

HAZE AND COLOR FILTERS IN AERIAL PHOTOGRAPHY

BY
VIRGIL KAUFFMAN

FROM THE PHOTOGRAPHIC STANDPOINT THE PRIMARY OBJECTIVES OF ALL OPERATORS ENGAGED IN VERTICAL AIRPLANE PHOTOGRAPHY ARE PHOTOGRAPHIC PRINTS OF EXACTING DEFINITION AND SELECT QUALITY. THE SUCCESSFUL ACHIEVEMENT OF THESE TWO FACTORS IS NOT CONSISTENTLY OBTAINABLE WITHOUT CAREFUL CONSIDERATION AND TREATMENT OF THE LIGHT WHICH IS REFLECTED FROM THE TERRAIN BEING PHOTOGRAPHED THROUGH THE LENS TO THE SENSITIZED MATERIAL ON WHICH THE PHOTOGRAPH IS MADE.

TO THE INEXPERIENCED THIS PROBLEM MAY SEEM A VERY EASY ONE SINCE TO MOST OF US, DURING DAYS WHEN AIRPLANE PHOTOGRAPHS ARE MADE, THE WEATHER APPEARS GOOD AND THE ATMOSPHERE CLEAR.

THE EXPERIENCE OF ALMOST EVERY AMATEUR PHOTOGRAPHER WHO HAS MADE A PICTURE OF A DISTANT LANDSCAPE OR MOUNTAIN RANGE WITH THE HOPE OF RETAINING A PERMANENT RECORD OF THE VIEW AND FINDING DISAPPOINTMENT IN THE FINAL PRINTS ON WHICH THE DISTANCES APPEAR VEILED AND INDISTINCT IS WELL KNOWN. THE SAME RESULTS CONFRONTED THE EARLIEST ATTEMPTS TO OBTAIN AIRPLANE PHOTOGRAPHS IN WHICH PICTURES, MADE APPARENTLY UNDER PERFECT WEATHER CONDITIONS, LACKED THE DEFINITION AND CONTRAST WHICH SEPARATED THE VARIOUS TONES OF THE SUBJECT.

VERTICAL AERIAL PHOTOGRAPHY DIFFERS FROM OTHER BRANCHES OF THE PHOTOGRAPHIC ARTS IN THAT THE DISTANCE BETWEEN THE CAMERA AND THE OBJECT PHOTOGRAPHED IS VERY GREAT AND BETWEEN THE LENS AND THE SUBJECT THERE EXISTS A DEPTH OF AIR WHICH REFLECTS LIGHT BACK INTO THE LENS IN ADDITION TO THE REFLECTED LIGHT FROM THE TERRAIN ITSELF. THIS LIGHT REFLECTED FROM PARTICLES OF WATER OR DUST SUSPENDED IN THE AIR AND TO A LESS EXTENT BY THE MOLECULES OF AIR THEMSELVES, SUPERIMPOSES A UNIFORM ILLUMINATION OVER ALL PARTS OF THE SUBJECT PHOTOGRAPHED, CAUSING A VEILING WHICH DIMINISHES THE CONTRAST AVAILABLE FOR REPRODUCTION IN THE PHOTOGRAPH. THE REASON FOR THE APPARENT VEILING AND UNSHARPNESS OF THE PHOTOGRAPHS UNDER THIS CONDITION HAS BEEN DUE TO THE OPTICAL TURBIDITY OF THE AIR AND IS GENERALLY TERMED "HAZE". THIS TERM "HAZE" THOUGH INDEFINITE SPECIFIES A PHENOMENON WITH WHICH EVERYONE IS FAMILIAR, AND OWING TO THE LARGE PROPORTION OF ACTINIC LIGHT REFLECTED BY IT THE EFFECT IS MUCH GREATER PHOTOGRAPHICALLY THAN VISUALLY. THEREFORE, UNLESS PRECAUTIONS FOR THE ELIMINATION OF THIS BOTHERSOME LIGHT ARE TAKEN IT WOULD OFTEN BE IMPOSSIBLE TO DISTINGUISH ANY GROUND DETAIL IN THE AVERAGE AERIAL PHOTOGRAPHY.

