Comparison of the Swift FM-31 Portable Field Microscope and an FM-31 Clone

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Both authors are collectors and users of portable field microscopes and this article reflects their opinions. Today there are a limited number of serious portable field microscopes being made and most are relatively expensive such as the *Omex MicroMet* and the *Evolution Portable.* As most models are expensive, the authors were interested in determining if an inexpensive Swift FM-31 clone could be appropriate for professional field use.

First, a clarification, occasionally, there is some confusion between the James Swift & Son Ltd and the Swift brand names. According to Bracegirdle[1],

> "In the 1960s a totally unrelated USA company, Swift Instruments Inc, SAN JOSE, California, established possibly in the nineteenth century, applied the name Swift to a range of Japanese microscopes marketed in the UK by a company called Pyser Britex (Swift) Ltd, of EDENBRIDGE, Kent, and this similarity in names can cause confusion".

The Pyser Britex company markets its microscopes under the brand name Britex, as well as Swift. In a 1963 ad in "The Quarterly Journal of Microscopical Science" [2] Pyser Britex notes they are "Manufacturers, including equipment by SWIFT" and they use the same Swift logo as the US Swift company. Interestingly, both James Swift of London and Pyser Britex of Edenbridge have ads in the same issue of that Journal.

The original Swift company was started ca. 1920 and was purchased by Speed Fair Co., Ltd. (Motic) July 2007. [3] The original FM-31 was introduced by Swift at the start of the 1980s. Although manufactured in Asia, the FM-31 model discussed here was sold by the "Swift Instruments, Inc., Scientific Instrument Division, San Jose, California, USA". Both the microscope's body label and the case for the instrument state "JAPAN". According to Swift [4] sales for the FM-31 were discontinued in 2006. The model's full designation from the time of introduction was FM-31 LWD. In most instances it was referred to more concisely as the FM-31. Unfortunately, from the authors' perspective, Swift currently has no plans to reintroduce this model or an updated version.

When the excellent original Swift FM-31 was discontinued, the market opened for FM-31 like field microscopes, i.e., FM-31 clones. Outwardly, the later models differ from the “original” FM-31 of the 1980s mainly by the focusing device: while the early model focusing is performed by a large black horizontal knurled knob located underneath the stage base, the newer model FM-31s and FM-31 clones have two vertical knobs, one on each side of the stage's base. There are several FM-31 clones, the relatively inexpensive model discussed here, and several more expensive examples including the Evolution Portable mentioned above.

The FM-31/FM-31 LWD and FM-31 clones use folded-optics and are designed to view slides upside down, that is facing the objective lens. Although visually close to a McArthur microscope, where slides

are also viewed facing downward, the FM-31 and its clones are of different design. The most obvious readily apparent visual differences are that the FM-31 has its objectives in a circle and its eyepiece tilted while the McArthur has it objectives in a straight line and its eyepiece vertical, the FM-31 design makes it larger than most McArthurs, although easier to hold and with its tilted eyepiece easier to use (see Figure 1). To aid in identification, the FM-31 is shown on the left and without stage clips in all comparison photographs.

