

Symposium: Radar Speedometers

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SYMPOSIUM: RADAR SPEEDMETERS*

PART I

THE SCIENTIFIC RELIABILITY OF RADAR SPEEDMETERS

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INTRODUCTION

The increasing use of radar speedmeters for the apprehension of drivers who exceed the speed limits on our streets and highways is cause for inquiry as to the mode of operation, accuracy, and reliability of this new method of measuring the speed of a moving object. How does the radar method work, what technical problems arise in the use of this equipment, and what operational procedures are recommended in using the radar speedmeter? In trying to answer these questions we shall begin with a brief discussion of the problem of making a measurement of speed, then show how speed may be measured by application of the principles used in the radar speedmeter, next take up the matters of over-all accuracy and reliability of the meter, and finally discuss the operational use of the meter.

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THE MEASUREMENT PROBLEM

The problem is to measure the speed of a vehicle moving with respect to a stationary observer. The making of any measurement requires that there be a standard of reference, a means of comparing the quantity to be measured with this standard of reference, and an observer. How accurately the comparison is made depends upon the means of measurement and the care and judgment of the observer. For example, if we try to measure the length of a fifty-foot stone wall with a linen tape we find that on dry days the length as measured by the tape is slightly less than it is on damp days, when the tape may have shrunk. On the other hand, if we measure the length of the wall with a steel tape, whose length will change only a negligible amount with variations of temperature and not at all with changes of humidity, we have a more accurate measure of the length of the wall. As another example, the accuracy of measurement of an interval of time depends upon the kind of clock used and upon the care of the observer in starting and stopping the clock at the right instants. Similarly, the accuracy of measurement of the speed of a vehicle on the highway by means of a speedometer in another vehicle depends upon how accurately the speedometer has been checked and upon how carefully the patrolman can maintain a constant, safe distance behind the speeding vehicle while he reads the speedometer. The method of measuring speed with a speedometer is a method accepted by the courts. The acceptance of this method is based on two premises:

- (1) That the speedometer is accurate, and
- (2) That the patrolman knows how to make the measurement.

Hence, in the method of measuring speed by radar the only scientific questions that arise are:

- (1) How accurate is the method, and
- (2) Does the observer know how to make the measurement with the radar speedmeter?

Accordingly, let us examine the principles of method.

PRINCIPLES OF THE RADAR METHOD

The word *RADAR* is made up from the capitalized letters in the set of words, *R*adio *D*etection *A*nd *R*anging. Thus, a radar method is one that may be used to detect the presence of a target and determine the distance of that target from the radar set. Radar methods can also be used to obtain information on the bearing of a target, its altitude, and speed. In all the methods electromagnetic energy in the form of radio waves is radiated from the antenna of the transmitter of the radar set so as to "illuminate" the target; when the target is thus illuminated, it reflects a certain portion of the energy back to the receiver of the radar set. Searching the sky for a target by means of a radar set is like scanning the sky at night with a searchlight. If a part of the light sent out by the searchlight comes back to our eyes, we say that something in the sky is reflecting the light, and we deduce from this fact that in the sky there is a cloud or airplane acting as a reflector. All this is a roundabout way of saying that we see a target. In a similar way a radar set is said to "see" a target.

There are several different types of radar systems, all well described in books.¹ Some of the types are quite complex, providing a lot of information about the target; other types are simpler, giving less information. An example of the complex type of radar is the pulse radar set, which sends out pulses of radio waves and measures the time it takes for the pulses to go to the target and come back to the receiver. As the pulses travel at the speed of light, you can find out how far away the target is by multiplying the speed of light by one-half the time elapsing between transmission of a pulse and the reception of its echo. Here, an accurate method of measuring time in millionths of a second has to be incorporated into the radar set. Such a radar method can also give information on the bearing of a target and its angle of elevation in the same manner that a searchlight

¹ RIDENOUR, *RADAR SYSTEMS ENGINEERING*, c. 5 (New York: McGraw-Hill Book Co., Inc., 1947); *M.I.T. Radiation Laboratory Series, No. 1*; HALL, *RADAR AIDS TO NAVIGATION 105-110* (New York: McGraw-Hill Book Co., Inc., 1946); *M.I.T. Radiation Laboratory Series, No. 2*.

beam can, because all you have to know are the bearing and elevation of the radar beam.

