The Tiyoda MKH Japanese Army Field Microscope of WW-II, and Notes on the Tiyoda Optical Co.

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Introduction

This is the third article about the Tiyoda MKH field microscope to appear in ***Micscape***. Earlier articles by Jay Stanley (2006) (article) and Manuel del Cerro (2008) (article) introduced us to this instrument. Since obtaining my own MKH, I have researched its history and can add to their accounts. This article traces the origin of the design to 1927 as the Reichert Heimdal microscope; subsequent licensing of the design from Reichert by the Japanese military; and evolution of the design through three successive Japanese versions. The final version, benefiting from in-the-field experience during World War II, has a number of improvements to the original Heimdal design. My own MKH has its original paperwork, and I've included copies with English translation for MKH owners who are missing those items. Finally, the article considers methods of determining the age of Tiyoda microscopes. A graph of date *vs.* serial number is provided for microscopes that are missing their documentation. A second dating method translates the Showa Imperial date found on factory inspection stamps.

Figure 1. *A family portrait of four of the author's Tiyoda microscopes.* ***A:*** *Tiyoda Model L (serial 30501), a 1950s duplication of the 1930s Zeiss L-stand, whose specifications were provided to Tiyoda by Zeiss during World War II. The trinocular head is Tiyoda's own design.* ***B:*** *Tiyoda Model B (serial 38950), a 1950s duplication of the 1930s Zeiss E-Stand; specifications provided by Zeiss.* ***C:*** *The large folding microscope of Tiyoda's own design, called Model MKQ through World War II, and Model Q after the war (serial 55161).* ***D:*** *The small folding microscope Model MKH, a design licensed from Reichert and modified by Tiyoda (serial 14585).* ***E*** *and* ***F*** *show C and D in folded position. The two portable microscopes open into 160mm tube length instruments that use standard optics. The MKH is half the weight of the MKQ, and folds to half the size. Zoom in for a more detailed view.*

Figure 2. *The MKH microscope kit is remarkably compact and portable for a nearly full-size instrument. Tiyoda employees nicknamed it the "Bento" for the similarity of the highly organized storage case to a Japanese bento lunchbox ("History of Tiyoda Microscopes" website). The instruction sheet lists (in Japanese) the kit components: 5x eyepiece,10x eyepiece, 10x objective lens, 40x objective lens, 90x oil immersion objective lens, cedar oil bottle, xylene bottle, blue glass filter. The inspection stamp in the lid has a Showa Imperial date of Year 19 (1944). This Third Version MKH (author's scope) is shown in its original configuration; it lacks only the original blue filter and an outer canvas case. The kit in its hard case is 5.1 x 7 x 2.5 inches (130 x 180 x 63 mm). The kit with a substitute outer soft case, four additional lenses, neutral density filters, and polarization filters weighs 5 pounds (2.27 kg).*

Portable Microscopes

Before tracing the development of the MKH, I would like to put it into context, and explain why I think it ranks with the best of the portable microscopes and is a candidate for continued use today. A wide range of portable microscopes have been brought to market over the years; Mike Dingley illustrates several in his 1997 ***Micscape*** article. The smallest portables have limited functionality. Many users favor a folded-light-path design as the best balance between small size and functionality. This category includes the McArthur (Bruce, 1995; Dingley, 2002; microscope-antiques.com), Nikon H (Amos, 1997; Guida, 2009), Chinese Army TWX-1 (Kreindler and Goren, 2011a; Mach six part article), and Swift FM-31 (Kreindler and Goren, 2011b). Like the MKH, these are all out of production and only available second hand, although FM-31 copies are available new. These folded-light-path instruments are the best choices for many field applications, but they still have compromises. With rare exception, each accepts only the few lenses specifically designed for it. From an ergonomic point of view, they are convenient for short work sessions, but are not comfortable for multiple hours at the eyepiece. The MKH is the next step up from the folded-light-path design; it is more versatile and more comfortable to use at the cost of increased size and weight (Figure 3). The MKH accepts most of the 160mm tube length lenses made in the last 100 plus years; as we shall see, this versatility was one of its design goals.

Figure 3. *A 1944 Tiyoda MKH and a 1981 Swift FM-31. The MKH is larger and heavier, but is easier and more comfortable to use. It accepts interchangeable optics like this "no cover" objective that is a mainstay of the author's field work – just one example of a lens not available for folded-light-path designs.*

Tiyoda Corporate History

Early History. Tiyoda has a number of "firsts" in Japanese microscope history: first commercial Japanese microscope in 1914, first commercial Japanese phase microscope in 1949, and one of the early Japanese fluorescence microscopes in 1954. The company began in 1912 with the name "M-Katera", a contraction of the founders' names: **M**atsumoto, **Ka**ndo, and **Tera**da. Terada was the optical engineer; in 1920 he also designed the first microscopes for the newly formed Olympus Corporation (*History of Olympus* website). In 1934, M-Katera was renamed Tiyoda. With an eye on the export market, products were labeled in Western script as "Tiyoda" rather than 千代田.

World War II and the Zeiss Connection. Tiyoda was the major supplier of field hospital microscopes to the Japanese military with its large portable MKQ and small portable MKH. Even before WW-II, Tiyoda followed Zeiss's lead, producing many designs that looked like Zeiss instruments. A high-level political decision during WW-II that promoted German-Japanese co-operation gave Tiyoda access to Zeiss technical data. Zeiss wasn't happy about this, but had no choice. After the war, Tiyoda incorporated these designs into their product line (Figure 1A, B). James Soliday (2005) relates this same story in a microscope blog. His source of information is probably the same as mine: personal discussions in the 1970s with the US importer of Tiyoda products (Technical Instruments of San Francisco) who had both Tiyoda and Zeiss connections. Tiyoda microscopes of the 1950s are close enough to their Zeiss counterparts to provide repair parts for old Zeiss instruments. Tiyoda mechanical workmanship was excellent, and a few aspects even improved on Zeiss. For example, the arm of my 1950s Model B (retired from the San Francisco Medical School) is phosphor bronze, which is more stable than brass. Beating ship propellers into microscopes is even better, from my point of view, than beating swords into plowshares. Glass is a different matter. WW-II Tiyoda optics are professional grade, but don't stand out from the crowd. Contrast isn't great; fields are neither flat nor wide. Objectives are approximately parfocal. Later Tiyoda optics are of excellent modern design. Replacing 1940s optics with 1970s Tiyoda optics is a good way to update an old stand.

