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SPEEDMETERS

By: E B Thomson

Introduction

This short article describes the features of an early laboratory model of the new optical speedmeter which is now undergoing development by The Marconi Company. The information given herein is supplementary to the demonstration and includes an outline of the broad principles of the new design concept.

History and Experience

It could truthfully be said that vehicle speed measurement concerning private motorists is quite a tricky business - a phrase of thought-provoking ambiguity, for there is certainly no trickery in doppler radar! Often in roadside checks the speeding motorist appears to be completely unaware of his true speed and may be vehement in denial. It is the steadfast denials which have led us over the years into not so joyful affrays in court to hear all sorts of arguments put forward in defence. Statistically speaking, the authorities have seldom lost the case, proof indeed of official confidence in the accuracy and reliability of the radar speedmeter Marconi PETA (Portable Electronic Traffic Analyser). However, certain sparse but highly publicised successes for the other side have spotlighted the pitfalls encountered by the use of slant-angle doppler radar, the technique of which offers admirable scope for imaginative counsel. The main theme put in counter-evidence is that the radar beam by its oblique incidence on surfaces and the inviolate laws of reflection, may have bounced off a fence, or parked vehicle, or 'suitably' placed object,thence being redirected to another moving but faster vehicle. Better still, is to suggest erroneous speed readings on PETA, much higher than true, caused by a double-bounce effect; twice off the defendant's vehicle but the first bounce to and back from a stationary object.

The tantalizing feature of these suppositions is that anyone who is familiar with the safeguards built into PETA and its restrictive range capability knows that it just didn't happen. But so proving is quite another story!

Moreover, in court debate it sometimes seems that the radar considerations outweigh, or merge into obscurity, the opinion of police observers that the vehicle in question was travelling well above the prescribed speed limit.

PETA has been in continual use by police forces in the UK since 1964 and as a vehicle speed measuring system has withstood adverse critical comment extremely well. So much so that it is nowadays seldom, if ever, challenged in terms of its basic accuracy and any condemnation is aimed at its mode of use in practical situations.

Having reached this mellow state it would be some comfort, from our point of view, if by the force of circumstances we had to continue with PETA for an undefined period in the future. This cannot be, for police users regard the equipment, in an era of small devices, as cumbersome and inconvenient to set up at the roadside. Hence they are seeking, through the appropriate Police Committees, a compact portable instrument which is easy to read and operate. (We are also guided in this respect by the Scientific Advisory Branch.)

Dimensions and Facilities

A fact of life regarding doppler radar speedmeters, of the slant-radiation type, built to a technically acceptable standard of performance, is that the dimensions of the 'box' are mainly determined by the high gain, narrow beam,aerial which is of slotted waveguide construction. The higher the frequency of operation of the radar - PETA works in X band (7 - 11.5 GHz) - the smaller the aerial may become, although it is only reduced in inverse proportion to the operating

frequency. Thus for speedmeters operating in J band (11.5 - 18.5 GHz), a more difficult frequency "performance-wise", the aerial size is not much reduced.

However, from a technical viewpoint more important than instrument size is the choice of technique, bearing cost in mind, to be employed for vehicle speed measurement. It must be said that CW slant-angle doppler radar is extensively used in several countries, perhaps for lack of any other acceptable method. The thought occurs that controversy may be less potent elsewhere than in our legal courts. To reduce legal controversies one continental manufacturer resorts to considerable complexity in speedmeter design, but at relatively high cost. British police have standardized with PETA,and on the Continent two models of speedmeter, both of the CW slant-angle doppler radar type, are particularly well known. One, the Multanova referred to above, is highly sophisticated in design and versatile in operation and offers photographic and hardcopy recording amongst other facilities, but is much more costly than PETA. The instrument is of Swiss manufacture and makes use of beam-bouncing off the road surface to effectively disregard the presence of vehicles in traffic lanes adjacent to that under scrutiny.

The other speedmeter is the SFIM (France) Mesta which is not unlike PETA in format and price but has digital instead of meter scale readout of speed.