In contrast to the complexity of the pulse radar method is the simplicity of the method that is used in radar speedmeters. With the speedmeter the radio waves do not move as short disconnected pulses, or groups of wave crests. Instead, the radio wave crests move out from the transmitting antenna continuously without break, and the number of them leaving the antenna each second is constant. The number of these wave crests leaving during each second is called the "frequency" of the radar transmitter. For an average radio broadcasting station the frequency of the main, or carrier, wave that brings music and the sound of voices into our radio receivers at home is about one million wave crests per second. For the radar speedmeter made by a well-known manufacturer the frequency is 2455 million wave crests per second. In scientific work our viewpoint with respect to wave motion is slightly different. Instead of thinking of the number of wave crests passing a point, we think rather of the total motion executed by a little particle as it goes up and down from trough to crest of the wave and back again, and we refer to this complete periodic motion as a cycle of events for the little particle. Accordingly we speak then in terms of cycles per second rather than wave crests per second. Thus the frequencies of the broadcasting station and the speedmeter are, respectively, one megacycle per second and 2455 megacycles per second, where a megacycle is equal to one million cycles.

This beam of radio waves that is leaving the transmitter of the speedmeter at constant frequency can be directed upon any object in the same way that the beam of a searchlight may be directed upon an object we wish to see. When this beam of radio waves strikes an object, part of the beam may be reflected back toward the receiver part of the speedmeter. If the object is stationary with respect to the radar speedmeter, then the frequency of the "echo" returned by the object to the receiver is exactly the same as the frequency of the beam of radio waves sent out by the transmitter. But if the object is moving with respect to the transmit-

ter, then the frequency of the echo will be different from the frequency of the transmitted beam. If the object — in this case a vehicle — is moving toward the speedmeter, then the frequency of the echo will be greater than that of the transmitter; and if the object is receding from the speedmeter, the frequency of the echo will be less than that of the transmitter. The change of frequency that occurs when the reflecting object is moving with respect to a source of constant frequency is an aspect of an effect that Christian Johann Doppler (1803-1853), an Austrian physicist, called attention to in 1842. The Doppler effect has long been used for measuring the velocity of stars with respect to the earth, light waves being of the same nature as radio waves, but of frequencies of the order of 500 million megacycles per second. More recently the effect has been used to measure the speed of airplanes² and even the height of an airplane above the ground.³ Indeed, the Doppler effect can be noticed for all kinds of motion of a wave-like nature, as for example, sound waves. We have all observed that when we drive past a car whose horn is blowing, the pitch, or frequency, of the sound of the horn falls suddenly just as we pass the car. As we go toward the horn the pitch appears to us to be higher than it actually is, and as we go away from the horn the pitch seems to be lower than it actually is. The same effect would be noticed if we were to remain stationary and the blowing horn were to move. Thus, the Doppler effect is an apparent change in the frequency of a vibration occurring when there is relative motion between the source of the vibration and the receiver of the vibration.