Later History. Tiyoda remained a small manufacturer after World War II. As its competitors – Nikon and Olympus – scaled up production to supply the world with microscopes, Tiyoda continued making about 108 microscopes per month (based on serial numbers; see below). That business model was not sustainable, and in 1976 the parent company, medical technology manufacturer Sakura Finetek, shut down microscope production. Tiyoda exists today as a manufacturing arm of Sakura Finetek. The *History of Tiyoda Microscopes* website of retired Tiyoda employee Shiraishi Kazuharu illustrates instruments produced through the firm's 62 years of microscope manufacture. The former US importer, Technical Instruments, still sells odds and ends of Tiyoda microscope products on its eBay site as "new old-stock".

Friedrich Kurt Reinsch and the 1927 Reichert Heimdal Microscope

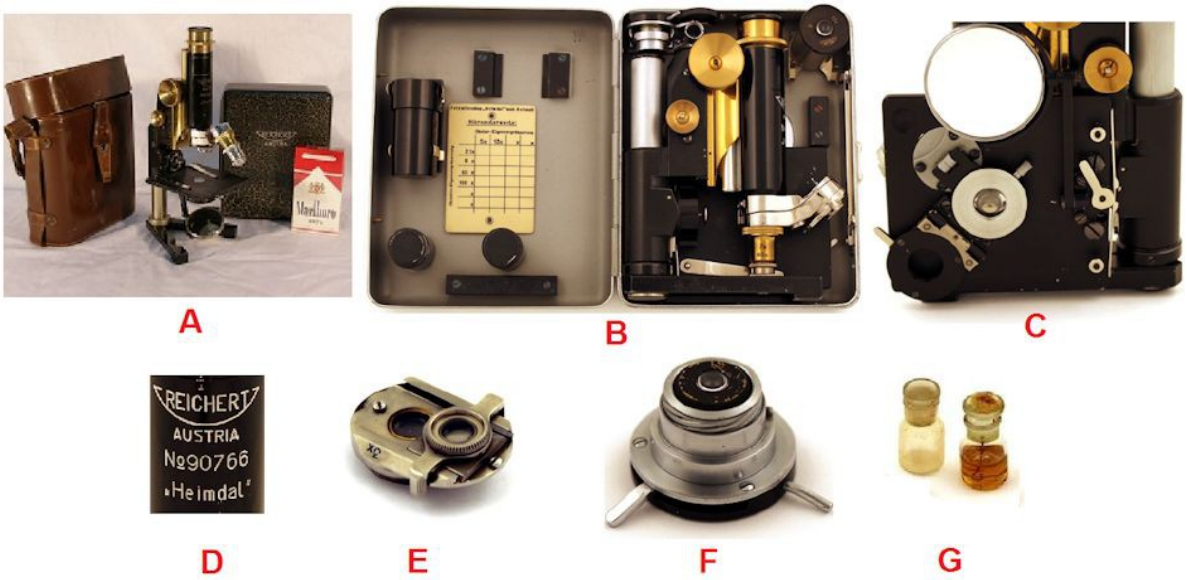


Figure 4. *Reichert Heimdal field microscope: the model for the MKH.* ***A.*** *Outer and inner cases.* ***B.*** *Folded and stored in the case.* ***C.*** *Substage showing: pre-focused fold-out Abbe condenser; fold-out iris diaphragm; stage lock lever; swinging tailpiece with mirror.* ***D.*** *Tube markings.* ***E.*** *Divisible objective 3.5x and 8x.* ***F.*** *Accessory dark field condenser.* ***G.*** *Immersion oil and solvent bottles. Source of images:* ***A:*** *Batyrbek. Kazakhstan auction photo, 2010 of No. 99981.* ***B-G:*** *Timo Mappes website images of No. 90766.*