The USA has many different models of doppler radar instruments but these differ in practical operation from PETA,since their beams are aimed straight down the road,whereas the beam of the Marconi instrument is directed at 20 degrees to the road's axis.

Operational trials arranged by the Directorate are at present taking place, by courtesy of the Chief Constables of several forces, with both Multanova and Kustom Prefect equipment (the latter is a straight-down-the-road model of USA manufacture) to evaluate the various facilities of these instruments.

In looking for a successor to PETA we invited industry to propose compact speed measuring systems and from the subsequent proposals selected an optical concept put forward by The Marconi Company. The optical system is presently undergoing Home Office funded development in the Marconi laboratories and depends on optical sensing of movement combined with electronic processing for the speed readout. It has several prospective advantages over CW doppler radar for this application and these will be listed later.

Principle of Operation of Optical Speedmeter

At this comparatively early stage in the development, due to be completed in April 1972, it would be unwise to go beyond the basic principles, the design details of which are constantly under review.

We should begin by thinking of a camera aimed straight across the road. The focussed image of passing vehicles will flit across the image plane of the camera at a speed directly determined by the diminishing product of the actual speed of the vehicle and the magnification (much below unity) of the camera lens. For a fixed lens magnification this premise is true only if the camera is insensitive to variations in the distance between the passing vehicles and the camera. Distance compensation, obviously valid only over declared limits but with ample tolerance, is achieved by making the object (vehicle) appear to be at infinity even though the object-image distance is no more than a few tens of feet. This is an application of the telecentric principle used particularly in microscopy to measure image size against a calibrated scale without parallax error. (By one version of this technique an aperture stop, as exit pupil, is placed at the second focal plane of the lens. The stop will admit only light rays, from an object in front of the lens, that are parallel or nearly parallel to its axis. The entrance pupil is then effectively at infinity.)

The aperture stop in the speedmeter consists of a number of parallel-spaced vertical slits in a thin plate behind which is placed an optical grating of vertical orientation located at the image plane. The grating and aperture stop are parallel aligned to one another. Since both grating and aperture stop will alternately admit and cut off rays of light from the moving image a flicker effect will be seen behind the grating. The flicker is known as the spatial frequency and when sensed by a photo-electric cell, provides a means of measuring the speed of the vehicle image from which the true vehicle speed is derived. After suitable filtering the output of the photo cell is an electrical analogue of the vehicle speed and is easily processed to give a speed read-out. There are ideas to deal with the various factors relating to vehicles in motion such as body vibrations, vertical displacements, wheel rotation, etc.

Prospective Features/Advantages of the Optical Method

a For daylight use no energy of any sort is radiated, ie the system is passive. In consequence battery power conservation is significant. An illuminating source, probably of invisible infra-red light, could be used after nightfall.

b The field of view when looking straight across the road is much more confined than slant-angle doppler radar.

c It should be possible, using range finding methods and/or change of optics, to measure only the speed of vehicles in a selected traffic lane of a multi-lane road and also to d scriminate between directions of traffic flow.

d Errors in the setting-up alignment, possibly on a tripod, will only impart negative error (lower) in speed reading.

This is of psychological value only since, although errors caused by incorrect setting-up of PETA may in practice be either positive or negative, they are not really accountable in magnitude. Alignment calibration factors for PETA and the optical speedmeter are, respectively, Cos 20° and Sin 90°. It will be seen that for the new meter any deviation around 90° which represents its alignment angle to the axis of the road, gives less error and does not alter its sign.

e The speedmeter, when transported in a vehicle and pointed downwards at the road surface, will effectively monitor the speed of that vehicle.

f If placed in permanent installations underneath bridges spanning motorways, it will enable speed checks to be carried out on under-passing vehicles in selected lanes.

g The instrument promises to be compact, probably about 1/6 cubic foot in volume.

Conclusion

As stated earlier, the new optical equipment is still at a fairly early stage of development, and design changes are almost inevitable. Nevertheless, as the subject is of general interest it was considered desirable to include this brief paper, even at the risk of later correction being necessary. In the event of significant design changes before that occasion, an amendment sheet will be issued at the Leicester Exhibition.