THE USE OF THE DOPPLER EFFECT FOR MEASURING SPEED

Let us suppose that an automobile is moving along the road toward a radar speedmeter from whose antenna radio waves are being emitted at the rate of 2455 million wave

² HALL, *RADAR AIDS TO NAVIGATION* 105-110 (New York: McGraw-Hill Book Co., Inc., 1946); *M.I.T. Radiation Laboratory Series, No. 2.*

³ CHANCE, HULSIZER, MACNICHOL, AND WILLIAMS, *ELECTRONIC TIME MEASUREMENTS* (New York: McGraw-Hill Book Co., Inc., 1947); *M.I.T. Radiation Laboratory Series, No. 20.*

crests per second. If the car were standing still it would receive 2455 million wave crests per second, but since it is moving it runs into some wave crests in one second that it would not have met until the next second had it been standing still. Hence, to the car the frequency of the transmitter seems to be slightly greater than 2455 megacycles per second. Because it is reflecting these wave crests back toward the receiver of the radar speedmeter the car becomes a moving source of waves of this slightly higher frequency. Since the car is now a moving source, the wave crest reflected at the end of a given second does not have to travel so far to the speedmeter as the wave crest reflected at the beginning of the second. The consequence is an apparent further increase in the frequency already slightly greater than 2455 megacycles per second. The result of these two increases in frequency can be expressed by a very simple, ideal formula as follows:

$$F_R = \frac{c + v}{c - v} F_T, \quad (1)$$

where F_R = the frequency of the radio waves received by the speedmeter receiver after reflection from the car

F_T = the frequency of the speedmeter transmitter

c = velocity of the radio waves

v = velocity of the car.

At first thought it would seem to be extremely difficult to measure the value of either F_R or F_T down to the last cycles per second in a number that already amounts to 2455 million cycles per second. Fortunately, however, there is another phenomenon, the use of which renders the task quite easy. This is the phenomenon of "beats", used by players of stringed musical instruments for tuning their instruments. If, for example, two adjacent keys on a piano are struck simultaneously, the combination of the two tones will have alternate increases and decreases in intensity, the throbbing of the sound being called "beats". The number of beats per second is equal to the difference of the frequencies of the two vibrating sources. In the same way that

beats occur with sound waves of different frequencies so can they also occur with radio waves or light waves of different frequencies.

In the case of the radar speedmeter the antenna will receive radio waves of two different frequencies. It will receive part of the energy of the radio waves being emitted by the transmitter at the frequency F_T , and it will receive part of the energy of the waves of frequency F_R reflected from the moving car. The beat frequency for these two waves will be $F_R - F_T$. Let us see the result of subtracting F_T from F_R , making use of formula (1).

$$\begin{aligned}
 F_R - F_T &= \frac{c + v}{c - v} F_T - F_T \\
 &= \frac{c + v}{c - v} F_T - \frac{c - v}{c - v} F_T \\
 &= \frac{c + v - c + v}{c - v} F_T \\
 F_R - F_T &= \frac{2v}{c - v} F_T. \tag{2}
 \end{aligned}$$

For convenience let us denote $F_R - F_T$ by F_D , where the subscript D stands for difference or Doppler. Further, let us observe that v , the velocity of the car, is very much less than c , the velocity of radio waves. For a car going sixty miles per hour, the value of v is one-sixtieth mile per second, while the value of c is 186,281 miles per second. Hence, we may drop the v from the denominator of the right side of equation (2) because it is negligibly small compared with c . Our modified formula is now

$$F_D = \frac{2v}{c} F_T, \tag{3}$$

and we see that for all practical purposes F_D , the number of beats per second between the transmitted and received waves, is directly proportional to v , the velocity of the car. A further manipulation gives

$$v = \frac{1}{2} \frac{F_D}{F_T} c, \tag{4}$$

so that we now have the velocity of the car given directly in terms of the beat frequency, the frequency of the transmitter, and the velocity of radio waves. Let us use some numbers in formula (4) to see the simplicity of the calculation. Suppose that F_D is found by measurement to be 500 cycles per second, and suppose that the frequency of the speedmeter transmitter is 2455 million cycles per second. The speed of radio waves is known to be within one or two miles per second of 186,281 miles per second; the speed in miles per hour would be the speed in miles per second multiplied by the number of seconds in an hour, or 186,281 times 3600. The speed of the car will then be given as follows:

$$v = \frac{1}{2} \times \frac{500}{2,455,000,000} \times 186,281 \times 3600 = 68.3 \text{ miles per hour.}$$

Table I shows values of speed of a vehicle corresponding to various values of the number of beats per second as counted by the speedmeter.

