Columbia Instruments' FM 600, A Unique US Army Field Microscope [i]

Part I: Background and Development

R. Jordan Kreindler (USA)

Background[ii]

Figure 1. John F. Kennedy Special Warfare Center and School, Ft Bragg North Carolina. Photo courtesy of U.S. Army Special Operations Command

The FM 600 began its life in 1984. In August of that year Columbia Instruments of Trussville, Alabama USA (a microscope vendor) was invited to participate in a presentation at the JFK Special Warfare Exhibit Hall at Fort Bragg, North Carolina USA [iii] (Fig, 1). Columbia Instruments was asked to bring a Swift FM-31 field portable microscope [iv], Fig. 2, with the hope it might be an appropriate replacement for the American Optical 3050, US Army, field microscope.

Figure 2. Swift FM-31 Field-Master microscope

FM 600's Predecessor: The AO 3050

In 1984 the Army was using the monocular American Optical (AO) Field Microscope Model 3050, Fig. 3**,** c. 1970, *FSN [Author: Eleven Digit 'Federal Stock Number', 1949-1975, Army Navy Product ID] 6545-926-8961, Microscope Set, Medical Laboratory Equipment Set, Lightweight, Field*. This model had been preceded by a monocular microscope, the Spencer Model 60. The AO 3050 was to become the immediate predecessor to the FM 600.

Figure 3. AO 3050 Field Microscope - Immediate predecessor of the FM 600

In some cases, when AOs were sent for repair they were replaced with a Nikon microscope, instead of another AO 3050. While the Nikon was praised by military medical staff for its quality, it came in a large wood storage case rather than fitting into the green storage/travel case designed for the AOs. Many of these Nikons were returned as soon as the binocular FM 600 replacement microscope became available.

The AO 3050 model was collapsible, in the tradition of many former military field microscopes. However, for storage, its legs folded in a quite unique manner, Figs. 4 and 5. The AO 3050 came with three infinity-designed achromatic lenses: 10x/0.25, 45x/0.66, and an 100x/1.25 containing an iris diaphragm.

This microscope could be used for either bright or dark field examinations. It came with a dedicated rechargeable nickel-cadmium "Power Pack" battery containing five replaceable nickel-cadmium cells, (replaceable with standard 'C' size batteries) that could be charged using either a vehicle battery or standard 110 or 220 volt, 50-60 cycle AC power lines. The battery when fully charged could power the microscope continuously for about four hours, with a recharging time of about 3 hours for each hour of runtime. It was supplied with a No. 55, 6 volt, bayonet base, incandescent bulb.

Figure 4. AO folded legs fully closed

The AO microscope is stored in a military green storage case, made of heavy-duty, non-rigid, plastic, with appropriate cutouts for the microscope, battery, etc., Fig. 6. The case had a simple press on/off cover without a handle. The microscope is described in its accompanying manual, Fig.7, as "Lightweight", although lighter than an equivalent laboratory instrument, it was not exceptionally light, particularly in its travel case.

