto lens used for fast sports will need to be as fast as possible. However a similar focal length lens for slow nature photography can be lot smaller and may even be diffraction limited giving the highest resolution possible. When we consider the design of zoom lenses that are now probably the most common lenses used by amateur photographers, then all sorts of compromises arise. But even there, the ability of a modern camera to take that into account can allow images that are every bit as good as a high-performance prime lens.

The writer did test a few lenses well away from standard lenses, but nowhere nearly at a level of detail to be fully conclusive. Should anyone want to test the wide and tele worlds then some understanding of the limitations of the lenses, the form of image degradation that applies to each focal length, and the whole matter of matching the lenses to the image sensors has to be obtained. That will take the analysis into a whole new set of worlds. But where do you start? You could simply set up some tests for wide angle lenses and restrict to, say, half the focal length of a standard lens, and use the same camera for testing. But in a year or so you have to do it all over again as the sensor performance at high incident angles might improve with new technology.

At the tele and super-tele end it is a bit more straight forward, as the sensor limitations are not so significant. However, consider the range of apertures involved, and for a given focal length, "wide open" might mean f2 for one lens and f8 for another, and either or both could be diffraction limited. Further, and probably quite importantly, the central design of standard lenses is likely to be one of the anastigmats with 4-6 elements while those tele-lenses have a very wide range of designs from primes to compacts where the total length of the lens is a lot less than its focal length.

Generally speaking from some testing on a few lenses with "suspected" issues, the writer discovered huge performance differences at the very wide angle end – far greater than the differences on the most extreme standard lenses – and the shorter the lens, the worse the situation seems to be. For full frame work, most 35mm lenses do a good job but only a few 15mm lenses had performance even approaching that of decent standard lenses. However where those very short lenses were also corrected using in-camera or post-camera processing, even the poor lenses could produce good images.

Quite a few long lenses performed poorly – very poorly if they were also low cost. Pay more money and the performance improves very significantly, and diffraction effects become the evident limiting factors. Older lenses tend to have poorer contrast – and there are good reasons for that which modern manufacturers are learning to overcome.

Somewhere around 500mm for full frame work, mirror lenses come into their own. It was always possible to make good ones but their prices were out of the reach of most photographers, however today manufacturing techniques have improved dramatically to the point that maybe every 500mm reasonably-priced mirror lens is good. The usage of those lenses varies a bit and when you find a lens that works very well at an object distance of a kilometre – but does not even focus down to 50 metres – it is hard to be completely objective when comparing that with a unit that is quite happy down to 10 metres.

Of course not all "500mm mirror lenses" are designed the same way – they vary from "two mirrors and no dispersive elements" to "2 mirrors and half a dozen dispersive elements". One new mirror lens had a design feature which did not immediately appear to be attractive (a rear surfaced rather than front surfaced reflector) but on test performed very well indeed. In practice that probably had the effect of dropping the manufacturing cost as it is far easier to protect a mirror surface on the rear of an element than it is to protect a front-surfaced reflector. What was that lens? It was the f8/500mm Zeiss Mirotar made for the Contax RTS. Some of these lenses might look superficially similar but their design characteristics will be very different…. So much is happening in lens design at the present time.

Caveat: *In presenting these test results, I must observe that in most cases the figures are from a single cycle of testing on a single lens example. We must then question the matter of whether these results are reliable for all examples of the same lens design or even model. There were a few lenses that tested poorly and I had the opportunity to test more examples of the same type - in one case I went out and purchased another one to double check. In the case of the poor performance (Zeiss Jena Biotar 58mm f2) there was measurable variation from unit to unit - calling into question quality control etc. The "purchased" unit was a new Sony 28-70 Zoom for the A7R. Those two produced identical results. In all cases I repeated tests in an attempt to avoid testing errors and to present the lenses in the best light. For genuine validity, all tests should have been repeated by another operator, at different temperatures and other varying conditions that have the ability to affect lens performance. The work behind this article was very time-consuming - doing it more thoroughly would have delayed the results significantly.*

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