Table I

F_D (beats per second)	v (miles per hour)
1	0.14
10	1.37
100	13.7
200	27.3
300	41.0
400	54.6
500	68.3
600	82.0

A calculation made by letting v equal one mile per hour in equation (3) will show that there will be 7.31 beats for each mile per hour of speed of the vehicle, so that for a car going sixty miles per hour, the beat frequency will be 438.6 cycles per second.

From the foregoing it is clear that the speed of an oncoming vehicle may be measured by use of the Doppler effect provided that there is a way of counting the beats. Hence, we come to a brief description of how the beat frequency is measured, after which we will be in a position to

discuss the answers to the questions on accuracy of method and knowledge required by the observer to make the measurement.

MEASUREMENT OF THE BEAT FREQUENCY

The receiving antenna of the speedmeter receives radio waves of frequency F_R reflected from the moving vehicle, and it also receives a part of the radio waves of frequency F_T emitted by the transmitting antenna. The combination of the waves of the two different frequencies produces in the antenna a small current of high frequency and of an amplitude that varies comparatively slowly, that is, at the beat frequency. This small current passes through a crystal detector, producing a small voltage of the order of a few thousandths of a volt varying in amplitude at the beat frequency. This small voltage is then amplified about one hundred times in a preamplifier. The output voltage of the preamplifier is applied to a section of the electronic circuit that further amplifies the beat wave and in addition transforms the wave shape from a smooth type of variation, such as characterizes the ripples on a pond, into a square type of wave resembling the end-on view of a series of parallel walls with vertical sides, all of equal width and each separated from the next by a distance equal to the width. This squared-off voltage wave now passes to an electronic frequency meter,⁴ whose output voltage is applied to a vacuum tube voltmeter. The reading of the vacuum tube voltmeter may appear on either an ordinary indicating meter or an ordinary recording meter. This voltage reading is a measure of the beat frequency and accordingly of the speed. To make the final meter read in terms of miles per hours it is necessary only to graduate a scale in such terms and affix it to the meter. All sections of the entire beat frequency meter — crystal detector, preamplifier, squarer, frequency meter, vacuum tube voltmeter, indicating and recording instruments — are made according to conventional design procedure.

⁴ELMORE AND SANDS, *ELECTRONICS* 250 (New York: McGraw-Hill Book Co., Inc., 1949).

ACCURACY OF THE METHOD

In discussing the accuracy of any method of measurement we attempt to state the tolerances involved in the final result. For example, if we measure the length of a fifty-foot wall quickly with a six-inch pocket rule the answer we get might be in error by as much as six inches; that is, the result might be 49.5 feet or 50.5 feet. The error, then, is six inches in a length of 600 inches, which is equivalent to one part in one hundred, or one per cent. If the length of the wall is known to be fifty feet, then the error in measurement, or tolerance, is one per cent. With a steel tape the length of the wall can easily be measured to within one-quarter inch, so that the error is now one-quarter inch in 600 inches, or one part in 2400. We say that we know the length of the wall to within about 0.04 per cent. Hence, in assessing the accuracy of a method of measurement we evaluate the tolerances in the individual parts of the method, add them all together to see what the maximum possible tolerance is, and then claim that the method can be used to make the measurement to within the tolerance found.