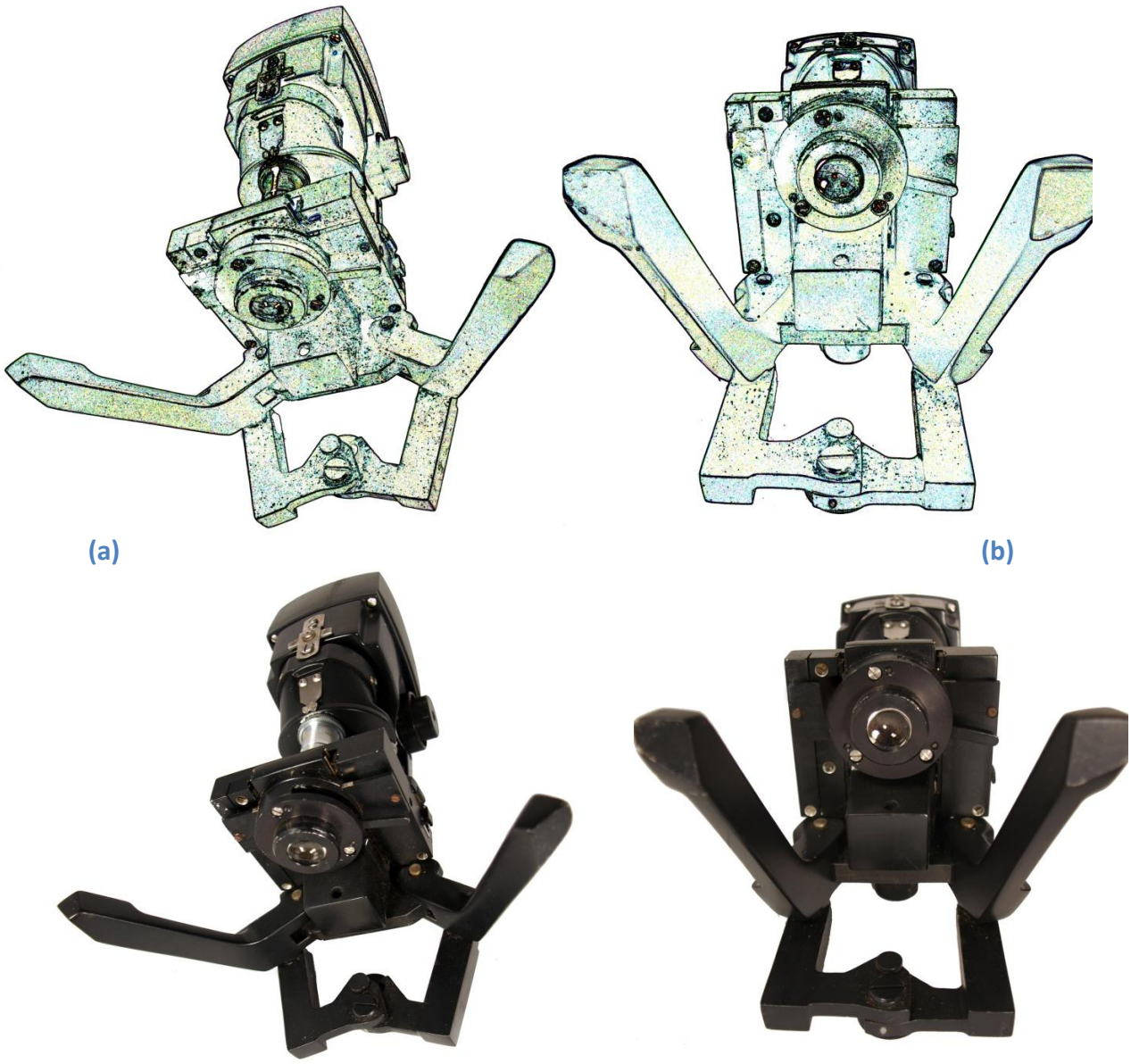
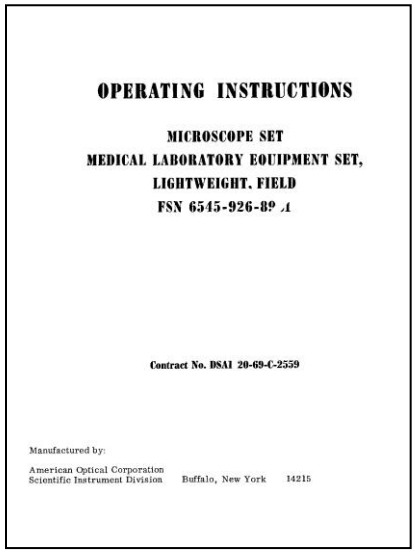


Figure 5. AO 3050 folding legs (a) partially open, and (b) open.
Above: edge enhanced and lightly colored to better show the folding mechanism.
Below: without enhancement

Figure 6. AO 3050 field microscope in case

The AO 3050 microscope weighted approximately 4 pounds 15 ounces by itself, and with its travel case approximately 12 pounds 9 ounces. With improvements in transportation, field microscopes no longer needed to be as lightweight as they were several decades earlier [v].



