LEITZ Plano objectives „PLAN“
New series of objectives for microscopy

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Introduction

The optical system is the nucleus of the microscope. Its optimum performance is achieved through far-reaching elimination of the optical aberrations (spherical and chromatic aberration, astigmatism, coma, and curvature of field), i. e. through correction of the deviations from the ideal rendering of an object point inherent in the geometrical optical image formation. This is achieved through the choice of suitable lens shapes and diaphragm positions as well as through the combination of several lenses of opposite effect in a system. The residual aberrations characterise the state of correction of the objectives. We accordingly distinguish between the following objective systems:

- Achromats
- Plan-achromats
- Plan-semi-apochromats
- Plan-apochromats

To make all criteria for the improvement of the optical performance fully effective, LEITZ objectives are today computed on the basis of the most up-to-date computer programs. The high optical performance is achieved through the use of special glasses developed by LEITZ, of glasses of abnormal partial dispersion, through meniscus-shaped lenses, the concave surfaces of which serve to flatten the field, through reflection-reducing multiple layers coated on the lens surfaces to improve light transmission and contrast, as well as through extremely high manufacturing tolerances. A large field of view, high numerical aperture, and high colour correction demand a correspondingly great optical and precision-mechanical input, from the development of new types of glass to optical computation, to the number of the components and that of the elements, and to the mechanical mounts.

Through many years of research and development, based on more tha 125 years' experience in the field of microscope and otpical manufacture, LEITZ have succeeded, with the aid of modern techniques, in reaching the limits of what is physically possible.

But maximum performance is not always the aim. In practice, it is essential for the optical system of the microscope to be specially adjusted to the problems it has to solve. For this purpose LEITZ offer a wide range of objectives. The importance of the correct choice of optical equipment becomes clear in the light of the information content required: it is determined by the diameter of the field of view in the eyepiece and by the resolving power and the contrast rendering of the objective. It is precisely these conditions which are often ignored. Through the one-sided magnification of the diameter of the field of view with the aid of eyepieces of higher field-of-view index detail recognition is not improved. Improvement is possible only through a higher numerical aperture (measure of the resolving power of an optical system) and optimum colour correction (this prevents the occurrence of colour fringes in the image), i. e. through the increase of resolution and of contrast rendering as well as improved flattening of the field.

The input of development of production technology required for the manufacture of objective systems of various classes necessarily results in different prices. A LEITZ plan-apochromatic oil immersion objective of 100× primary magnification, for instance, consists of 8 optical components with a total of 14 elements in 16 mechanical mount components. The accuracy of the optical adjustment of the individual elements and components to each other is of the order of one light wave length. With this plan-apochromat the highest possible optical resolution at optimum image contrast and pin-sharpness across the entire field of view of 28 mm diameter is achieved.

Such an optical performance obviously has its price. Every owner of a microscope should therefore answer the question of the need for such a high-value optical system for his or her specific work. The answer will always be no whenever the microscope is used only for the observation and checking of mainly well-known structures. For this purpose objectives of extremely high resolution are rarely essential.

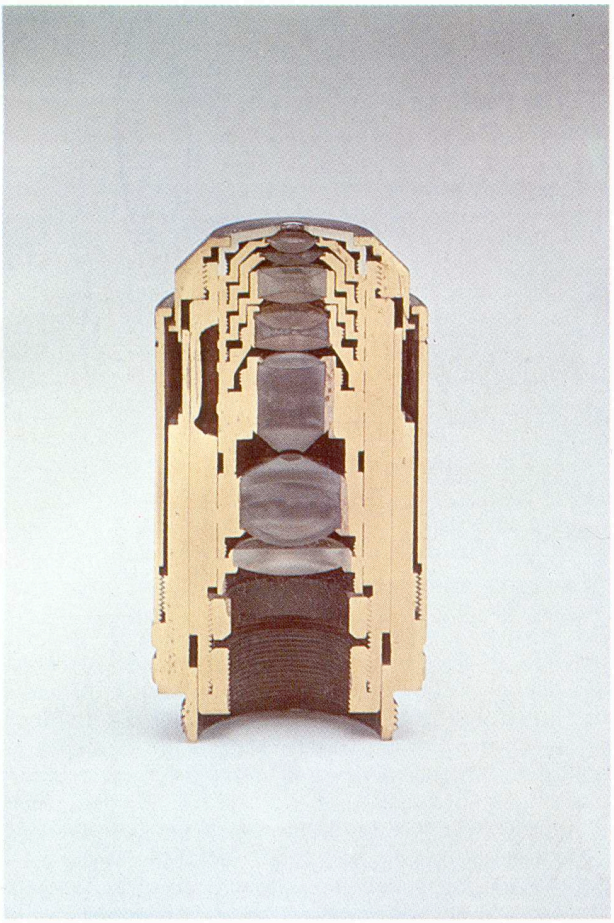

Fig. 1: Cross section through a modern plan-apochromatic LEITZ objective.