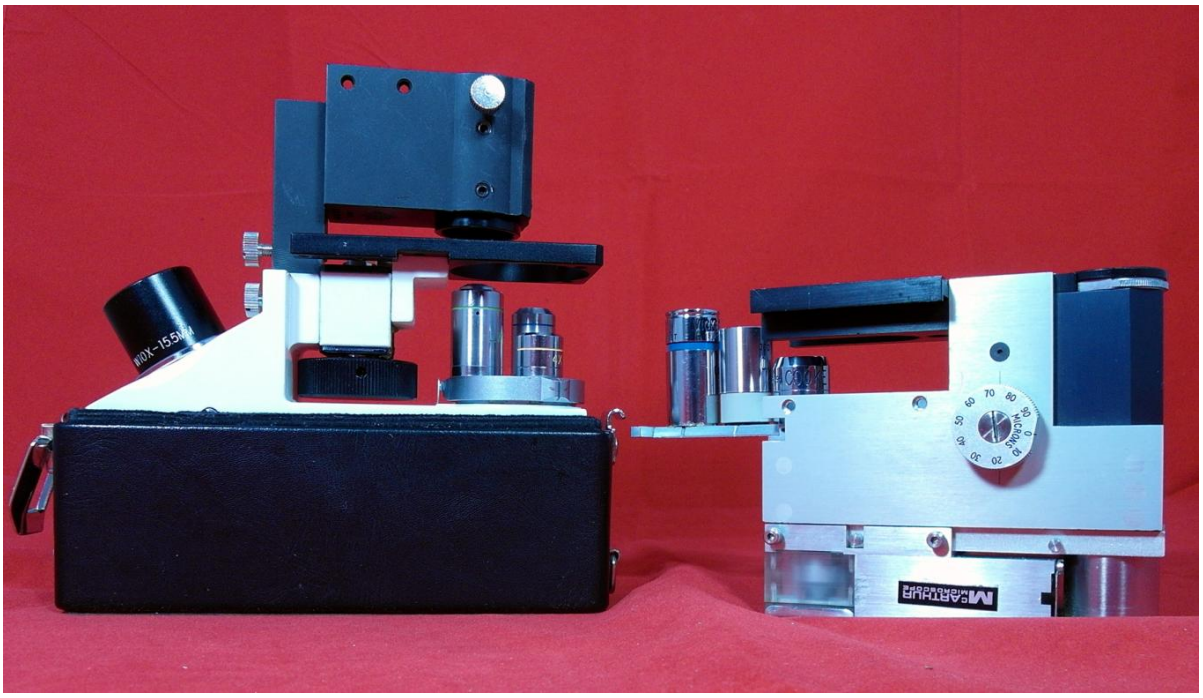

Figure 1 - FM-31 and McArthur Microscopes

The FM-31 uses mirrors, as opposed to more expensive prisms, to produce a "U" shaped light path. The light entering an objective is focused downward to an angled mirror in the microscope's base and reflected across the base to another angled mirror and then reflected upward into the eyepiece (see Figure 6).

The FM-31, particularly with its Long Working Distance (LWD) high power objectives, is generally considered to be very good optically and mechanically and can be, and has been, used for serious field work [5], especially in harsh and remote conditions [6]

A question that arises is what is the difference between the clones and the original FM-31, and can these clones be used in the field as effectively as the FM-31. We only attempt to answer this question for the clone model discussed here, which is one of the lower cost clones and now often sells for 1/2 to

1/3rd the cost of a pre-owned FM-31. One might reasonably expect that the more expensive clones would be at least as capable.

Below are comparison pictures of an original FM-31 and an FM-31 clone. The clone has the newer focusing system similar to the later FM-31s.