HAZE MAY BE CAUSED BY WATER VAPOR, DUST, SMOKE, OR ANY OTHER ATMOSPHERIC MATERIAL WHICH TENDS TO DIMINISH THE TRANSPARENCY OF SPACE WHICH IT OCCUPIES. THERE ARE MANY TYPES OF HAZE. AT TIMES IT IS STRATOSPHERIC NEAR THE GROUND AND AT OTHERS AT HIGH ALTITUDE. ON A RELATIVELY CLEAR DAY IT OFTEN EXTENDS UNIFORMLY TO GREAT HEIGHT IN THE AIR. ITS VISUAL QUALITY OF COLOR ALSO VARIES NOT ONLY DUE TO THE VARIOUS SOURCES BUT ALSO TO THE SIZE OF THE SUSPENDED PARTICLES OF WHICH IT CONSISTS.

IT IS ACCEPTED THAT HAZE IS PRESENT IN THE ATMOSPHERE TO SOME EXTENT ALL OVER THE WORLD. THE CLIMATE, THE WEATHER, THE SEASON AND THE LOCALITY AFFECT ITS DENSITY. SOME PARTS OF THE UNITED STATES, IN WHICH THE RAINFALL IS SPARSE AND THE HUMIDITY QUITE LOW, ARE RELATIVELY FREE OF THIS ATMOSPHERIC CONDITION AND THE HAZE IS PRACTICALLY INVISIBLE. THE WESTERN PLATEAU COUNTRY AND THE ROCKY MOUNTAINS ARE AREAS OF THIS TYPE. ON THE OTHER HAND, THE EASTERN SEABOARD AND AREAS SUCH AS THE GREAT SMOKY MOUNTAINS OF WESTERN NORTH CAROLINA AND EASTERN TENNESSEE ARE UNDER A VEIL OF HEAVY VISIBLE HAZE PRACTICALLY ALL THE TIME.

THE VISIBILITY OR INVISIBILITY OF HAZE HOWEVER, TO AN OBSERVER IS NO CRITERION OF ITS EFFECT ON PHOTOGRAPHIC FILM. HAZE IS TRANSPARENT TO THE LONGER LIGHT WAVES BUT SCATTERS AND REFLECTS THE SHORTER WAVES OF BLUE, VIOLET, AND THE INVISIBLE ULTRA-VIOLET. THE REFLECTING POWER OF THESE RAYS IS WHAT OFTEN GIVES IT THE NOTICEABLE BLUE COLOR.

THE FACT THAT HAZE IS NEITHER COMPLETELY TRANSPARENT, NOR OPAQUE, BUT IS TRANSPARENT TO CERTAIN COLORS OF THE SPECTRUM, WHILE IT REFLECTS AND SCATTERS THE RAYS OF OTHER COLORS, INDICATES THAT AERIAL PHOTOGRAPHY REQUIRES SOME UNDERSTANDING OF COLOR AND COLOR PHOTOGRAPHY. IT IS COMMON KNOWLEDGE THAT WHITE LIGHT OR SUNLIGHT IS MADE UP OF ALL THE COLORS OF THE VISIBLE SPECTRUM, AS

WELL AS THE INVISIBLE RAYS OF THE ULTRA-VIOLET AND INFRA-RED. WE SAY AN OBJECT HAS A BLUE COLOR IF IT REFLECTS BLUE RAYS, OR A RED COLOR IF IT REFLECTS RED RAYS. THE SOURCE OF LIGHT, HOWEVER, IS COMPOSED OF ALL COLORS, SO A CONCEPTION OF A RED OBJECT IS NOT ONLY ONE WHICH REFLECTS RED RAYS, BUT ALSO ONE WHICH ABSORBS OTHER COLORS.

