The photography of a diesel fuel spray

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SUBJECT The Photography of a Diesel Fuel Spray

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ISSUED TO

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SUMMARY

In order to photograph the fuel-spray from a Diesel engine fuel injector an optical bench and spark system were set up. Since this arrangement is suitable for many such applications, the apparatus and technique are described in some detail. The spark power supply is not described, since it has been superceded by an improved unit.

1. REQUIREMENTS

The requirement arose to photograph the spray of fuel as it left the injector nozzle of a large Diesel engine, in order to see if the use of cold or hot fuel led to any visible difference in the form of the spray.

Since the spray was being injected at pressures of the order of 2000 psig, its velocity was high, and extremely short photographic exposures were needed, with an adequate quantity of light to give a good exposure on high contrast fine-grain film. The image on the film had to be at least life-size, so that a reasonable degree of enlargement would reveal the details of the spray. Finally, the exposures had to be made precisely at the same time in the injection cycle, so that all the pictures would show comparable development of the spray.

2. DESCRIPTION OF APPARATUS AND METHOD

These conditions were met by using a back-lighting system of the type described by North, of NPL (1) together with a spark illumination circuit designed by Wadsworth, triggered by a cam and microswitch assembly. These units were mounted on a plywood optical bench made for the purpose, which enabled the electrical and optical systems to be adjusted at leisure, away from the Diesel injection rig.

The synchronization of the spark was obtained by putting a cam on the injector rig flywheel, and allowing it to strike a microswitch which closed the spark-firing circuit. The microswitch was mounted on a leadscrew so that it could be moved, and fire the spark earlier or later relative to the fuel-spray timing. A push-button switch was put in series with the microswitch so that although the microswitch made contact on each cycle of the injector, with the injector rig running at 275 rpm it was possible to fire the spark only once on each test run, and so avoid getting a multiple exposure on the negative.

With this arrangement, the experiment was carried out in several separate phases.

In the first place the optical system was lined up, using the light of the projection lamp, to obtain the most uniform field of illumination possible. Since the light from this lamp was focused on the spark gap, and the image here used as the light source of the main optical system, this should assure that the projection lamp or the spark could be used alternatively without any further adjustment of the system. Extremely careful alignment of the various optical elements was necessary to achieve this, however, after which the various lens mounts and spark unit were fixed in position by pouring molten paraffin wax around them and allowing it to set without disturbing them.

A wire loop was then set up on the bench to simulate the spray, and the camera carefully focused on the wire loop. Test photographs of this loop were then taken with spark illumination to verify the suitability of the negative material, slit size, definition, etc. These negatives confirmed that 5" x 7" contrast process ortho cut film met the requirements, and that the 10,000 volt spark of approximately 1/10 microsecond duration gave sufficient light. Provision had been made for firing the spark in an Argon atmosphere for added luminosity at the expense of a longer exposure, but this proved unnecessary.

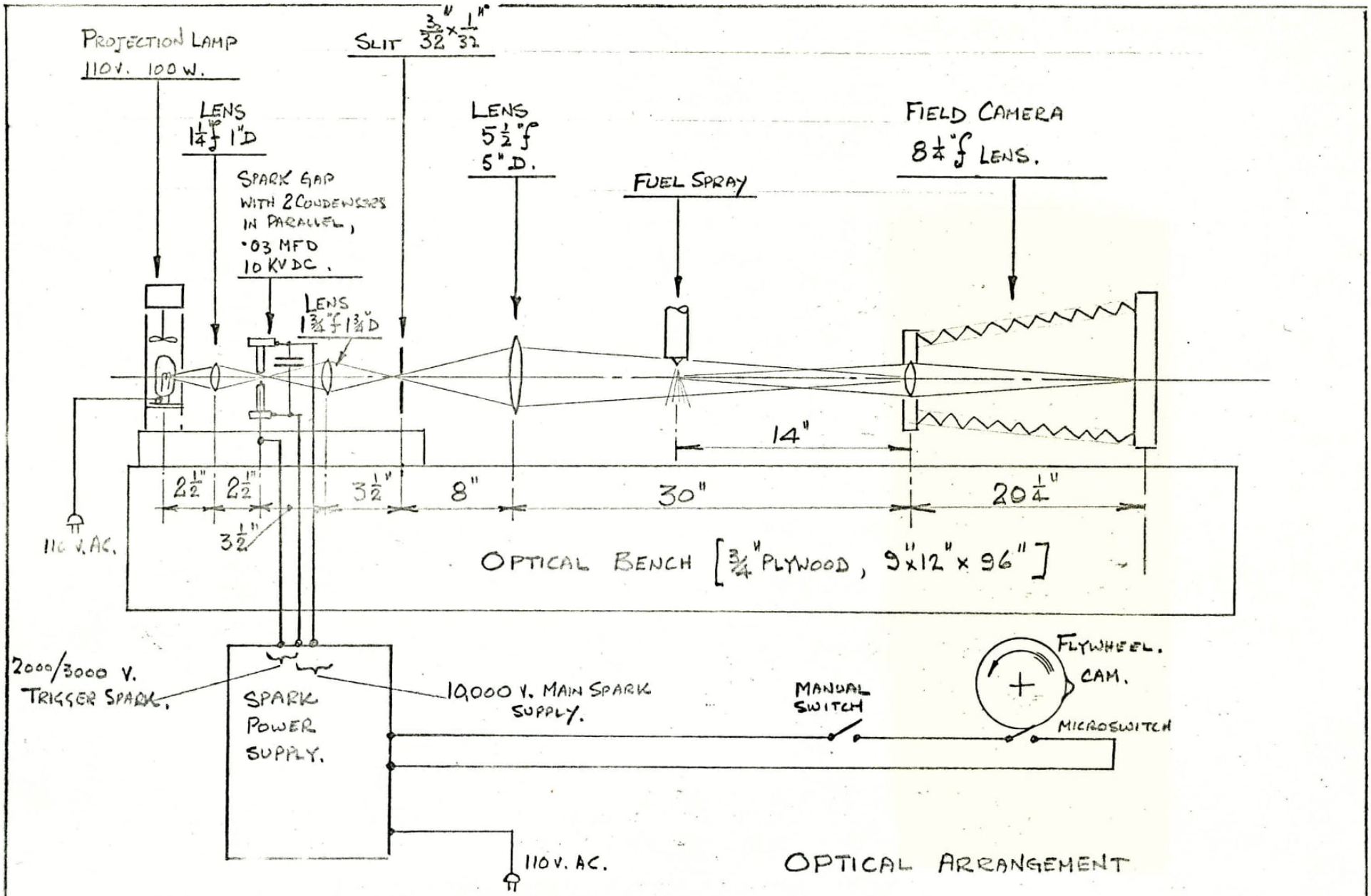
The optical bench was then put in position on the injector spray rig, so that the fuel spray coincided exactly with the wire loop already referred to. The cam-operated microswitch was then put into the firing circuit. With the manual firing button held "on" and the rig running, the repeated flashes showed the spray clearly on the camera viewing screen. As the flash timing was altered by adjusting the leadscrew, the spray could be seen in the various phases of its development.