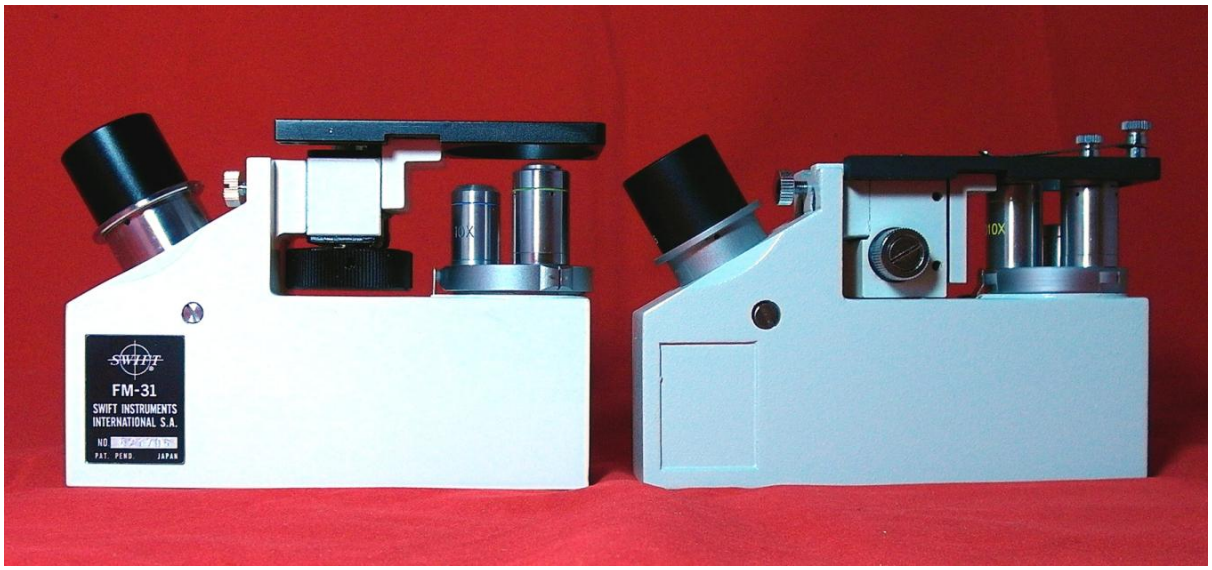

Figure 2 - Original FM-31 and FM-31 Clone Fronts

Both models come with a triple nosepiece and objectives, the three provided objectives are 4x, 10x, and 20x or 40x, with plain stage. A mechanical stage was readily available for the FM-31 and is available for some clones. The clones usually are provided with LED illumination as the model here, while the FM-31 had a variety of illumination options, most of its original illuminators used incandescent bulbs.

Figure 3 - Original FM-31 and FM-31 Clone Backs

As can be seen the paint color on both is almost identical, with the original slightly more ivory. The finish on the FM-31 is quite smooth, on the clone a bit more textured and thus easier to grip. Both models have a rectangular indention in the same location. The original has a Swift label in this indention; on the clone it is unoccupied.

On both models the eyepiece is extended for use. On the original FM-31 the eyepiece is raised approximately 14mm before it 's locked in place, on the clone about 9mm. Both eyepieces have "L" openings in the bottom of their housing (see Figures 4 and 5) . The long portion of the L to raise and lower the eyepiece, and the short portion to lock the eyepiece in place.

Figure 4 - FM-31 Eyepiece Tube

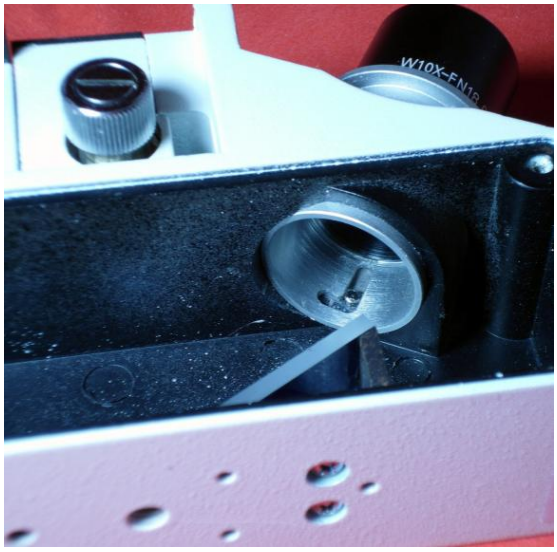

Figure 5 - Clone Eyepiece Tube

As can be seen in these photographs, the travel distance for the original FM-31 eyepiece (on left) is greater than for the clone. Also from these photos it's easy to see that the internal finish, invisible unless the microscope covers are removed, is better and more uniform on the FM-31 than the clone. On the FM-31 the paint used for light baffles is a flat uniform matte black. The clone's black paint is not uniform, and has some bright inclusions, and is thus not as effective as a light baffle.