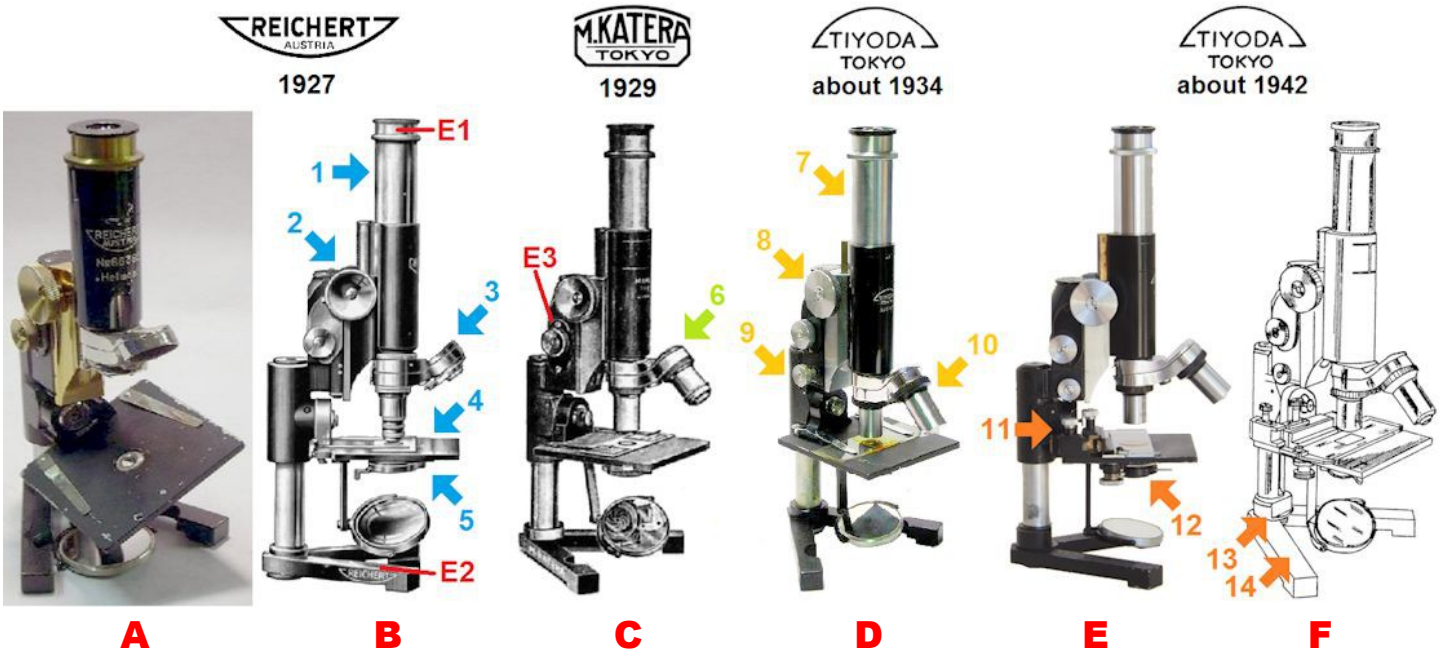


Figure 5. *The Reichert Heimdal and its evolution through three successive Tiyoda MKH versions. Arrows point to distinguishing details mentioned in the text. E1, E2, and E3 are errors (inaccuracies) in the drawings that should not be taken as evidence of model differences.* ***A.*** *Early Heimdal 86385 (auction site photo).* ***B.*** *Heimdal drawing from Reichert product catalog.* ***C.*** *First Version M-Katera MKH ("History of Tiyoda Microscopes" website).* ***D.*** *Second Version Tiyoda MKH (Leitzmuseum.org).* ***E.*** *Third Version Tiyoda MKH (author's scope).* ***F.*** *Third Version Tiyoda MKH (instruction sheet drawing). MKH versions are successive generations; they were not produced concurrently.*

The design of the Tiyoda MKH microscope originated with Friedrich Kurt Reinsch, a German microbiologist (biographies at Müller 1999, German Wikipedia, and Timo Mappes website). Reinsch was not satisfied with available portable microscopes, so he built a prototype of his own design that he used in Iceland in 1925. After an initial field season, he became associated with Reichert in Vienna where he finalized the design of the Heimdal portable microscope, named for the Norse god of heightened senses. In a 1927 publication, Reinsch described his design goals for the Heimdal:

- Standard interchangeable optics provide flexibility, and make the best quality lenses available.
- No loose parts to drop or misplace.
- Setting up requires no assembly or screwing together of threaded parts. Parts slide or rotate and click into place.
- Minimal size and weight, but still operates in a familiar manner and performs the functions of a full size microscope.

Reinsch died in 1927 while his paper was in press, and before the Heimdal was released for sale. Following the Heimdal's introduction, favorable reviews appeared in German and Austrian scientific journals, but it was little noticed in English language publications. Fifty years after its introduction, the Heimdal was described by D. B. Payne (1977), who mentions some of its specialty accessories – polarization, attachable mechanical stage, attachable dark-field condenser.

The Heimdal kit (Figure 4A) consists of the microscope, an inner metal case, and an outer leather cover resembling a binocular case. The metal case (Figure 4B) holds the microscope, its lenses, and two small bottles for immersion oil and solvent (Figure 4G). The best illustrations of a Heimdal kit are on Timo Mappes' Heimdal web page.

Other authors have already described the Reichert Heimdal and the Tiyoda MKH, so in this article I will skip the basic description and concentrate on differences between the successive models. Figure 5 summarizes evolutionary changes between the Heimdal and the MKHs that followed it; this figure serves as an "index map" for items mentioned in the text.

Style and Finish. The 1927 Heimdal stand is black with bright lacquered brass (Figure 5 arrow 1) and nickel highlights (Figures 4, 5A). Focus knobs are concave with scooped-out centers and knurled rims (Figure 5 arrow 2). Over all, the styling is a little old-fashioned for 1927, compared to the sleek trend-setting Zeiss microscopes of the same time period.

Objectives (Figure 5 arrow 3). The Heimdal has a two position objective turret; this is fewer positions than desired, but it allows the scope to fold flat. Any standard objective lens can be used, but three were usually provided: a divisible low power lens giving 3.5x and 8x, a 60x high dry, and a 100x oil immersion. These are paired with 5x and 13x eyepieces. The divisible objective (Figure 4E) is an optical compromise with two practical advantages. It gives an effective three lenses on the two position turret, and its small size allows it to remain attached when the microscope is packed for storage. A cut-out in the base provides clearance for the long 60x objective, so it also remains attached. Without the need to attach and remove objectives (one of Reinsch's design goals), the microscope can be quickly set up and packed away.

Stage (Figure 5 arrow 4). The stage is plain, with captive stage clips. An optional attachable mechanical stage was available for the Heimdal. It did not fit in the hard case, and had to be carried separately.

Substage (Figure 5 arrow 5). The Heimdal has a unique condenser. It is an Abbe condenser, but the lens and iris are on hinges and swing out of the way when not needed (Figure 4C). This design results from one of Reinsch's criteria: no loose parts to drop or lose. The condenser is pre-focused for standard slide thickness.

Reinsch designed the Heimdal for his own research in fresh water microbiology. It is a high-quality and adaptable portable microscope for biological research that can be used at the sample site. The manufacturer, Reichert, had greater plans for the Heimdal, intending from the start for it to be used as a military medical field microscope.