OPERATING INSTRUCTIONS

MICROSCOPE SET
MEDICAL LABORATORY EQUIPMENT SET,
LIGHTWEIGHT, FIELD
FSN 6545-926-89 A

Contract No. DSAI 20-69-C-2559

Manufactured by:

American Optical Corporation
Scientific Instrument Division Buffalo, New York 14215

Figure 7. AO 3050
Courtesy US Army
Public Domain Manual

FM 600 Evolution

While at Fort Bragg, the representative for Columbia Instruments, Larry Crowe, Fig. 8, was approached by James 'Jim' Fetherson, a medical material specialist.

Mr. Crowe learned the FM-31 would not meet the Army's need for a microscope that would match, as closely as possible, the functionality of a standard laboratory instrument, and so was not suitable as a replacement for the AO 3050. Although as discussed below, assemblies from other Swift microscopes were selected as core components in the development of the FM 600.

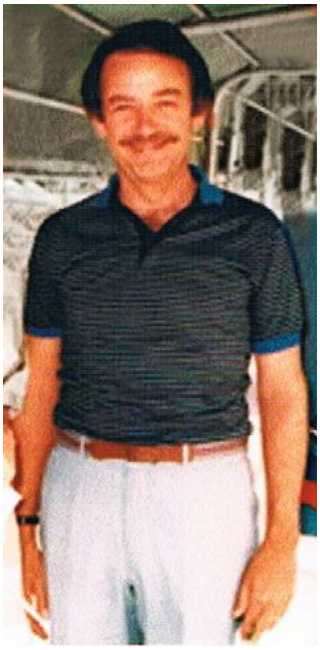


Figure 8. Larry Crowe about the time of the Ft. Bragg, North Carolina, USA Presentation (1984). Photo courtesy of Columbia Instruments and Mr. Larry Crowe

Specialist Fetherson outlined the basic requirements for an AO 3050 replacement:

(1) A compound microscope with binocular head,
(2) Abbe condenser with 1.25 N.A.,
(3) A mechanical stage,
(4) An illumination system capable of using normal power mains, i.e., 110/220 VAC, or using either a 12 or 24 Volt vehicle battery.,
(5) Compact enough, with its storage case, to fit inside a backpack also containing a centrifuge and chemicals.
(6) The storage/travel case requirements:
    (a) "Bumpers" to allow the case to be set down on one side,
    (b) Spring-loaded handles, to allow for easier transportation and carrying,
    (c) An air release valve, to allow the case to be easily opened even with ambient pressure changes,
    (d) Form-fit cutouts to store the FM 600, and its auxiliary power pack safely for travel.

Columbia Instruments, and Larry Crowe in particular, set about to satisfy these requirements. Several trips were made to Fort Bragg, and several FM 600s prototypes were sent for evaluation. This work culminated in 1986, with Jim Fetherson and Larry Crowe traveling to Fort Detrick, Maryland USA, the home of the U.S. Army's Medical Research and Material Command

(MRMC), where they gave an FM 600 presentation to a military panel. Both Specialist Fetherson and Mr. Crowe felt the presentation did not go well.

After the presentation, Specialist Fetherson asked Mr. Crowe if Columbia Instruments was a small business. When he answered "Yes", Specialist Fetherson said if he had known, he would have attempted to obtain funding for R&D before the presentation.

Figure 9. Columbia Instruments during the time of FM 600 production. Photo courtesy of Columbia Instruments

Their initial assessment turned out to be overly pessimistic.

In 1987 the Army placed its first order for thirty-two FM 600 microscopes and storage cases. Other orders followed over the next few years, usually for less than 150 at a time. In the summer of 1995 Columbia Instruments received a five year Army contract. They had anticipated the U.S. Army, if it decided to procure this field microscope, would need about 459 copies. They were surprised when they received a contract order for 672 FM 600s (see Attachment A), with unit price $2,078. [Author: The unit price is frequently shown incorrectly high in reseller listings]. This was filled with nineteen separate shipments.