IN GENERAL, WHITE LIGHT CAN BE BROKEN UP INTO THREE COMPONENTS, NAMELY BLUE, GREEN, AND RED. THE VARIOUS OTHER COLORS SUCH AS BLUE-GREEN, YELLOW, AND ORANGE ARE VARIOUS COMBINATIONS OF THE FIRST THREE. IF WE KEEP IN MIND THE CONCEPTION OF OBJECTS ABSORBING CERTAIN COLORS, IT WILL BE SEEN THAT AN OBJECT THAT ABSORBS BLUE AND RED LIGHT WILL APPEAR GREEN. THIS ASPECT OF COLOR LEADS US TO A DEFINITION OF COMPLEMENTARY COLORS. A COMPLEMENTARY COLOR IS COMPOSED OF THE REMAINING LIGHT RAYS AFTER THE ABSORPTION OF ONE OR MORE OF THE COMPONENTS OF WHITE LIGHT.

RED IS COMPLEMENTARY TO BLUE AND GREEN. GREEN IS COMPLEMENTARY TO RED AND BLUE. IF THE GREEN RAYS ARE ABSORBED THE OBJECT APPEARS RED-BLUE OR MAGENTA. IF THE BLUE RAYS ARE ABSORBED THE OBJECT APPEARS GREEN-RED WHICH IS YELLOW TO THE EYE. YELLOW AND BLUE ARE SEEN TO BE COMPLEMENTARY COLORS. IT CAN BE SAID IN GENERAL THAT THE LIGHT REFLECTED BY AN OBJECT IS COMPLEMENTARY TO THAT ABSORBED BY IT.

TO WITHIN A FEW YEARS AGO SENSITIVE NEGATIVE PHOTOGRAPHIC MATERIAL WAS SENSITIVE MOSTLY TO SHORTER LIGHT WAVES SO THAT THE REFLECTED LIGHT FROM HAZE PHOTOGRAPHED FAR HEAVIER THAN THE LONGER RAYS OF LIGHT REFLECTED FROM THE TERRAIN BEING PHOTOGRAPHED. MANUFACTURERS OF SENSITIVE PHOTOGRAPHIC MATERIAL CONTINUED TO IMPROVE EMULSIONS TO A POINT WHERE PRACTICALLY ALL LIGHT RAYS HAVE AN EFFECT ON SENSITIVE PHOTOGRAPHIC BASE AND THIS RESULTANT BASE IS KNOWN AS PANCHROMATIC.

WHILE PANCHROMATIC FILM IS SENSITIVE TO ALL COLORS, BY NO MEANS DOES IT RECORD COLORS IN THE SAME MANNER AS DOES THE HUMAN EYE. IT IS STILL SENSITIVE TO A MUCH GREATER EXTENT TO THE BLUE, VIOLET, AND PARTICULARLY TO THE ULTRA-VIOLET RAYS WHICH ARE INVISIBLE, THAN IT IS TO THE GREEN OR RED. SINCE THE LIGHT RAYS REFLECTED BY AERIAL HAZE ARE PREDOMINATELY BLUE, VIOLET, AND ULTRA-VIOLET, OBVIOUSLY SOME METHOD MUST BE USED TO ABSORB THESE RAYS TO ENABLE US TO MAKE A PHOTOGRAPHIC RECORD OF DETAIL ON THE GROUND. THE PREDOMINATE COLORS OF GROUND DETAIL ARE GREEN AND YELLOW. IT WILL BE RECALLED THAT YELLOW IS A COMBINATION OF GREEN AND RED. SINCE MOST OF THE DETAIL WHICH WE WISH TO PHOTOGRAPH IS COMPOSED OF SOME SHADE OR COMBINATION OF GREEN AND RED, IT IS OBVIOUS THAT OUR FILM MUST BE SENSITIVE TO THESE COLORS. SINCE THE OBSTACLE TO CLEAR PHOTOGRAPHY OF GROUND DETAIL IS AERIAL HAZE, SOME METHOD MUST BE USED TO ABSORB ITS OBJECTIONABLE LIGHT RAYS. HENCE THE USE OF COLOR FILTERS.