First Version MKH (M-Katera Brand) of 1929

Helen Purtle writes in the Billings Microscope Catalog (1974, page 113):

> *"Reichert established his business in 1876, and in 1930 introduced a small portable microscope that he supplied to the Japanese Army. The latter instruments were marked as if Japanese made, but it is not known if Reichert established a factory in Japan."*

This bit of industry gossip is not documented; did she know, or did she assume that Reichert made a deal with the Japanese military? She thought Reichert might have done the actual manufacturing of the MKH, but we know that is not the case, at least for the Tiyoda-branded production. Accepting Purtle's statement, it appears that the Japanese military licensed the Heimdal design from Reichert, who was actively marketing it for just that purpose, and assigned the license to Tiyoda for production. Purtle's 1930 date should be 1929 according to the *History of Tiyoda Microscopes* website. In 1929, Tiyoda was still known as "M-Katera", and microscope model names began with "MK". The "H" is for "Heimdal", so the model designation "MKH" signifies "The M-Katera Heimdal".

This First Version MKH is something of a mystery. Little is known about it beyond the catalog line drawing in Figure 6 (this is a larger representation of Figure 5C). It has not been found documented in museum collections, and copies have not turned up in auction listings. Figure 6 is basically identical to the Heimdal, and its styling is quite different from other M-Katera microscopes produced at the same time. It is possible this First Version MKH was an actual Heimdal manufactured by Reichert, as Purtle (1974) suggests, but I doubt it. It is more likely that M-Katera simply stayed close to the original design on this first MKH. Focus knobs are in the Heimdal style. Whether the finish was bright brass like the Heimdal or nickel like later MKHs can't be determined from the drawing with certainty, but the tube in Figure 6 has darker tones than the nosepiece, suggesting a brass tube. The First Version MKH differs from the Heimdal in two ways: it bears the M-Katera name, and M-Katera eyepieces and objectives replace Reichert products (Figure 5, arrow 6). Lenses have the styling M-Katera used at the time. The stage and substage are unchanged from the Heimdal. Storage cases and accessories are not illustrated, and remain unknown.

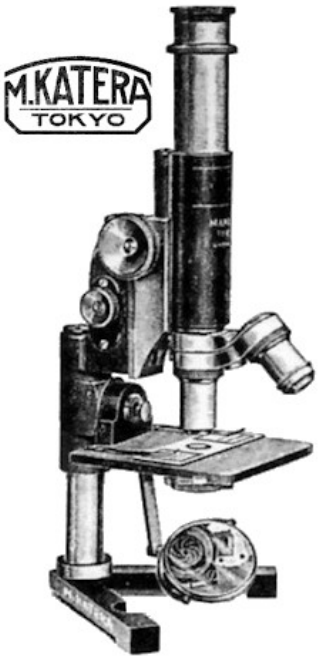


Figure 6. *First Version MKH. Made 1929-1934 (from History of Tiyoda Microscopes website).*

This First Version MKH has a range of objectives suitable for medical use, and it has already taken a small step away from Reinsch's 1927 criteria. The stand is unchanged from the Heimdal, but now an objective must be removed when packing the scope into its box. This slows use of the microscope a little, because "some assembly is required".

Second Version MKH (Tiyoda Brand)

Figure 7. *Second Version MKH, produced intermittently from approximately 1934 to 1942.* ***A.*** *Outer soft case and inner hard case.* ***B.*** *Microscope in its hard case. The inspection stamp in the lid has a Showa Imperial date of 17-4 (April 1942).* ***C.*** *Substage condenser is the same as the Heimdal. The stage lock lever is gone; this function was moved to the side of the scope.* ***D.*** *Plain stage with clips. Condenser and iris diaphragm are hanging down for the benefit of this photo; they are not normally left in this position.* ***E.*** *Tube inscription.* ***F.*** *Blue filter in bayonet housing.* ***G.*** *Inscription on the top of the arm.* ***H.*** *90x immersion lens with immersion oil and solvent bottles. Source of images:* ***A, C, G:*** *May 2009 eBay auction photos of No. 9299.* ***B, E, F:*** *July 2010 eBay auction photos of No. 8783.* ***D:*** *May 2014 photo on Turkish auction site Sahibinden of No. 9329.* ***H:*** *Leitzmuseum.org images of No. 8747.*

In the early 1930s the M-Katera company changed its name to Tiyoda, and the MKH microscope received a face lift to bring its styling into line with other Tiyoda products. Already recognizing the inconvenience of the small MKH stand for some uses, Tiyoda introduced a larger MKQ portable microscope (Figure 1C). The MKH and the MKQ were in use concurrently, with the MKH better suited to mobile use, and the MKQ providing more convenient operation at established locations where its greater size and weight were not a handicap. Many copies of the Second Version MKH exist, so it is well documented. It can be summed up as optically like the First Version MKH, with styling changes to the stand.

Stand. Where the Heimdal has bright brass finish, the MKH has nickel plating (Figure 5, arrow 7). The focus knobs (Figure 5, arrow 8) are redesigned to follow contemporary Zeiss styling as used on other Tiyoda products. The stage tilt lock changed from a cam lever under the stage to a clamping wheel below the fine focus (Figure 5, arrow 9); this is a small design change that improves access and use of the locking mechanism. The stage and substage retain the original Heimdal design. The cutout in the feet – originally designed to stow the Heimdal's long 60x objective – is retained, even though the shorter 10x objective that occupies that position on the Tiyoda MKH does not need it.

Optics. Tiyoda objectives (Figure 5, arrow 10) are updated from the older M-Katera objectives; they follow Zeiss styling. The microscope has 10x, 40x, and 90x achromatic objectives; 5x and 10x Huygenian eyepieces. The Abbe condenser is still the original Heimdal design. The Heimdal's dark field condenser was not used.

Immersion Oil. The MKH has small vials for cedarwood immersion oil and xylol (ie: xylene) solvent (Figure 7H). These are the cutest little things, well suited to a doll house science lab, but not practical in a medical microscope environment where larger bottles can easily be used. Most MKH kits have as-new vials that never contained oil or solvent.