To find the tolerances for the radar speedmeter we begin by considering equation (4),

$$v = \frac{1}{2} \frac{F_D}{F_T} c, \quad (4)$$

The questions are how closely can F_D be measured, how closely is the frequency of the transmitter held at F_T , and how closely do we know the value of c . The value of c is known to be within one or two miles per second of 186,281 miles per second, so that the tolerance in c is at the most about two in 200,000, or 0.001 per cent. The frequency of the transmitter can be set to within 0.05 per cent of 2455 megacycles per second. The characteristics of the oscillating circuit of this transmitter are such that if its frequency were to try to shift more than about 0.1 per cent, the circuit would not oscillate. Hence, the tolerance for F_T is very small. With regard to the measurement of F_D , small errors

can result from changes in the voltage of the battery used to supply electric power to the part of the system involving the squarer, the frequency meter, and the vacuum tube voltmeter. However, there are provisions for adjusting the speedmeter to read correctly after it has been set up "on location" so as to take account of changes of battery voltage. The operator has merely to note from time to time whether or not the pointer on the indicating or recording instrument stands at zero when no vehicle is moving within the operating zone of the speedmeter. If the pointer does not stand at zero he makes it do so by a simple mechanical adjustment. A consideration of all possible changes in final reading of the instrument due to changes in battery voltage leads to the conclusion that the speedmeter will read speeds to within two miles per hour. Compared with this, the one-thousandth per cent tolerance in c and the one-tenth per cent tolerance in F_T , equivalent to 0.06 mile per hour for v equal to 60 miles per hour, are negligible.

Another factor affecting the accuracy of measurement has to do with the actual application of the instrument rather than with technical aspects of the instrumentation. Ideally, formula (1) is valid when the direction of motion of the car is along the line of sight between the car and the speedmeter. As such a condition is not usually possible, there is an angle A between the direction of motion of the car and the line of sight, so that the value of v is more accurately given by formula (5) below,

$$v = \frac{1}{2} \frac{F_D}{F_T} \frac{c}{\cosine A} \quad (5)$$

The magnitude of the cosine A term may be seen from the following example. Assume that a car is 175 feet from the speedmeter, that it is traveling along the center line of a road 50 feet wide, and that the speedmeter is set up 10 feet from the edge of the road. Then the factor, cosine A , will be 0.98 for all practical purposes of calculation. If the speedmeter reads 70 miles per hour, the true speed of the car is 71.4 miles per hour. In actual practice the meter is placed closer to the road, but it will always read slightly less than

the true speed unless it is directly in the path of the moving vehicle.

Certain additional technical questions arise as to the accuracy of the method, some of them having to do with the speedmeter itself, others having to do with the operational use of the method. For example, the meter should be allowed to warm up for a period of five to ten minutes before being put to work. The operating zone of the meter covers a span of about 200 feet along the road, so that a car may enter this zone at that distance and stay within the view of the meter until it is almost abreast of it. After a car enters the zone it takes the meter about one-fifth second to respond. As regards possible zero shifts arising after the meter has been properly set up and which have not been adjusted out by the operator, the effect is additive. For instance, if the pointer of the meter reads five miles per hour with no car in its zone, and if then it reads 65 miles per hour when a car passes through, the actual speed of the car is 60 miles per hour. Diathermy apparatus in the vicinity can give false readings, which would be noticed as sudden jumps to say seven miles per hour at switching-on of the diathermy machines, and sudden drops back to zero at switching-off. While such effects can be zeroed out, their intermittent nature more or less precludes the value of doing this, and the operator would do well simply to note when the effect is present or absent in making his speed measurements.

An important feature of the speedmeter is that it will read the higher of the speeds of two cars running simultaneously through the zone at different speeds. If two cars are running abreast of each other at the same speed through the zone the speedmeter cannot tell which car is being observed, but its reading will be the speed of either of them. It is then up to the operator to ascertain that the cars are traveling abreast of each other. If one is passing the other the speedmeter reads the higher of the two speeds. This raises the question of what happens if a car is going through the zone in the other direction. The meter reads the speeds of both oncoming and receding vehicles with equal ac-

curacy. However, a car traveling along the other side of the road, going in a direction opposite to that of the cars being observed, will be father away when it is in the operating zone of the meter than one in the lane being observed, and will reflect back a much weaker signal than that coming from an approaching car. The effect due to receding cars can be largely eliminated by keeping the speedmeter within about three feet of the edge of the road and by pointing its beam more or less down the lane being observed. On recording meters there is a difference between the records of approaching and receding vehicles, when a certain orientation of the speedmeter is used.