Reflection concerns are obvious on the inside of the clone's cover. While the FM-31 is painted in the same matte black finish as elsewhere, the inside of the clone's folded-optics compartment cover is left unpainted, shiny and reflective, and it shows some signs of discoloration, probably hydrated ferric oxide (rust).

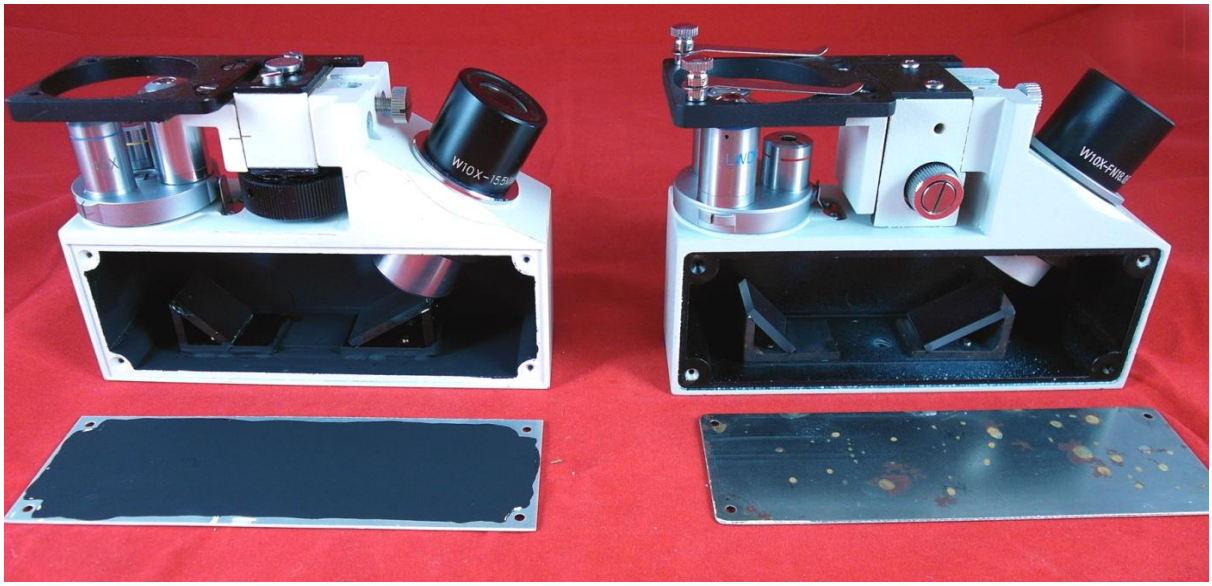

Figure 6 - FM-31 and FM-31 Clone with Mirror Housing Covers Off

Removing as much rust and discoloration as possible and spraying with a black matte paint, easily eliminates one potential source of image degradation.

These photographs also identify a concern for a microscope designed for field use. The inside of the central tripod socket of the FM-31 is covered with additional material to seal out dust and dirt with a 'hard stop'. The clone has an uncovered and open tripod socket and unless that socket is covered with tape or with a matching “blind” screw it will allow dirt and dust to enter the folded optics housing and thus degrade the image.

As mentioned previously, the original FM-31 used a relatively large horizontal wheel for focus and later FM-31s and clones a more convenient knurled 13mm screw. The redesign of the focusing mechanism allows for a larger L bracket and greater contacting areas, and as a consequence greater stability of the focusing housing. However, the new focusing mechanism's design limits the stage to a fairly restricted travel distance, less than 3mm, approximately 1.6mm up and 1 mm down. The original FM-31's stage can move vertically up/down in excess of 11mm, about 8.5mm up and 3mm down. That is, the original FM-31's stage can travel more in either vertical direction than the combined up/down stage travel distance of later FM-31s or clones. Greater travel distance provides more flexibility and easier access to the objectives.