Patent Number. The same patent number 214050 is inscribed on the MKH (Figure 7G) and the MKQ large portable. Both have a tilting stage. The contemporary Tiyoda MKR portable has a fixed stage and does not have the patent number. One can conclude that the patent refers to the stage tilting mechanism.

Storage Cases. The MKH aluminum storage case (Figure 7A, B) is 10% larger by volume than the Heimdal case, being shorter, but wider and thicker. The MKH case and latch are more robust than the Heimdal case, as one would expect of military equipment. Two tubes hold the 40x and 90x objective storage cans. A slightly smaller tube in the upper right hand corner of the case holds the 10x eyepiece (Figure 7B). Immersion oil and solvent vials fit into spring-cushioned tubes closed by metal caps marked "C" (cedarwood oil) and "X" (xylol). The Second Version case has the Tiyoda logo printed on the outside of the lid (Figure 7A). The outer soft case is canvas with a maroon synthetic leather covering.

Serial Numbers and Production Dates. A limited sample size of 11 Second Version MKHs, mostly ebay auctions, have serial numbers from 7601 to 9397. This is about 18 months of production from early 1941 to mid 1942. Dating methods are discussed later in this article. This sampling of Second Version MKHs doesn't include examples from the early years of production; the search continues for additional examples.

A Break in Production?

The MKH seems to have been produced in batches, rather than continuously. Serial numbers cluster. There is a gap in serial numbers from 9397 (Second Version) to serial number 14050 (Third Version). This serial number gap is probably a break in production of the MKH. The apparent size of the gap is probably inflated due to inadequate samples through that time interval.

Third Version MKH (Tiyoda Brand)

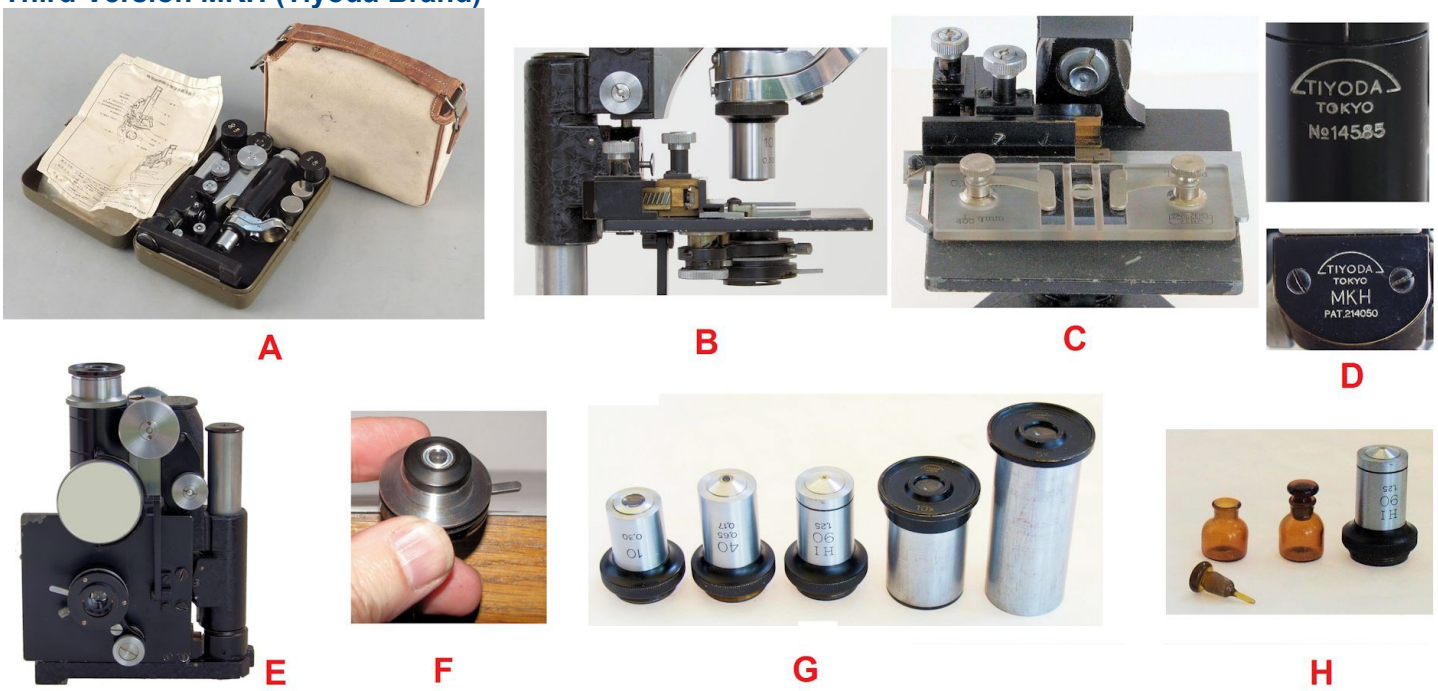


Figure 8. *Third Version MKH, produced from late 1942 or early 1943 to 1945.* ***A.*** *Kit with outer and inner cases. One improvement was the inclusion of an instruction sheet.* ***B.*** *Closeup showing the two design changes in this version: the mechanical stage and the revised focusing condenser.* ***C.*** *Mechanical stage seen from the front with a Zeiss hemacytometer.* ***D.*** *Markings on the tube and the top of the arm. These are the same as on the Second Version MKH.* ***E.*** *Substage showing the revised condenser and its helical "quick acting screw" focus.* ***F.*** *Condenser removed from the substage.* ***G.*** *Lenses included with the kit.* ***H.*** *Immersion oil and solvent bottles. Source of photos:* ***A:*** *March 2014 auction photo, Susanin's Auctioneers.* ***B-H:*** *author's scope No.14585.*

A second round of design changes in late 1942 or early 1943 improved two aspects of the Heimdal design and brought the MKH more into line with standard microscope design: stage clips were replaced by a built-in mechanical stage, and the condenser was changed to a conventional focusing design. MKH microscopes illustrated in previous ***Micscape*** articles by Jay Stanley and Manuel del Cerro are both Third Version models with a mechanical stage and the revised substage. Figure 2 shows an overview of a Third Version MKH kit; Figure 8 has some detail views.