To fulfill the Army orders, Columbia Instruments, Fig. 9, used about a dozen work stations placed in an approximate circle (See Attachment B). Delivery of the microscopes from Swift was staggered (see below) so Columbia Instruments could not work straight through to complete all microscope at one time, although they did have, at times, 4-5 people working on preparation of the field microscopes. They received orders from Swift in varying batches. In February 1996, two shipments arrived consisting of 112 and 100 units. In March four shipments of 100, 50, 50, and 50 (See Attachment C for an example of a production schedule).

With such distributed shipments, they put in quite a few 16 to 18 hours days to complete the microscopes with a reasonable delivery schedule.

Before the purchase program was completed, approximately 1,200 FM 600s had been sold, with shipments to both US stateside and overseas locations. Multi-unit orders for FM 600s continued through 2005, with some later individual orders. The last order was placed November 16, 2011 by the DLA Troop Support, Medical Supply Chain, Philadelphia USA.

Thus, this microscope that took approximately four years to develop (1984 through 1987), was used by the US military for at least 25 years.

The manufacture, construction and assembly, of each FM 600 microscope was a tedious and time-consuming process, and one portion of the illumination system, the bulb, was handmade, see below.

The coarse adjustment pinion gear required extensive attention to detail. It needed to be machined appropriately to allow sufficient space for the substage, and thus easier access to the controls of the mechanical stage. If the slide stage became too dry, it would stress the mechanical stage, and this stress might be transferred to the pinion sleeve. Therefore, two extra 6-32" Allen head, hex, set screws were used to secure the sleeve. This means hex keys

are required for assembly or disassembly of the FM 600. The base plate was made of aluminum and so required a separate spraying with a vinyl wash before paint would adhere.

A large sheet of aluminum was feed to a numerical control (NC) machine which cut the sheet, and drilled, and countersunk the holes. A single large sheet of aluminum yielded, possibly, sixteen base plates.

The krypton bulb used for internal illumination is worthy of special mention. It was designed by retired Naval officer, and mechanical engineer Joe Ross (now deceased). It was hand-made by removing the globe from a 20 Watt, 120 Volt Swift MA2201. MA2201 bulbs were used in Swift's M950, M970, M2240, M2251B, and M3200B microscopes. The krypton lamp was soldered to the contacts in the Swift bulb's base, and fiberglass was carefully placed around the contacts. The contacts were then given some time to "set". Finally a threaded ring was tightened to the bulb housing.

A small case production business, Volunteer Case and Container Inc., was started by an Oak Ridge, Tennessee USA entrepreneur, with his former high school teacher. He, apparently, decided to start the business after reading an article on how to make money building cases in Popular Mechanics Magazine. Volunteer Case and Container Inc., made the original case mold at a cost of $3,200, and continued to manufacture cases for the FM 600 until the late 1990s.

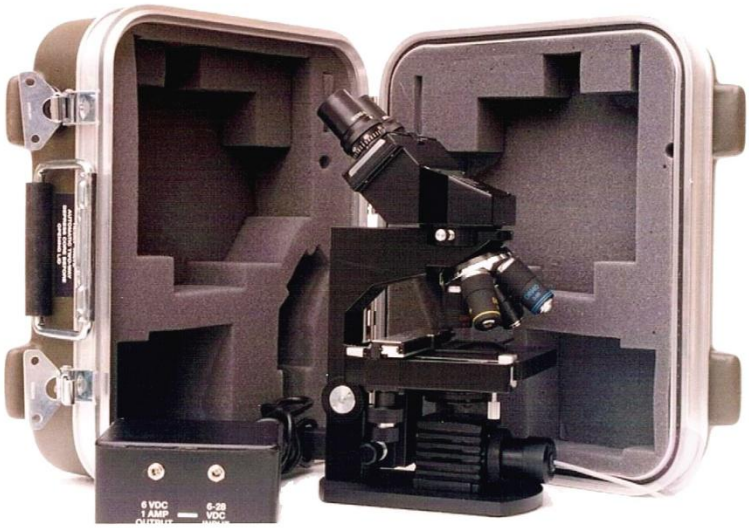


Figure 10. A production version of the FM 600 Field Microscope
Photo courtesy, and with permission, of Columbia Instruments

Columbia Instruments initially considered a different microscope for the core of the FM 600, one made by Southern Precision Instruments (SPI), but decided instead to use Swift components for the FM 600.