Physically the two models are almost identical, measuring approximately 40mm x 440mm x 90mm tall. Accessories, e.g., original FM-31 illuminators fit comfortably on the clone as does the FM-31's mechanical stage. Without illuminator or stage clips the original FM-31 weights approximately 1 lb 11oz (503.5 gr.) and the clone with stage clips, but also without illuminator, weighs in at 1 lb 12 oz (508 gr.). Thus, weight wise, carrying either model in the field is essentially identical.

Chemical analyses of the clone's cover and body were made with a portable X-Ray Fluorescence (pXRF) spectrometer. We used a Niton XLt-900 GOLDD pXRF, equipped with a silicone drift detector and using the mining matrix (see Figure 7). The analysis of the cover shows it's approximately 89.2% iron with some trace elements (Mn, Pb, Ti, Ba, Cu, Ag, Sn, BI, and Cl), rather than aluminum alloy that might be expected for a portable instrument. This is probably one of the ways the manufacturer has kept the cost relatively low. The same analysis made on a polished section of the base where the paint was abraded to expose the base metal, revealed a composition of aluminum-silicon alloy (Silumin) containing (normalized weight%) 73.7% Al, 11.6% Si, 6.06% Fe, 2.5% Cu, 1.8% Zn, and trace elements (Ca, Ti, Mn, Cr, K, Ni, Cl, Pb, and Ba).

Figure 7 - Chemical Analysis of Clone Body Using X-Ray Fluorescence Spectrometer

A quick check with a magnet on the clone and the FM-31 indicates magnetic attraction only to the clone's mirror compartment door and the screws holding the stage to the body, but none to the main body of the clone. The FM-31, including its screws, showed none. The body of the FM-31 illuminator housing was attraction-free, except for its screws which were not. The clone's LED illuminator, except for its screws, was also attraction free. Thus, other than its folded optics cover and screws, the clone should show strong corrosion resistance. If left unpainted, however, the inside of the mirror housing cover will likely develop significant rust.

The eyepiece of the clone can be removed by loosening the small set screw holding it in; a small 1.8 X 40mm flat-tip screwdriver seems just about right. The eyepiece is standard size so other manufacturer's

Figure 8 - Clone Eyepiece

Figure 9 - Clone with Original Eyepiece Removed and Other Manufacturer's Eyepiece in its Place

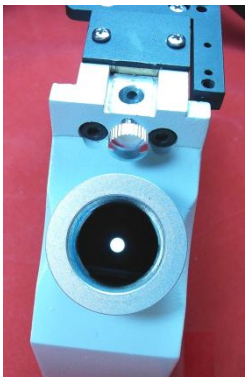

Figure 10 - View Through Eyepiece Tube with Eyepiece Removed

eyepieces can be used in place of the clone's. The authors have successfully used 12.5x and 15x eyepieces. With the eyepiece removed light through an objective can be seen on the mirror below the eyepiece housing. When inserting an eyepiece care should be taken not to handle the tubular section below the top ring as that area is covered with a light grease to facilitate the raising and lowering of the eyepiece housing.

Possibly the most significant question, however, is how do these models compare optically. To check this a variety of subjects including material from plants, insects, larger animals, humans, and inanimate objects were examined on both instruments under differing powers.

The two photographs immediately below, although not quite as sharp as a visual view, were taken through the clone at the 100X magnification, showing Lily pollen and fresh water protozoa. Optically the original and clone systems are not quite comparable. Our results show that the clone displays reasonable quality, although the field is far from being flat (see Figures 11, 12 and 13). At the common objective magnifications of 4x and 10x both instruments provide bright images with good contrast. The original FM-31 proved better in most areas, in particular, seeming to have the advantage across the full field of view. Although the optical differences may be due to sampling variation, we found similar optical results with two clones