Mechanical Stage. The built-in rack-and-pinion mechanical stage (Figure 5, arrow 11 and Figure 8B, C) is a valuable addition for any work involving systematic scanning or counting; it makes the Third Version MKH the most desirable version for continued use. The mechanism does not increase the size of the microscope or its storage case, but to maintain a compact size, geared movement is limited (Figure 9). Limited movement is compensated by a sliding dovetail that acts as a coarse adjustment to set the location of the X-axis geared travel. Any portion of the slide's 76 mm width can be brought within range of the geared movements. The slide carrier can be removed to provide a clear stage top.

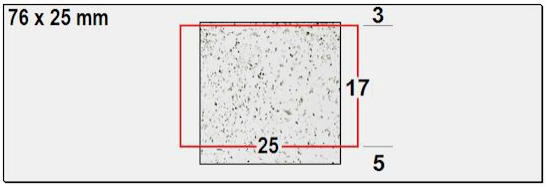


Figure 9. *The red rectangle marks the 25 x 17 mm adjustment range of the mechanical stage relative to a centered 20 mm square cover slip.*

Figure 8C shows the mechanical stage in use with a Zeiss hemacytometer (blood cell counter) of a style contemporary with the microscope. Blood counts were a major application of medical field microscopes during WW-II, and the MKH stage size and range of movements handle this job nicely.

The mechanical stage has no scales, so it does not serve as an object locater. A home-made Maltwood-style finder could be used if you need this function. Two white marks on the Y-axis are aligned before folding the microscope so the mechanical stage doesn't hit the frame. A mechanical stage was available for the Reichert Heimdal, but it was carried separately and attached before use. F. K. Reinsch would have approved of this modification to his Heimdal design.

Condenser. A focusing sub-stage Abbe condenser of conventional design replaced the Heimdal fold-out condenser (Figure 5, arrow 12 and Figures 8B, 8E). The new condenser can be used whole, its top lens screws off, and the entire condenser can be removed. The condenser has a standard design, but a non-standard size, and interchangeable substitutes are not available. F. K. Reinsch probably would **not** have approved of this change; it violates his design goal that no parts be detachable. Medical microscopes don't need low magnifications, and in practice, there is no need to remove the condenser or its top lens. Condenser focus is added via a reliable old design: a helical "quick acting screw" (Fig. 8B).

Stand Changes. The base of the pillar was flattened (Figure 5, arrow 13) to provide clearance for the mechanical stage. The circular cutout in the feet was omitted (Figure 5, arrow 14); this docking station for the Heimdal's long 60x objective had not been needed for some time.

Tripod Socket. The Heimdal had a tripod socket under the removable rear foot pad; this feature was retained in the MKH (Figure 10). The socket allows the microscope to be attached to a tripod, or clamped to a table. The screw size, unfortunately, falls between the modern tripod standards of 1/4 inch or 3/8 inch, so a custom screw is necessary to use this feature. Payne (1977) calls it a "standard continental pre-war camera thread."

Storage Cases. The Third Version hard case has the same dimensions as the Second Version case, but differs in a few details; compare Figures 2 and 7. The 10x eyepiece storage tube moved; the support piece inside the lid changed; and the Tiyoda logo was omitted. The soft outer case material also changed to a more durable canvas (Figure 8A).

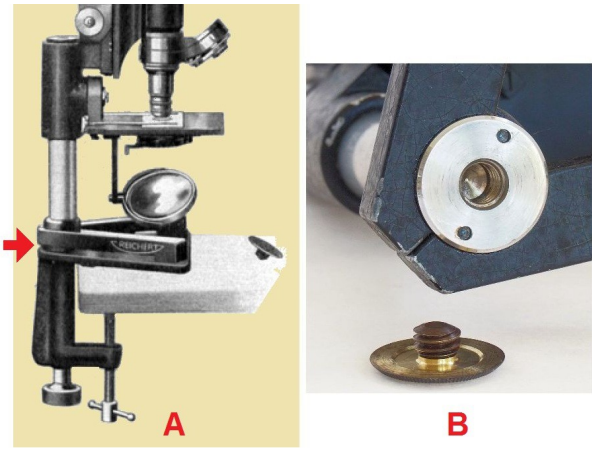


Figure 10. *Tripod mount.* ***A.*** *Heimdal on a table mount C-clamp. (modified from a Reichert advertising image via Timo Mappes website).* ***B.*** *Third Version MKH tripod socket (author's scope).*

Late-War and Early Post-War Mash-Ups: A Confusing Mix

Figure 11. *Anomalous combinations of mixed parts: late-war and early post-war mash-ups.* ***A.*** *Microscope with no serial number and with mis-matched cases (April 2014 eBay auction photo.)* ***B.*** *Tiyoda post-war factory image illustrates a microscope without logo or serial number on the tube (History of Tiyoda Microscopes website).* ***C.*** *Third Version microscope serial 14611 with a Second Version foot and Second Version case (Facebook "Portable Microscopes" page).* ***D.*** *A post-WW-II MKH in a wooden case, serial 25392 (March 2011 eBay auction photo.)* ***E.*** *"Kyowa portable" illustrated by Jay Stanley (2006) is probably a Tiyoda unmarked frame with Kyowa-branded lenses attached.*

Toward the end of World War II, and for a while after the war, a number of one-off assemblies of mixed parts were made. At this time, the Tiyoda factory was operating from a temporary site 100 miles from Tokyo (Sakura Seiki history). MKH production nominally stopped at the end of World War II, but a few were assembled after the war from parts on hand.

No Serial Number. Figures 11A and 11B show MKH microscopes with no logo on the tube, and no serial number.