The full utilisation of a high-performance objective is often rendered ineffective by the imperfections of the specimen to be investigated: the microtome sections or the smear preparations are too thick or so uneven, especially in routine work, that the microscopic image cannot be focused across the entire field of view, no matter how well corrected the objective.

But if structures are to be demonstrated which are only just resolved by the optical microscope, yet alone photomicrographs obtained of them, the highest demands must be made primarily of the quality of the specimen. If these are met, the question of the need for a high-quality optical system can be answered with a definite yes. The performance of objectives of extremely high resolving power, optimum contrast rendering, and pin-sharpness to the edge of the image field will then be fully utilised. The LEITZ objective range is subjected to a continuous process of innovation, i. e., it is continuously adapted to the practical demands of microscopy, with the use of novel technological possibilities.

LEITZ plan-achromats

The achromat represents the simplest state of correction of a microscope objective. Here the chromatic aberration is corrected in the red and blue region of the spectrum, i. e. for two colours. This is achieved through the combination of a crown glass collecting lens and a flint glass dispersing lens of always different dispersion. The new LEITZ plan-achromats (engraved: PLAN) are of far better quality than the just described „classical" achromats. Through a considerable optical input, from the development of high-quality glasses, through optical computation, to the use of additional cemented components and negative elements a series of achromatic objectives has been successfully developed, which especially with an improved flattening of field offers an appreciably better optical performance: the field performance of these objectives is at least 20 mm; their use up to field-of-view 25 is possible. All new plan-achromats are used with the also newly developed PERIPLAN GF 10× and PERIPLAN GF 12.5× high-point eyepieces, of field-of-view index 20.

In addition to their brightfield version plan-achromats are also available in a phase-contrast version (PLAN PHACO). The plano objective series is ideal for all medical and biological routine investigations, and in addition obviously well suited for photomicrography. The price of this series of objectives has a particularly favourable relationship to the performance it offers.

Table 1

Designation of the objectives Reproduction ratio/aperture	*Free working distance in mm*	*Focal length*	*Coverglass correction*	*Variant for phase contrast*
PLAN 4/0.10	14.54	37.47	DO	–
PLAN 10/0.25	0.25	15.57	DO	PHACO 1
PLAN 20/0.45	0.73	8.99	D	PHACO 2
PLAN 40/0.65	0.25	4.53	D	PHACO 2
PLAN 100/1.25 Oel	0.19	1.67	D	PHACO 3

DO = to be used with or without coverglass
D = to be used with overglass only

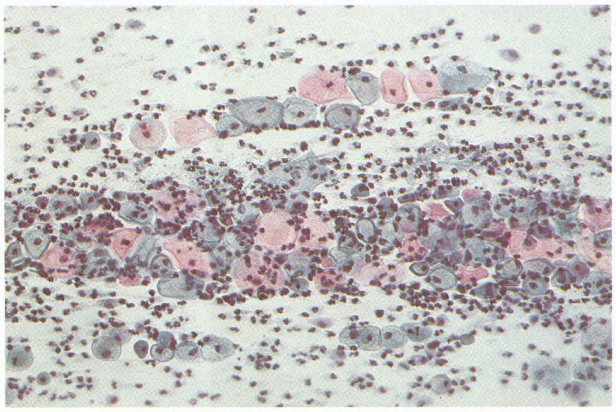

Fig. 2: Vaginal smear; PLAN 20/0.40 objective.

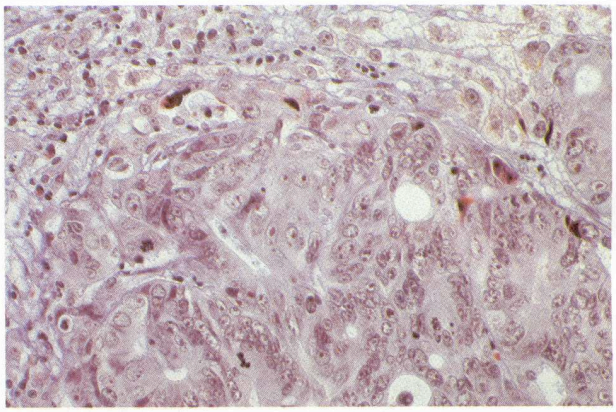

Fig. 5: Metastasis of adeno-carcinoma; PL FLUOTAR 40/0.70 objective.