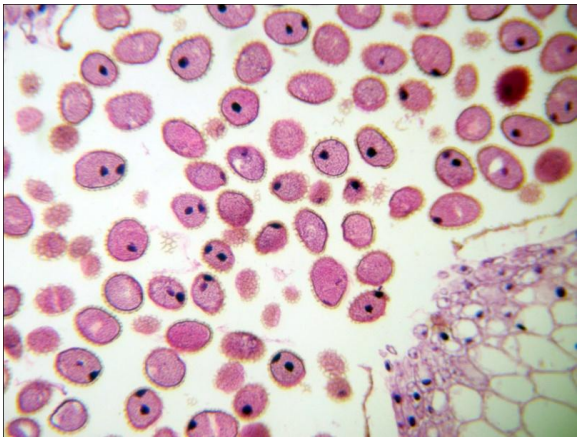

Figure 11 - Lily Pollen

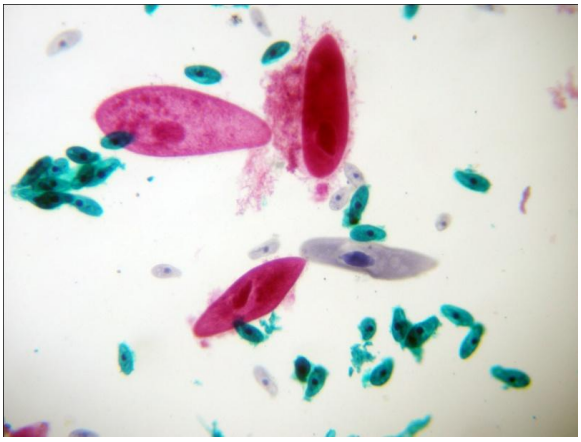

Figure 12 - Fresh Water Protozoa

Conclusion: The low cost clone discussed above while not as finely finished as the FM-31 can with modest changes, e.g., paint to the interior of the mirror housing cover and sealing of the tripod socket, function mechanically almost as well as the original FM-31. The original FM-31 had a more flexible focusing system, although the clone's focusing system is a bit more stable and easier to use. The photo on the right, slightly adjusted in Photoshop, is of an older Tilia stem taken through the clone's optical system, i.e., 10x eyepiece and 10x objective using a blue filter from the original FM-31's illuminator. The clone's optics while seemingly not as capable as the original FM-31, demonstrate adequate central focus, resolution, brightness and contrast acceptable for most field work, making it a reasonably low-cost alternative to the original except, perhaps, in more demanding situations. Thus, a low-cost FM-31 clone is now probably the most cost-effective solution for a field portable microscope, with the caveats noted above.

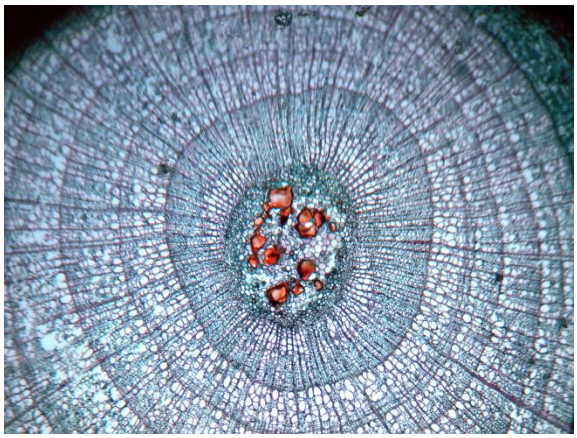

Figure 13 - Photo Through Clone's Optical System using its 10X eyepiece and 10X objective.

Bottom-line: In the opinion of the authors, it would appear that if the folded optics cover and screws were replaced, the opening to the environment sealed, and the profit per unit reduced (possible with larger scale production), this low cost clone might be price competitive and as useful in the field as the planned Millennium Health Microscope [7]. Perhaps, even more to the point, the clone is available now, with accessories, and its predecessor has been field tested and proven in a variety of environments.

The authors would appreciate any suggestions for corrections, improvement, or expansion. In particular, any further information on the history of the original Swift FM-31 would be appreciated. They can be can be contacted at,

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