Thus, for Army production from 1984 until 1999 Columbia Instruments used stands and condensers made by Swift.

One of the earliest FM 600s Columbia Instruments built, had a horse shoe base and used non-DIN ((Deutsches Institut für Normung), non-infinity corrected, objectives.

The scope first produced for evaluation originally had plan achromats, but as these would have cost too much to supply in large quantities, the objectives were changed to standard DIN objectives, with working distances of about 45mm.

Fig. 10 shows a production version of the FM 600 with power supply and case. During their production, Columbia Instruments had painted the earliest FM 600s black. Because of this color, Swift asked Columbia Instruments to pay $200,000 with their order, just in case it was cancelled. The components produced by Swift, for their own instruments, were normally beige.

An FM 600 Replacement

With the arrival of the "digital age", the FM 600 set was replaced by the "Medical Equipment Set Laboratory Special Operations, Forces" , NSN: 6545-01-543-450 microscope. The NSN (National/Nato Stock Number) was assigned Sept 2006, which identifies the approximate date this instrument went into military inventory. The DC3-163 microscope in this set is used by the US Air Force, Army, and Navy. It is also stocked by the Defense Logistics Agency. The microscope's manual was prepared by the U.S. Army Medical Material Agency, Fort Detrick, MD.

This binocular microscope was designed for computer connectivity and video display. It includes a built-in relatively low resolution 0.4 MP (712 x 582 pixels) camera, and provides video images at 30 fps, and NTSC analog video at 480 TV lines. It comes with a 5.25 x 5.5 inch stage. It can be used with 100-240 VAC 50 or 60 Hz power mains. It is essentially a 12 volt microscope. Its associated power pack converts the mains input to 12 volts for its built-in 20 watt, intensity-controlled halogen lamp.

The microscope appears similar, if not identical, to the "National Optical DC3-163 Video Biological Microscope" now sold by Microscopeworld for $1,449 with Motic software, but without the accessories included in the military version, such as the power pack. Its built-in camera has a modest resolution, by today's standards, and it provides modest video resolution. The first generation of digital cameras (e.g., Canon's RC-710, c. 1986, electronic still camera) had 0.4 MP resolution, so this is an early standard. This resolution is, possibly, on the low-side for serious documentation or the examination of microscopic images.

In 2011 this microscope sold to the US military for a unit price of $2,480. The microscope comes with four objective magnifications, 4x, 10x, 40x, and 100x and with 10x/18mm eyepieces, identified as widefield. The 40x and 100x objectives are built with retractable, spring loaded, components. The microscope set includes a CD-ROM, which only works with 32-bit MS operating systems (OSs) and the Mac 9.2, but will not operate with MS 64-bit OSs.

FM 600 Production Video

http://www.microscopy-uk.org.uk/mag/artmar12/rjk-FM600-Production.wmv

Video courtesy, and with permission, of Mr. and Mrs. Larry Crowe

This video starts with a milling process. Here the milling machine is taking off a few 1,000ths of an inch from the underside of the stage plate. It continues, and concludes, with video of some of the microscope components ready to pack and ship to the US Army.

Part II

Part II of this paper will cover the FM 600's mechanics, functionality, and accessories and will be coauthored with Dr. Yuval Goren, Ph.D.