Swinging signs, swaying trees, and flying birds can give momentary small readings of five to twenty miles per hour, but the readings are of short duration and can be properly interpreted; in any event their effect is not additive, owing to the property of the meter that it reads the highest velocity it observes.

As to aging of the parts, the general long-time effect would be for the speedmeter to read less than actual values. All in all, the cumulative effect due to decrease of battery voltage during operation, the gradual wearing out of vacuum tubes, and the use of the meter at the side of the road instead of in the direct path of a vehicle, is an indicated speed that is less than the true speed by one or two miles per hour.

The accuracy of the meter can be measured in the laboratory without recourse to any specialized equipment. As was seen in equation (4) the meter is in essence a beat frequency meter, whose readings are given in miles per hour instead of in beats per second. Thus, any electronic audio oscillator, whose frequency range has been properly checked, can be used to check the readings of the speedmeter. For example, when an alternating voltage of 500 cycles per second is applied at the proper points in the meter, the indicator should read 68.3 miles per hour. However, as the speedmeter has a radio transmitter, its operation comes under the jurisdiction of the Federal Communication Commission, which requires that any person who

does work on the transmitter possess a first or second class commercial radio operator's license. In view of this requirement, all such checking of accuracy of the speedmeter is best left in the hands of one legally qualified to do so.

OPERATIONAL USE OF THE METER

Having discussed the question of general accuracy of the method, we come to the question of the knowledge required by the observer to use the instrument. In the opinion of the author the average person engaged in traffic control work can learn to use the radar speedmeter after about one and one-half to two hours of instruction. He need not know the details of design and construction any more than he needs to know those of the speedometer on his patrol car. It should be assumed that he has been provided with an instrument of sufficient accuracy; after that, proper and adequate use of it depends upon his care and judgment.

Accordingly, from a scientific point of view, the author recommends certain operational procedures as far as the speedmeter and its use are concerned. Such procedures include the checking of the speedmeter before and after use in each location, the keeping of records, and other details.

It is important to check the meter for accuracy each time it is set up for use; if the meter is to be used at two sites in one morning then it should be checked at each site to avoid the contention that the meter was thrown out of adjustment during transit. The meter should be checked before the beginning of the period of observation of a highway and at the end of the period. In scientific work it is usual to assume that if a given instrument reads correctly at the beginning and ending of a set of measurements, its readings during the interval were also correct. The check can be made by having a car with calibrated speedometer run through the zone of the meter twice, once at the speed limit for the zone and once at a speed ten or fifteen miles per hour greater. As the test car goes by the meter the driver can notify the operator of the meter what his speed is. If the difference between the speedometer reading and the radar meter reading is more than two miles per hour,

steps should be taken to see why this is the case and to remedy the matter. Such a test naturally requires a periodic checking of the speedometer of the test car. If such a procedure is carried out each time the radar meter is set up, the check measurements made with the automobile speedometer become supporting evidence.