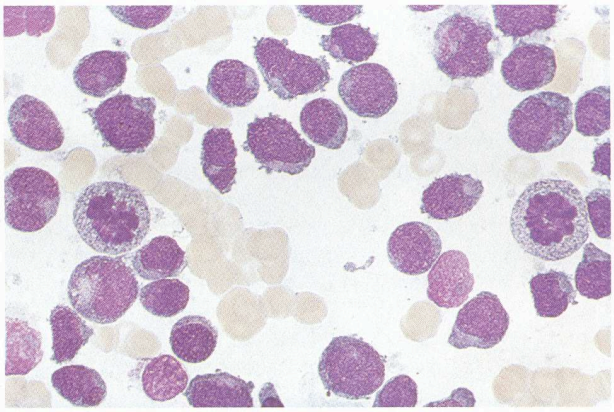

Fig. 3: Myelogic leukaemia; PLAN 100/1.25 Oel objective.

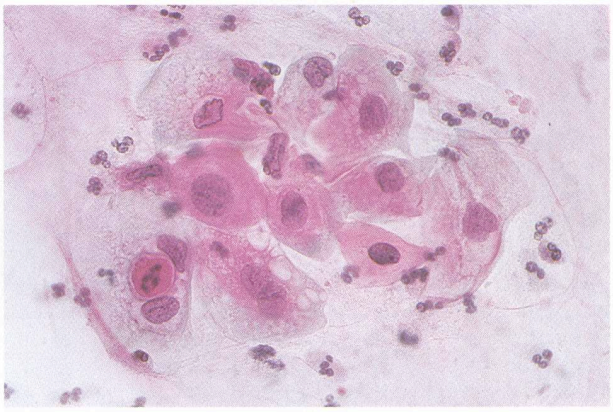

Fig. 6: Tumor cells (vaginal smear); PL FLUOTAR 100/1.32 Oel objective.

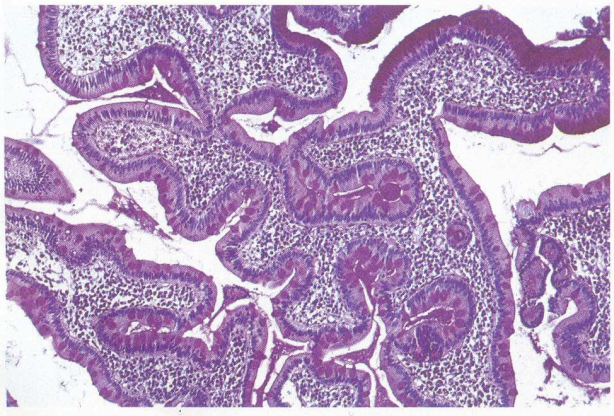

Fig. 4: Chronic duodenitis; PL FLUOTAR 16/0.40 objective.

Fig. 7: Chlamydia trachomatis; NPL-FLUOTAR Fluoreszenz 40/1.30 Oel objective.

LEITZ Plan Fluotar objectives

It is obvious that the chromatic aberration of an optical system cannot be completely corrected simply by the elimination of the aberration for two colours as in the case of the achromats. Microscope objectives in which the colour correction is considerably improved through the use of fluorspar or materials resembling this substance instead of the usual crown glass, are called fluorite systems or semi-apochromats.

In the *Plan-Fluotar* objective series (engraved: PL FLUOTAR) the colour correction is superior to that of the semi-apochromats. All other aberrations, too, have been reduced to the possible minimum. The large numerical apertures result in a high resolving power, enhanced contrast rendering, colour purity and brilliance of the image across the entire field of view. At the same time curvature of field, caused by the convex shape of the lenses and clearly visible because of the short focal length of microscope objectives, has been eliminated. This has been achieved by the use of additional elements and thick meniscus lenses with enhanced concave surfaces. In the *Plan-Fluotar* series LEITZ have realised the flattening of field with semi-apochromatic colour correction up to a field of view of 25 mm diameter. In conjunction with the PERIPLAN GF 10× and PERIPLAN GF 12.5× high-point eyepieces for field-of-view index 20 (with tube lens 0.8×) a field performance of 25 mm is utilised. The objectives produce an image which is perfectly sharp to the edge of the field of view. In conjunction with the PERIPLAN GW 8× and GW10× wide-field eyepieces a field-of-view index as high as 28 is achieved.