Attachment A - US "Defense Personnel Support Center" Contract for FM 600

JUN 27 '95 8:58 FROM DPSC MQA/B PAGE.002

AWARD/CONTRACT	1. THIS CONTRACT IS A RATED ORDER UNDER DPAS (15 CFR 350)	RATING	PAGE OF PAGES
		DOC9	

2. CONTRACT (Proc. Inst. Ident.) NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQUEST/PROJECT NO.
SP0200-95-D-8706	27 JUNE 1995	VARIOUS

5. ISSUED BY	CODE	6. ADMINISTERED BY (If other than item 5)	CODE
DEFENSE PERSONNEL SUPPORT CENTER 2800 SOUTH 20TH STREET PHILADELPHIA, PA 19145-5099 BUYER SYMBOL: MARK ANTHONY/DPSC-MQBA-P44 PHONE: 215-737-5978	SP0200	DCMAO BIRMINGHAM 2121 8th AVENUE NORTH, RM 104 BIRMINGHAM, AL 35203-2376	

7. NAME AND ADDRESS OF CONTRACTOR (No., street, city, county, State and ZIP Code)	8. DELIVERY	9. DISCOUNT FOR PROMPT PAYMENT	10. SUBMIT INVOICES (4 copies unless otherwise specified) TO THE ADDRESS SHOWN IN:	ITEM
COLUMBIA INSTRUMENTS, INC 202 WIMBERLY DRIVE TRUSSVILLE, AL 35173 ATT: MR. LARRY CROWE	☐ FOB ORIGIN ☒ OTHER (See below)	2% 10 DAYS		12

CODE	FACILITY CODE
0AA55	

11. SHIP TO/MARK FOR	CODE	12. PAYMENT WILL BE MADE BY	CODE
TO BE CITED ON EACH INDIVIDUAL DELIVERY ORDER		DFAS/CO SOUTHEAST P.O. BOX 182225, COLUMBUS, OH. 43218-2225	

13. AUTHORITY FOR USING OTHER THAN FULL AND OPEN COMPETITION:	14. ACCOUNTING AND APPROPRIATION DATA
☐ 10 USC 2304(c) ( ) ☐ 41 USC 253(c) ( )	MC: 97X4930 5CMO 01 26.0 S33150

15A. ITEM NO.	15B. SUPPLIES/SERVICES	15C. QUANTITY	15D. UNIT	15E. UNIT PRICE	15F. AMOUNT
0001	OPTICAL FIELD MICROSCOPE WITH CARRYING CASE ACCELERATED DELIVERY IS ACCEPTABLE AT NO ADDITIONAL COST TO THE GOVERNMENT.	650 (MAXIMUM)	ea	$2,078.00	$1,350,700.
				15G. TOTAL AMOUNT OF CONTRACT	$ 4,052,100.

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CONTRACTING OFFICER WILL COMPLETE ITEM 17 OR 18 AS APPLICABLE

17. ☐ CONTRACTOR'S NEGOTIATED AGREEMENT (Contractor is required to sign this document and return _____ copies to issuing office.) Contractor agrees to furnish and deliver all items or perform all the services set forth or otherwise identified above and on any continuation sheets for the consideration stated herein. The rights and obligations of the parties to this contract shall be subject to and governed by the following documents: (a) this award/contract, (b) the solicitation, if any, and (c) such provisions, representations, certifications, and specifications, as are attached or incorporated by reference herein. (Attachments are listed herein.)

18. ☒ AWARD (Contractor is not required to sign this document.) Your offer on Solicitation Number SP0200-94-R-8085* _____, including the additions or changes made by you which additions or changes are set forth in full above, is hereby accepted as to the items listed above and on any continuation sheets. This award consummates the contract which consists of the following documents: (a) the Government's solicitation and your offer, and (b) this award/contract. No further contractual document is necessary. *AMEND 0001, NOV 4, 1994; AMEND 0002, 2 JUNE 1995; BAFO, 9 JUNE 1995.

19A. NAME AND TITLE OF SIGNER (Type or print)	20A. NAME OF CONTRACTING OFFICER
	GENEVA POLINI

19B. NAME OF CONTRACTOR	19C. DATE SIGNED	20B. UNITED STATES OF AMERICA	20C. DATE SIGNED
BY _____ (Signature of person authorized to sign)		BY Geneva Polini (Signature of Contracting Officer)	27 June 95

NSN 7540-01-152-8069
PREVIOUS EDITION UNUSABLE

26-107
Form designed using PerForm Pro software.