It is highly advisable to record all pertinent information regarding an observation at the time it is made because of the difficulty of remembering details. It is therefore desirable to use a recording meter for speed measurements. Good scientific procedure requires the following information to appear on the recording chart: date and time of starting a test; name of the operator of the meter; names of other observers and their duties; number of the speedometer; number of the car in which the meter is installed; the weather conditions. All of this can be written down in less than a minute; its entry at the time of observation can save hours of wrangling later. When it is decided that a given car is to be apprehended the meter operator should put a pencil mark beside the speed indication on the recording chart paper as he watches the car go by, call out over the radio telephone to his partners the speed, color, and kind of car, some part of the license number if possible, and then write on the chart paper this information and the time and his initials. These notes should be corroborated by the persons in the apprehending car by telephone so that all details get completely entered. Thus, the speed indication recorded on the chart will have permanently associated with it the details essential in making the charge. Similar information should be entered on the chart when check runs are made. At the end of each day the chart record for the day should be rolled up, have a tag affixed to it bearing the date of the record, and be placed in a safe. A log book should be kept to show the location, date, times of beginning and ending of observation of traffic, names of all patrolmen concerned, and the speed limit at the location. Records should not be kept on scrap paper and then copied, for errors may be made in copying. If errors are made in writing down information, a line should be drawn through

the incorrect parts, and corrections entered with a notation as to why they were made and by whom. It is recommended that the operator of the meter and the people in the apprehending car be within sight of each other so that the operator of the meter can see the apprehended car and signal ahead whether or not the right car has been stopped.

CONCLUSION

The Doppler effect has been used for approximately a century for the determination of the speed of stars, and for over a decade for measuring the speed of airplanes and finding their height above the ground. Now this effect is being used for the measurement of the speed of objects traveling over the ground. The relation between the speed of an object with respect to a radar speedmeter and the Doppler beat frequency is direct. A speedmeter has been constructed with the use of a number of conventional electronic sections so as to give a reading of speed within one or two miles per hour of the actual speed. The value of the evidence it can furnish will depend largely on how carefully that evidence was correlated with other supporting evidence at the time it was obtained.

PART II

RADAR GOES TO COURT

HERBERT R. BAER*

"RADAR AHEAD!" Automatically the motorist releases the pressure on his accelerator. Rightly or wrongly he has been advised that somewhere ahead there lurks a scientific ogre manned by officers of the law and prepared to condemn him to penal action should its super-human eye detect a violation of the speed limit. However ignorant he may be of the scientific processes which activate the monster reported to wait him, the average motorist pays respect to its reputed powers to determine the speed of a moving object more accurately than the human eye unaided by electrical or mechanical contrivances. Nevertheless, opposition to the use of evidence of speed gained through radar equipment has been made both in and out of court.¹

With the development of each scientific advance the courts have been confronted with the problem of whether

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¹ Radar evidence of speed was objected to for various reasons and with varying results in the following cases which are listed in the order in which they were decided: *State v. Moffitt*, 100 A. 2d 778 (Del. Super. Ct. 1953); *People v. Offerman*, 204 Misc. 769, 125 N. Y. S. 2d 179 (Sup. Ct. 1953); *People of City of Rochester v. Torpey*, 204 Misc. 1023, 128 N. Y. S. 2d 864 (Monroe County Ct. 1953); *People v. Katz*, 205 Misc. 522, 129 N. Y. S. 2d 8 (Ct. Spec. Sess. Yonkers 1954); *People v. Sarver*, 205 Misc. 523, 129 N. Y. S. 2d 9 (Ct. Spec. Sess. New Rochelle 1954); *People of City of Buffalo v. Beck*, 205 Misc. 757, 130 N. Y. S. 2d 354 (Sup. Ct. 1954) and *State v. Dantonio*, 31 N. J. Super. 105, 105 A. 2d 918 (1954). The details and rationale of these cases will be discussed later in this article.

While much has appeared in the newspapers both for and against the use of radar speed detectors and legislative halls have resounded to vocal support and attacks on the use of radar, the basis of objection seems to have been not only the possibility of inaccuracy of the instrument or inept use by its operator but the "unfairness" of the speed violator being caught by an apparatus hidden from his view. Thus H. B. No. 183, introduced in the 1955 General Assembly of North Carolina, among other things provides that officers operating speed checking devices on the highways do so in "full view" of motorists.