COLOR FILTERS ARE MADE OF STAINED GLASS OR GELATIN AND ARE USUALLY PLACED IN FRONT OF THE CAMERA LENS ON A SPECIAL MOUNT. IN AERIAL PHOTOGRAPHY FILTERS GENERALLY USED FOR ELIMINATING THE EFFECT OF HAZE ARE COLORED YELLOW. BY REFERRING TO THE PREVIOUS PARAGRAPH ON THE ABSORPTION OF COLORS, IT WILL BE SEEN THAT AN OBJECT WHICH APPEARS YELLOW IS ONE THAT ABSORBS THE BLUE LIGHT RAYS. THEREFORE, A YELLOW FILTER WILL ABSORB THE BLUE, VIOLET, AND SOME OF THE ULTRA-VIOLET RAYS REFLECTED BY THE HAZE, AND PERMIT THE RED AND GREEN RAYS TO PASS THROUGH AND TO BE RECORDED ON THE FILM. THE PERCENTAGE OR DEGREE OF ABSORPTION DEPENDS ON THE SHADE OF YELLOW USED. GELATINE FILTERS MAY BE INSERTED BETWEEN THE FRONT AND REAR LENS ELEMENTS OF THE CAMERA, OR THEY MAY BE MOUNTED BETWEEN TWO PIECES OF OPTICAL GLASS, AND FASTENED AS A UNIT OVER THE LENS BARREL AND IN FRONT OF THE LENS.

SINCE A FILTER ABSORBS SOME OF THE TOTAL LIGHT IT IS NECESSARY TO GIVE A LONGER EXPOSURE FOR A GIVEN TYPE OF FILM THAN WOULD BE NEEDED IF THE EXPOSURE WERE MADE WITHOUT A FILTER. EXPOSURES MADE WITH A DARK YELLOW FILTER REQUIRE MORE TIME THAN THOSE MADE WITH A LIGHT YELLOW FILTER. PANCHROMATIC FILM EMULSIONS ARE MADE FOR A VARIETY OF USES, AND ARE NOT SENSITIVE TO THE VARIOUS COLORS TO THE SAME DEGREE. IN THE PAST, THE INCREASED EXPOSURE NECESSARY IN USING A FILTER FOR AERIAL PHOTOGRAPHY WAS OF SOME CONSEQUENCE, RESULTING AT TIMES IN UNDER-EXPOSURE. IN THE LAST TWO YEARS, HOWEVER, MANUFACTURERS OF AERO FILM HAVE SO IMPROVED THE SPEED OF THEIR PRODUCTS THAT THE NORMAL INSTANTANEOUS EXPOSURES USED IN AERIAL WORK ARE QUITE SUFFICIENT EVEN WITH THE DARKER YELLOW FILTERS USED FOR EXTREME HAZE PENETRATION.

IT SHOULD NOT BE ASSUMED, HOWEVER, THAT THE FILTERS NORMALLY USED IN AERIAL PHOTOGRAPHY ABSORB ALL THE BLUE AND VIOLET RAYS. THEY DO, HOWEVER, ABSORB A SUFFICIENT PERCENTAGE OF THE OBJECTIONABLE RAYS TO PERMIT CLEAR PHOTOGRAPHY UNDER NORMAL CONDITIONS. IF EXTREMELY DARK YELLOW, ORANGE, OR RED FILTERS ARE USED, THE TOTAL AMOUNT OF BLUE VIOLET RAYS ABSORBED IS INCREASED, BUT THIS WILL INCREASE THE NECESSARY EXPOSURE TO THE POINT WHERE IT WILL NOT BE POSSIBLE TO PHOTOGRAPH FROM A MOVING AIRPLANE. FURTHERMORE, IF THE FILTER USED IS DARKER THAN IS NECESSARY TO PENETRATE THE HAZE PRESENT, THE RESULTING PHOTOGRAPH IS LIKELY TO BE OVER-CORRECTED FOR COLOR. IN AN OVER-CORRECTED PHOTOGRAPH THE YELLOW OF CLAY SOIL IS OVER-EMPHASIZED AND THE APPEARANCE OF THE PHOTOGRAPH IS OF EXCESSIVE CONTRAST.