STANDARD FORM 26 (REV. 4-85)
Prescribed by GSA
FAR (48 CFR) 53.214(a)

Attachment B - FM 600 Production Process Flow

Flow Chart of the Production Process

The basic microscope used for conversion to a field microscope is shipped to us consisting of a head, an arm and the optics.

Station 1

The eyepieces are removed and stored in a covered tray to prevent dust and foreign matter from entering the insides of the eyepiece. The four 2.6mm screws that hold the prisms assembly in the binocular head housing assembly are removed and placed in plastic bags to prevent dust from settling on the prisms surfaces. The 2.6mm screws are stored in plastic containers until needed for reassembling the head.

The four 1.3mm screws holding the inspection plate on the binocular head housing assembly are removed and stored in a plastic container until the plates have been painted and reinstalled on the binocular head housing assembly. The inspection plates are stored in a tray covered with plastic until they are prepared for painting.

Station 2

The four DIN achromat objectives are removed from the revolving nosepiece and stored in trays with plastic covers to protect them from dust.

Station 3

The four place nosepiece is removed from the arm in order to make the process of removing 27MM off the rear of the arm easier for down sizing.

The two 3MM screws holding the coarse adjustment stop are removed and stored in a plastic container while the stop is stored in a tray until it has been painted and reassembled to the arm. The two 3MM screws holding the binocular head adapter are removed and stored in plastics containers along with the binocular head adapter.

Station 4

The coarse and fine adjustment block assembly is then removed from the arm. At this time the coarse and fine adjustment block assembly and the arm are given identical numbers with a numbers punch so that the slideways match smoothly upon reassembly.

Station 5

At this point 5MM of metal is removed with a metal band saw from both sides of the stage support to allow the use of the Kyowa made mechanical stage to fit properly.

Station 6

The Abbe condenser sleeve housing along with the Abbe condenser s removed so that 2/100 of an inch can be removed from the bottom side of the stage plate to allow the mechanical stage to fit properly.

Station 7

The pinion metal and sleeve is removed and stored until which point the pinion and sleeve can be reduced in

length to properly clear the low positioned
controls on the mechanical stage.

Station 8

Jigs are set up and 27MM of surface is removed from the rear of the arm assembly. New jigs are set up and the arm has two 6-32 holes drilled and tapped for the inspection plate. A 4MM hole is drilled and tapped on the bottom of the arm to take the place of the one lost when 27MM section of the rear of the arm was removed. Inside the arm, two 6-32 holes are drilled and tapped to secure the pinion metal sleeve since the manufacturer did not use screws of sufficent size on the other side to always hold the sleeve in place.

Station 9

The pinion metal and sleeve are reduced 7MM on the left and 5MM on the right in order for the low positioned controls on the mechanical stage to be manipulated comfortably.

Bids are sent to suppliers for a sturdy all metal illuminator which can be easily modified to fit the base of the FM 600 microscope. Upon award of the bid and receipt of the illuminators, they are sent to station 10.

Station 10

The retaining ring holding the opaque and blue filters is removed. Individual containers for the retaining ring and the two filters are used until modification has been completed. The electrical cord and socket are sent to Mountain Electronics for conversion for use with their power supply. The rear section of the illuminator housing is removed using a metal band saw so that the housing is rectangular. The bottom plate is removed and and flipped over The 2.6MM holes are drilled and tapped to a larger 4MM for sturdier hold. On the left front of the plate a 6-32 hole is drilled and tapped and a 6-32 hole on the bottom left of the illuminator housing is drilled and tapped. This will allow the operator to easily remove the housing in an emergency and use the 35MM diameter mirror and fork.

Station 11

Aluminum sheets 4 X 8 feet are used to cut 1/4" thick plates 4 1/4" wide and 61/2" long. Three holes are drilled with a recess for the 4MM machine to attache the arm and two holes are drilled with a recess to hold the bottom plate of the illuminator housing in place.