To permit the use of these objectives also for fluorescence-microscopic purposes without restriction, special attention was paid to the lowest possible primary fluorescence and high transmission in the UV region during the selection of the glasses for the *Plan-Fluotar* series. Multiple coating of the lens surfaces results in a very effective reduction of reflection. The large numerical aperture doubly contributes to image brightness in fluorescence microscopy with incident-light excitation: on the one hand more exciting energy reaches the specimen, on the other a larger quantity of the fluorescent light emitted there is received for image formation.

Another characteristic of these objectives are the appreciably longer free working distances with their advantages during work with counting chambers and the possibility of using them also in conjunction with the inverted microscopes such as the LEITZ LABOVERT® and LEITZ FLUOVERT®. In addition, longer free working distances have operating advantages: when the revolving nosepiece is rotated the front lens of a dry system is not inadvertantly immersed in the immersion oil on the specimen, the focusing of a certain area in the specimen is improved through the improved view of the specimen. The new *Plan-Fluotar* objective series is available not only in the brightfield version, but also as a variant for phase contrast (PL FLUOTAR PHACO), and for polarised light (PL FLUOTAR P).

LEITZ NPL FLUOTAR *Fluoreszenz* objectives

Characteristic of these immersion objectives are their very large numerical apertures: large apertures concentrate much exciting light on the specimen and thereby produce bright microscopic images. With immersion objectives even larger apertures are achieved than with dry systems which offers the additional advantage of a further increase of the resolving power. The additional demands made of special objectives for incident-light fluorescence microscopy, such as high UV transmission and freedom from fluorescence from the lens glasses, are met by the NPL FLUOTAR *Fluoreszenz* objectives. Moreover, this objectives have outstanding chromatic correction, far beyond what is customary in such systems. In the absence of a demand for extremely large apertures — if these, as usual in an objective of 40× pri-

Table 2

Designation of the objectives	*Free working distance in mm*	*Focal length*	*Coverglass correction*	*Variant for*	
Reproduction ratio/aperture				*phase contrast*	*polarised light*
PL FLUOTAR 6.3/0.20	6.87	28.57	DO		P
PL FLUOTAR 10/0.30	7.60	18.00	DO	PHACO 1	
PL FLUOTAR 16/0.45	0.70	11.25	D	PHACO 1	P
PL FLUOTAR 25/0.60	0.50	7.20	D	PHACO 2	P
PL FLUOTAR 40/0.70	0.45	4.50	D	PHACO 2	P
PL FLUOTAR 100/1.32 Oel	0.19	1.80	D	PHACO 3	P

DO = to be used with or without coverglass
D = to be used with coverglass only

mary magnification, ranged between A 0.65 and A 0.75 — they would be be called apochromats, in which the highest degree of colour correction has been realised. In conjunction with the PERIPLAN GF 10× and PERIPLAN GF 12.5× high-point eyepieces of field-of-view index 20 fields of view of 20 and 25 mm, depending on the tube length, can be achieved.

The NPL FLUOTAR *Fluoreszenz* objectives meet all the demands made by the specimen and the method of illumination and typical of fluorescence microscopy. They also include special suitability for photomicrography. The NPL FLUOTAR® *Fluoreszenz* series of objectives exists in a variant for phase contrast (NPL FLUOTAR *Fluoreszenz PHACO)* in addition to the brightfield version.

Table 3

Designation of the objective Reproduction ratio/aperture	*Free working distance in mm*	*Focal length*	*Coverglass correction*	*Variant for phase contrast*
NPL FLUOTAR Fluorescence 10/0.45 Oel	0.30	17.80	DO	PHACO 1
NPL FLUOTAR Fluorescence 25/0.75 Oel	0.14	7.20	DO	PHACO 2
NPL FLUOTAR Fluorescence 40/1.30 Oel	0.16	4.51	D	PHACO 3

DO = to be used with or without coverglass
D = to be used with coverglass only

Conclusion

Demands are continuously increasing on the optical performance of the microscopes used in research, teaching, and diagnostic. Only a high optical performance offers the observer the guarantee of confident operation at minimum eyestrain. The decision in favour of a certain optical system also entails the decision in favour of a certain type of microscope or vice versa. The new PLAN, PL FLUOTAR, and NPL FLUOTAR *Fluoreszenz* objective series are used to the full extent of their optical performance on the ergonomically optimised new LEITZ DIAPLAN® microscope, which offers all the conditions for the utilisation of large fields of view from 20 to 28 mm. This microscope will be described in detail elsewhere in this issue.