CONSIDERABLE EXPERIMENTAL WORK HAS BEEN DONE IN LONG RANGE AERIAL PHOTOGRAPHY BY THE USE OF FILM WHICH IS SENSITIVE TO THE INFRA-RED RAYS, AND FILTERS WHICH ABSORB PRACTICALLY ALL THE RAYS EXCEPT INFRA-RED. THE INFRA-RED RAYS ARE AT THE END OF THE SPECTRUM OPPOSITE THE ULTRA-VIOLET AND LIKE THE LATTER, THEY ARE INVISIBLE. ONE OF THE CHARACTERISTICS OF INFRA-RED RAYS IS THEIR POWER TO PENETRATE HAZE TO AN ALMOST UNLIMITED EXTENT. IN AERIAL PHOTOGRAPHY, ADVANTAGE OF THIS CHARACTERISTIC HAS BEEN TAKEN TO MAKE OBLIQUE PHOTOGRAPHS OF THE EARTH AT EXTREME DISTANCE BY USING INFRA-RED FILTERS. THE INFRA-RED FILTERS ARE VERY DARK RED IN COLOR, AND FILTER OUT OR ABSORB SO HIGH A PERCENTAGE OF ALL VISIBLE LIGHT RAYS THAT OBJECTS CAN NOT BE SEEN THROUGH THEM. WHEN INFRA-RED FILM IS USED, HOWEVER, DETAIL AT DISTANCES OF OVER THREE HUNDRED MILES HAS BEEN PHOTOGRAPHED. DETAIL AT SUCH DISTANCES IS OF COURSE INVISIBLE, DUE TO THE HAZE BETWEEN THE VIEWER AND THE OBJECT. IN INFRA-RED PHOTOGRAPHY, EITHER OF GREAT DISTANCES, OR COMPARATIVELY NEAR-BY LANDSCAPES, WE HAVE A GOOD EXAMPLE OF OVER-CORRECTION IN COLOR. THE BLUE SKY PHOTOGRAPHS BLACK BECAUSE OF THE ABSENCE OF INFRA-RED RAYS AND THE LEAVES OF TREES AND GRASS PHOTOGRAPH ALMOST WHITE BECAUSE THE CHLOROPHYLL OF PLANT LEAVES HAS A VERY HIGH REFLECTING POWER FOR INFRA-RED. BECAUSE OF THIS OVER-CORRECTION, AND ALSO BECAUSE SUCH EXTREME HAZE PENETRATION IS NOT NECESSARY, NO ATTEMPTS HAVE BEEN MADE TO USE INFRA-RED FILM OR FILTERS FOR VERTICAL WORK.

THE GREAT AMOUNT OF AERIAL MAPPING BEING COMPLETED UNDER THE MANY VARIABLE CONDITIONS AT THE PRESENT TIME HAS MADE THE PROBLEM OF SECURING AVERAGE NEGATIVES OF THE SAME DEFINITION AND QUALITY A SERIOUS ONE. MOST OPERATORS HAVE FOUND THAT A LIGHT YELLOW FILTER SUCH AS AN "AERO ONE" IS SUITABLE UNDER EXCEPTIONALLY CLEAR CONDITIONS AND THAT A MUCH HEAVIER FILTER KNOWN AS THE "MINUS BLUE" IS NECESSARY UNDER AVERAGE OR EXTREMELY HEAVY HAZE CONDITIONS. IN WESTERN UNITED STATES THE LIGHTER FILTERS ARE USUALLY ALL THAT IS NEEDED. IN THE EASTERN UNITED STATES MOST COMPANIES STANDARDIZE ON THE "MINUS BLUE" SINCE IT IS DIFFICULT TO DETERMINE THE EXACT AMOUNT OF HAZE VISUALLY AND EVEN THOUGH THE "MINUS BLUE" GIVES OVER-CORRECTION AT CERTAIN TIMES OF THE YEAR BETWEEN LIGHT COLORED FIELDS AND DARK WOODLANDS, THE HAZE IS NOT PHOTOGRAPHED. EXPERIMENTAL WORK IS BEING CONDUCTED AT THE PRESENT TIME WITH THE USE OF GREEN FILTERS WHICH WILL ALLOW MORE GREEN COLOR FROM WOODLANDS AND GRASS FIELDS TO PHOTOGRAPH. THIS WOULD BE A DECIDED STEP IN PHOTOGRAPHIC APPEARANCE IN THE SUMMER TIME, BUT THE RESULTS AT THE PRESENT TIME HAVE NOT BEEN CARRIED TO A DEFINITE DETERMINATION OF THEIR VALUE.