Station 12

A vinyl wash is sprayed on the aluminum plates and then four coats of semi-flat black paint is sprayed onto the base plates and baked on. Four rubber pads are secured to the bottom of the base.

Reassembly of the Modified Microscope

The newly modified microscope is reassembled. New lubricant applied to the slideways of the coarse and fine adjustment assembly. Proper tension is set on the coarse adjustment so as to allow comfortable but firm movement of the coarse adjustment assembly. Securing the

stage plate is done only after the illuminator is aligned with the condenser to fill the aperture of all of the objectives. Diopter tubes are set at the factory settings for maintaining parfocality of the obejctives. The coarse stop is set to prevent slide damage. The mechanical stage is adjusted so that the specimen slide is secured close to the stage plate. A Vickers ring test slide is used to check parcentration of the objectives. A stained slide is use to check parfocality and possible chromatic aberration. Power supply batteries are fully charged before shipping.

The FM600 field microscope is now ready for shipment.

Attachment C - FM 600 Production Schedule, August 1995-April 1996

Note: There are some minor typos in the latter part of this schedule where 1996 is inadvertently typed as 1995

Production Schedule for FM 600 Microscope
Contract SP0200-95-D-8706

50 Swift microscopes arrived 8/15/95
50 Power supplies due 10/23/95 ***Reason for delay is transformer supplier's start up time and production.***
100 Carrying cases will arrive week of 9/11/95
50 Mechanical stages will arrive 9/25/95 ***Reason for delay due to shortage of material***

Modifications to be finished by 9/15/95
10 Days to paint, reassemble and **ship 10/25/95**

100 Swift microscopes due middle of November for modification.
Reason for delay due to unexpected demand and 380 units ahead of us.
100 Power supplies due middle of November.
100 Carrying cases in stock.
250 Mechanical stages due.middle of November.

Modifications to be finished by 12/1/95

10 Days to paint, reassemble and **ship 12/10/95**

200 Swift microscopes due January 1, 1995 for modification.
200 Power supplies in stock.
200 Carrying cases in stock
275 Mechanical stages in stock.

Modifications to be finished by 1/15/96
14 Days to paint reassemble and **ship 2/1/95**

200 Swift microscopes due February 1, 1995 for modification.
200 Power supplies in stock.
200 Carrying cases in stock

Modifications to be finished by March 1, 1996
14 Days to paint reassemble and **ship 2/15/95**

211 Swift microscopes due March 1, 1996 for modifications.
211 Power Supplies in stock.
211 Cases in stock.
211 Mechanical stages in stock.

Modifications to be finished by April 1, 1995
14 Days to paint, reassemble and **ship 4/15/95**

The author welcomes suggestions for corrections or improvement. He can be reached at:

R. Jordan Kreindler: leona111@bellsouth.net

End Notes

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[i] The author owes special thanks to Mr. Larry Crowe, Secretary/Treasurer of Columbia Instruments, for his inputs. Mr. Crowe was the driving force behind the design of the FM 600, and his knowledge of its development is truly unparalleled.

[ii] See Manuel del Cerro's interesting article in the December 2008 issue of Micscape, on *War and Its Microscopes: A review of the Spencer 60, the Tiyoda MKH, and the AO Microscope Set* for an alternate discussion of some microscopes used by the military.

[iii] The author would like to thank the U. S. Army's Public Affairs Office, Fort Bragg, North Carolina, USA for permission to use the picture of the John F. Kennedy Special Warfare Center and School, Fort Bragg, N.C., USA.

[iv] Kreindler, R. Jordan and Yuval Goren. *Comparison of the Swift FM-31 Portable Field Microscope and an FM-31 Clone*. Micscape Magazine, March 2011

[v] Kreindler, R. Jordan and Yuval Goren. *Baker's Traveller's Microscopes*. Micscape Magazine, May 2011 [Reprinted, Newsletter of the New York Microscopical Society.(NYMS) Volume 5 (25) Number 6. Summer 2011]

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