Needless to say the new series of objectives can also be used on other microscopes, such as the LEITZ LABORLUX®, but optimum matching of microscope and objectives should be carried out with due regard to the problems to be solved and to specific practical criteria. This is the only way of fully utilising the advantages of the various types of objective. Figs. 2—7 produce some typical photomicrographic evidence.

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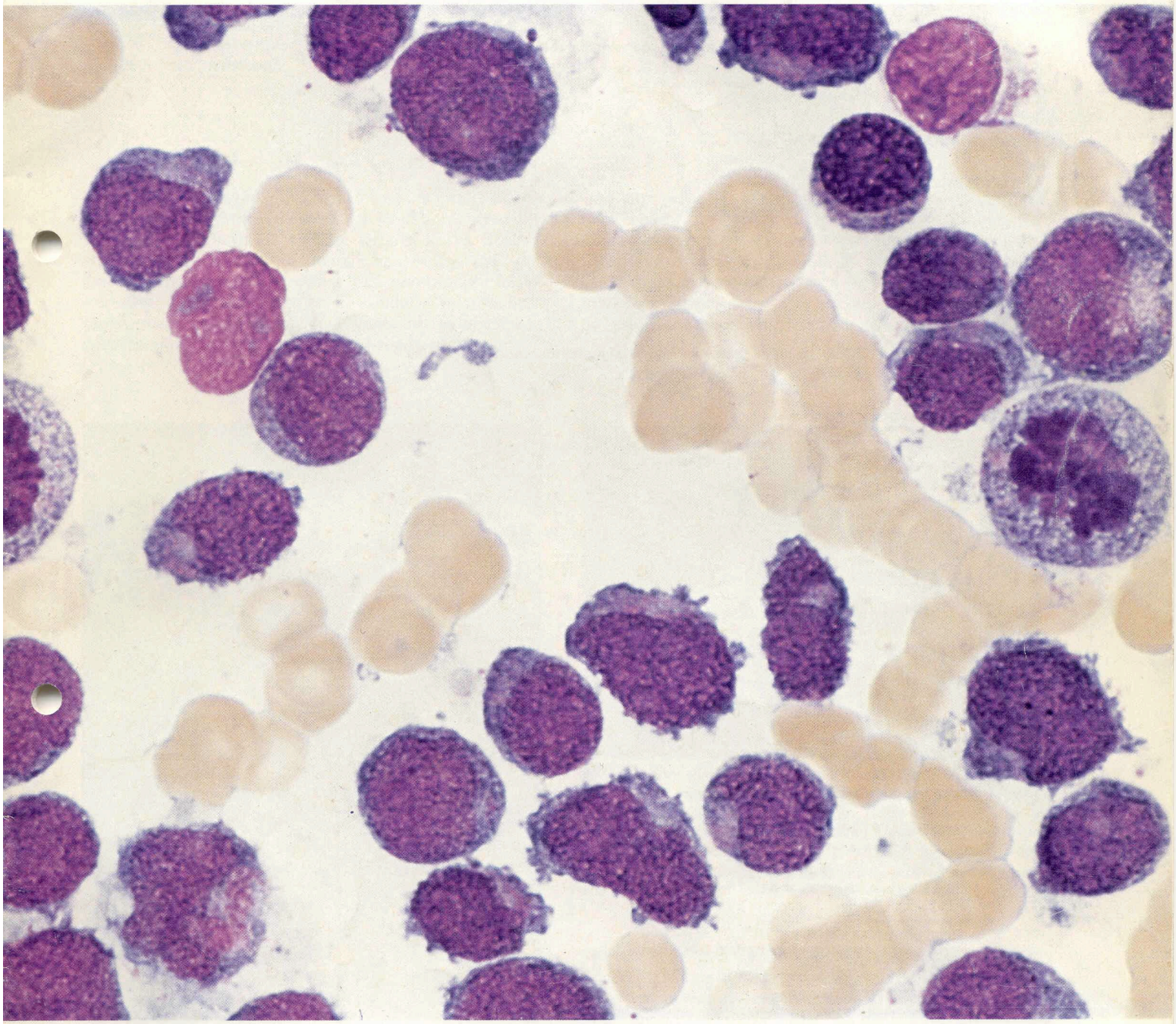
Scientific and Technical Information

Informations for ACHEMA 85



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