Finally, with the microswitch locked at the optimum timing position, a series of photographs was exposed, first with cold fuel, and then under identical conditions except that the fuel was heated to 180°C before injection.

The interesting areas of the 5" x 7" negatives were printed 6 x full size, and revealed the structure of the spray in some detail.

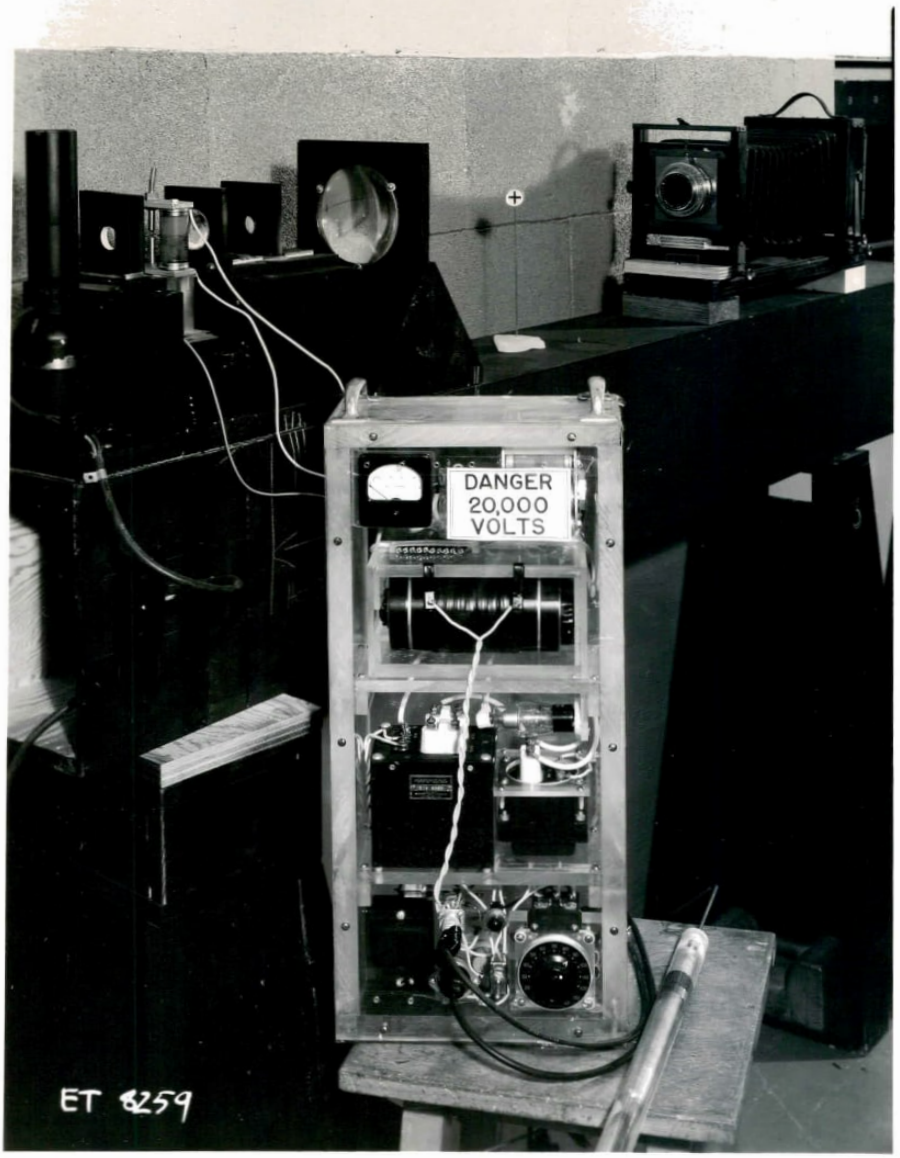
REFERENCE

North, R.J. - Proc. 5th Int. Congress on High Speed Photography - p.489 - 1962.



OPTICAL ARRANGEMENT FOR SPRAY PHOTOGRAPHY.

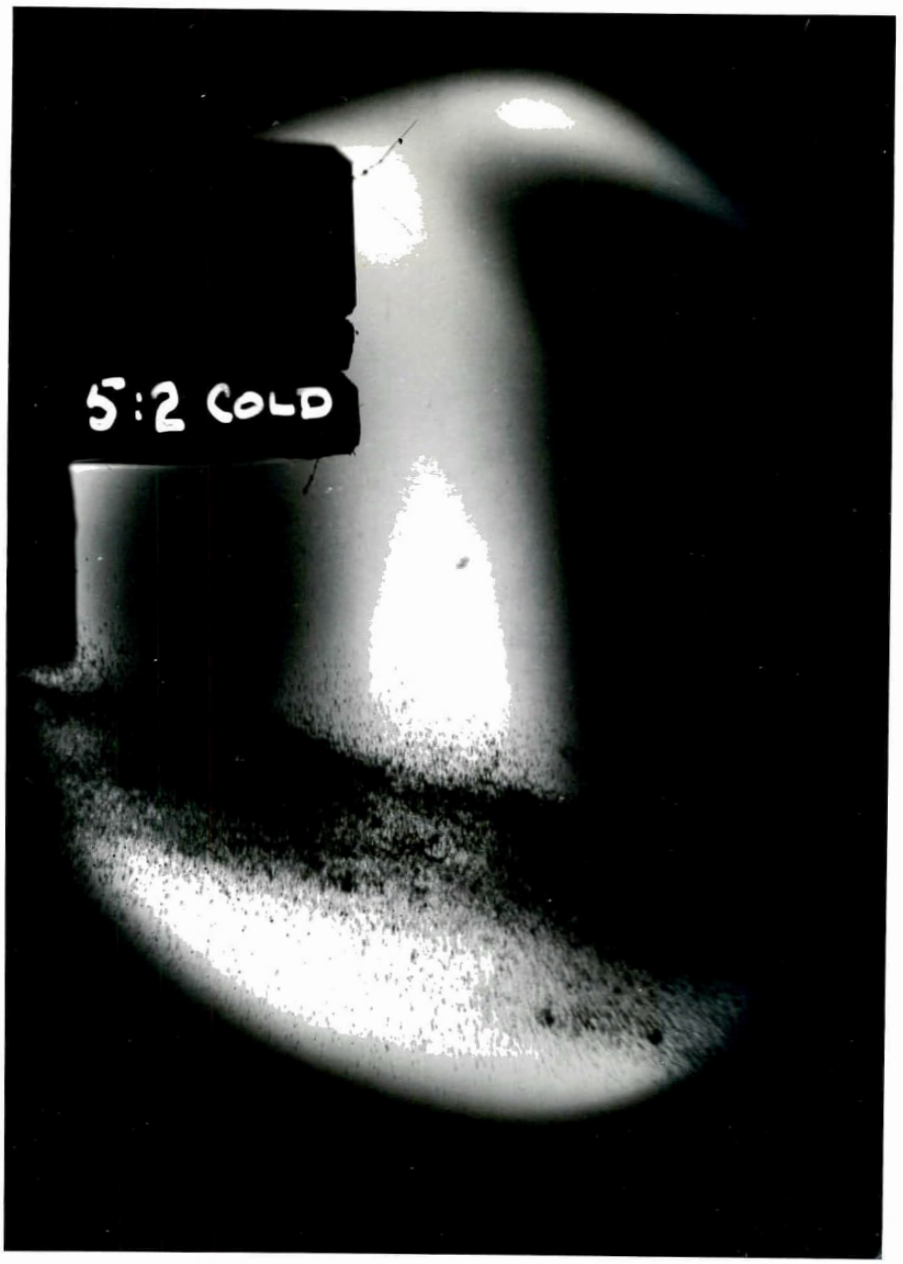
Fig. 1.



OPTICAL BENCH & LIGHT UNIT.

[SPRAY IS PLACED AT POINT ⊕ .]

FIG. 2.



TYPICAL SPRAY PHOTO.

FIG. 3.