Mixed And Recycled Parts. Figure 11A shows a Third Version stand and hard case combined with a Second Version soft case. The microscope appears to be new, but the hard case is beat up and looks recycled. Figure 11C is a Third Version MKH that has a Second Version base (cut-outs to stow objective), and a Second Version hard case. Some of this mixing could be a scrambling of components during use; it might be no more than putting a microscope in the wrong case. Figure 11C could represent a repair job using salvaged parts, or it could be the factory utilizing old parts on hand.

Wooden Cased Example. A microscope (Figure 11D) sold on eBay in March, 2011 is a Third Version MKH with serial number 25392, correlating to completion in 1949 (see below). A "Made In Occupied Japan" label was required on exports at that time; the absence of the label indicates the scope was intended for sale in Japan. This scope has an unusual wooden case resembling a scaled-down Model Q case. The auction description says it was purchased by an American soldier stationed in Japan after WW-II. This looks like a scope finished from parts on hand, and placed in a substitute case because the metal cases were no longer available.

"Kyowa Portable". This microscope (Figure 11E) was previously illustrated in ***Micscape*** by Jay Stanley (2006); his website source identified it as a Kyowa portable. It looks identical to a Third Version Tiyoda MKH, leading Stanley to suggest that it was made by the same manufacturer (ie: Tiyoda). In fact, nothing visible in the illustration identifies the stand as Kyowa; it looks like another Third Version Tiyoda MKH without markings, as in Figures 11A and 11B. My guess is that this is an unmarked Tiyoda stand to which someone added Kyowa-branded eyepieces and/or objectives.

Determining the Date of Manufacture of Tiyoda Microscopes

Japanese Dates. The traditional Japanese calendar uses Imperial Eras that count the years of an emperor's reign. Years are the same as Western calendar years, but they are named differently. Tiyoda microscope production falls in the Showa Era of Emperor Hirohito, which ran from 1926 to 1989. The formula for conversion is:

Showa year + 1925 = Western Common Era year

Tiyoda documentation uses Western-style dates on microscopes intended for export, and Imperial dates on microscopes intended for sale within Japan. Receipt slips for sales within Japan tend to have Imperial dates. Microscopes made for the Japanese military have Imperial dates.

Script Variation. Documents can be written in several ways, including: Western characters left-to-right, Japanese modern characters left-to-right, or Japanese traditional characters right-to-left. MKH microscope documentation uses all three styles.

Serial Numbers. Various models of Tiyoda microscope share a single series of serial numbers that began in 1934 with the renaming of the company, and continued until microscope production ended in 1976. Figure 12 summarizes my on-line research of Tiyoda microscopes. Knowing the serial number of your microscope, you can pick its year of manufacture off the graph. This is a work in progress; the graph will change as more data become available. 1942 and 1943 are a problem. The rate of production is twice other time intervals. It is reasonable that the wartime production rate would be higher, but I wonder if sometimes the factory might have used an old inspection stamp whose date had passed, making a longer time interval appear to have been a shorter interval. Additional data points are needed.

Figure 12 is useful for microscopes that have a serial number, but no documentation. Some microscopes, however, have an associated factory inspection date that can be read directly.

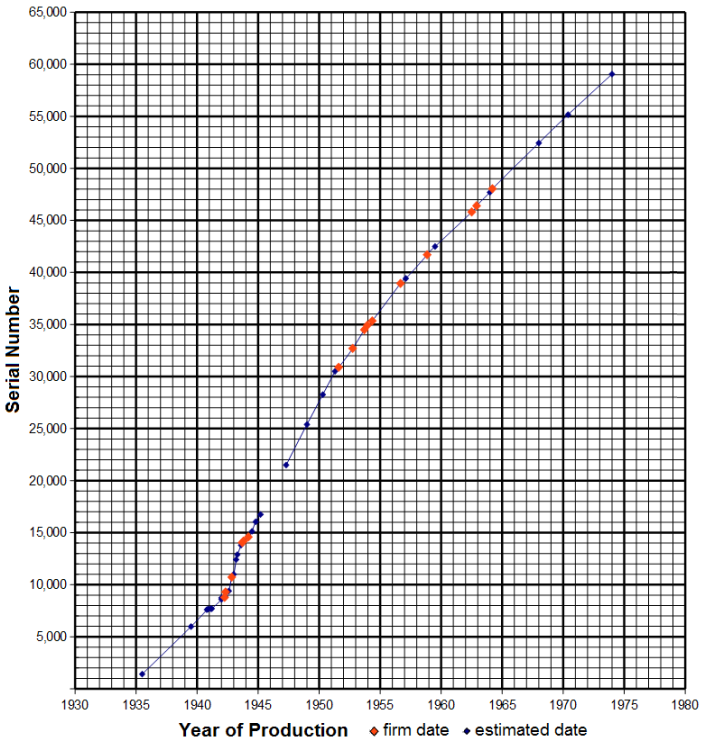
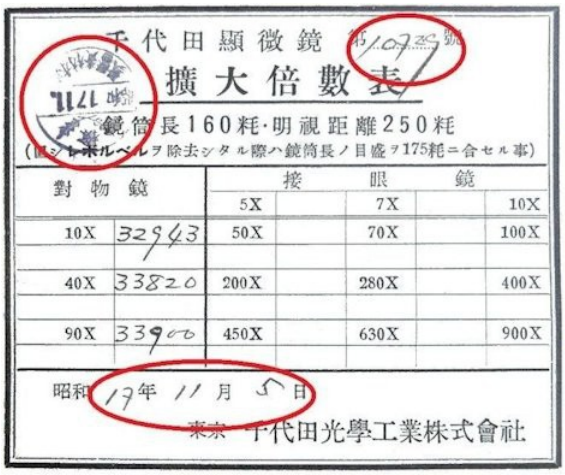


Figure 12. *Year of production of Tiyoda microscopes (all models). "Serial 1" projects to 1934, when M-Katera changed its name to Tiyoda. A pause in production at the end of World War II lasted less than one year; the larger gap on the chart is due to a lack of examples. Tiyoda microscope production ended in 1976.*



Year	Showa Imperial Date	Script (right to left)
1929	4 Year	年 四
1930	5 Year	年 五
1931	6 Year	年 六
1932	7 Year	年 七
1933	8 Year	年 八
1934	9 Year	年 九
1935	10 Year	年 拾
1936	11 Year	年 一拾
1937	12 Year	年 二拾
1938	13 Year	年 三拾
1939	14 Year	年 四拾
1940	15 Year	年 五拾
1941	16 Year	年 六拾
1942	17 Year	年 七拾
1943	18 Year	年 八拾
1944	19 Year	年 九拾
1945	20 Year	年 拾二
1946	21 Year	年一拾二

A **B** **C** **D**

Figure 13. *Inspection dates.* ***A.*** *"Table of Magnifications" card. In this example, Tiyoda microscope No. 10729 passed factory inspection on Showa 17-11-5 (November 5, 1942). A circular inspection stamp on the card repeats the year and month.* ***B.*** *Circular inspection stamp from Second Version MKH No. 8783. Showa Imperial date is 17-4 (April, 1942).* ***C.*** *Oval inspection stamp from Third Version MKH No. 14585, and its English translation. "Showa year 19" is 1944. The stylized "AAA" probably means "first quality".* ***D.*** *Table of MKH production years. Source of images:* ***A.*** *July 2014 eBay auction of a Tiyoda MKR.* ***B.*** *July 2010 eBay auction.* ***C.*** *Author's scope.*

Best Information: Year, Month, Sometimes Day. "Table of Magnifications" cards (Figure 13A) identify model, serial number, and date of factory inspection. It is necessary to distinguish Showa dates from Western dates. These cards provide good information for the post-war years, but they are often missing. During the war years, the cards were usually left blank; one can conclude that the number of microscopes produced per month was a war-time military state secret.

The card shown in Figure 13A is something of a Rosetta Stone as it contains the same date in two formats. It demonstrates that numbers on the circular inspection stamp are Showa year and month. This card is unusual for having serial number and date filled in; most wartime production leaves the card blank. A translation of the "Table of Magnifications" card is provided in the supplemental files that accompany this article (link at end of article).

Circular inspection stamps (Figure 13B) provide nearly complete information. They give a Showa year and month in Western script written left-to-right. The circular inspection stamp is commonly found on Second Version MKH cases. On-line photographs of MKH kits usually show frustratingly fuzzy images of this stamp that can't be read; Figures 13A and 13B are better than average examples.

Second Best Information: Year Only. Third Version MKH microscopes have an oval inspection stamp (Figure 13C) that contains a Showa year. These stamps have been seen with 1943 and 1944 dates; 1942 and 1945 are also possible. This stamp is written right-to-left in pre-WWII kanji characters. **10** is the old-style 拾 rather than the 十 used on the instruction sheet. Figure 13D translates Japanese script to Showa year, and then to Western Common Era year. With this table, MKH owners can date their microscope using either a round or oval style inspection stamp.

The Rest: Estimated Dates. Many microscopes have been separated from their documentation and provide only a serial number; microscopes in this category were incorporated into Figure 12 using the following constraints:

1. The estimated date falls along the extrapolated curve defined by the firm dates.
2. The date is within the time interval when that model microscope was in production.
3. The curve projects back to 1934 for its origin.
4. The curve projects to an endpoint in 1976.

If you have one of the end-of-war mash-ups that have neither serial number nor documentation, the best you can do is assign the microscope a date range from 1945 to 1950, and if the scope shows signs of wartime use, probably 1945.

Data Mining. Figure 12 allows us to measure rates of microscope production by Tiyoda. The slope of the curve can be categorized by some broad intervals:

Before WW-II: 88 microscopes per month
1942 and 1943: 250 microscopes per month
1944 to 1950: 178 microscopes per month
Post-1950: 108 microscopes per month

There might have been spurts of higher production. Microscopes number 8783 and 9299 have the same Showa date of 17-4 (April, 1942). If the inspection date is an accurate indicator, this would be at least 517 microscopes in that month. It is easy to imagine scenarios to explain away this high production rate: stockpiling production for later inspection; using the inspection stamp after its expiration date; skipping serial numbers, etc. Again, more data would be helpful.

Request for Information

Additional data can help refine the story presented in this article, and that data can come only from those who own copies of the MKH or other Tiyoda microscopes. The author would like to hear from anyone who can provide dates, serial numbers, or models for additional examples of Tiyoda microscopes. If we can crowdsource enough additional information, we can make an improved version of the "serial number *vs* date" chart, and perhaps tie down some uncertainties about when model changeover took place.

Supplemental File with Third Version MKH Documentation

A supplemental file contains copies of the Japanese language documentation that accompanied the Third Version MKH from the factory. I've added English translations. There is a one page instruction sheet, a table of magnifications card, and a factory inspection stamp. Although the instruction sheet is specific to the Third Version MKH, it can serve well enough for the Second Version. For a Second Version MKH, ignore the instruction to align the mechanical stage (there isn't one) before folding the stand; the remainder of the instructions are the same.

The supplemental file can be downloaded at http://www.microscopy-uk.org.uk/mag/artsep14/jp-Tiyoda-supp.zip

Acknowledgments

I wish to thank Jade Erisman for her translation of most of the Japanese language MKH documentation into English. The "History of Tiyoda" website of Shiraishi Kazuharu is an invaluable resource of information that would otherwise be lost. In the 1970s, Ray at Technical Instruments in San Francisco provided me with information about Tiyoda products in general. Manuel del Cerro and Jay Stanley each provided information about their MKH scopes.

Photos of microscopes other than my own were taken from various on-line sources – largely but not exclusively eBay auctions. Photo sources are credited in the captions; photos are reproduced for educational purposes under the fair use clause of US copyright law. I thank all the photographers that I was not able to contact in advance.

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Published in the September 2014 issue of Micscape Magazine at www.microscopy-uk.org.uk