It is not the purpose of the author to discuss the merits or demerits of the hidden aspect of radar. See reference to this characteristic in *State v. Moffitt, supra*. Suffice it to say that it seems to this writer that if it appeared that someone was stealing chickens nightly from a hencoop the best way to catch the culprit or culprits would not be to light up the hencoop and put an officer outside in full view, but would be to have an officer in hiding to catch the thief when he thought the coast was clear for his illegal operation. To place the officer in full view would most likely drive the culprit to some other hencoop not so well protected.

or not the story told by the scientific apparatus or process in question is to be presented to those who must ultimately determine the fact. The problem before the courts is three-fold: (1) Should the data as revealed by the scientific instrument or process be received in evidence; (2) as a prerequisite to its receipt must expert testimony be introduced as to the theory, operation and accuracy of the device or process in question; and (3) what weight or value is to be according such data if received?

No one today would think of ruling out evidence offered by even a lay witness that he weighed a certain article and it weighed ten pounds. Being assured that the witness carefully read the scale the most that would be required would be evidence that the scale was in accurate working order and properly used for the purpose in question. Similarly, a witness is without serious objection, or any objection whatsoever, permitted to testify that at the time of a specific event he observed the speedometer of the car in which he was riding and that it recorded a speed of fifty miles per hour. In the average case opposing counsel would not call for evidence that the speedometer was in accurate working order. Why, then, should there be any question about the admissibility of testimony by a police officer to the effect that the reading of a radar speedometer in his control and in proper working order showed the speed of a given car subject to observation by the radar device and the officer to be so many miles per hour?

The answer would seem to be that radar is something comparatively new, that its method of operation is not within the understanding of the bulk of the people, that the purported ability of radar to accurately determine the speed of a moving object through unseen electrical impulses is so far beyond the comprehension of the average person that there is a reluctance to condemn on such evidence, and that the radar process is such that error in the instrument or improper handling by its operator could easily produce a false testimonial conclusion. With variable degrees this same sort of hesitancy to admit has evidenced itself in other instances of scientific achievement.

Thus, the use of fingerprints as a means of identification has been recognized by our courts to have existed before Christ,² but it was only in 1905 that fingerprint evidence was first introduced in an English trial.³ In 1893, long before the fingerprint method of identification was in general use by our police departments, Mark Twain in his novel *Pudd'nhead Wilson* had attorney Wilson graphically describe the conclusive character of fingerprint identification in his address to the court and jury.⁴ Wilson's fingerprint evidence acquitted his own clients and convicted Twain's fictional personage Tom Driscoll, but the first actual conviction in the United States based on fingerprint identification did not occur until 1906⁵ and the first appellate court decision in this country passing on the admissibility of fingerprint evidence did not appear until 1911.⁶ Today no one questions the admissibility of such evidence as a means of identification merely because it is now generally, if not universally, accepted that no two persons will have the same fingerprint.⁷

² *Stacy v. State*, 49 Okla. Cr. 154, 157, 292 Pac. 885, 887 (1930), where the court said, "From an examination of the authorities . . . it appears that an allusion to fingerprint impressions for the purpose of identification is referred to in writings as early as 650 A.D., and they are traced back to a period some 100 years before Christ. Fingerprints were first used as a manual seal to give authenticity to documents. . . . In conformity to decisions of the courts in many states, we take judicial knowledge that there are no two sets of fingerprints exactly alike."

³ WIGMORE, *THE SCIENCE OF JUDICIAL PROOF* 280 (3d ed. 1937), where the author refers to the trial of the Strattons as discussed in S. T. Felstead's "Sir Robert Muir, a Memoir" at p. 186 (1927).

⁴ TWAIN, *PUDD'NHEAD WILSON* c. XXI, p. 192, "These marks [fingerprints] are his signature, his physiological autograph, so to speak, and this autograph cannot be counterfeited, nor can he disguise it or hide it away, nor can it become illegible by the wear and mutations of time . . . this signature is each man's own — there is no duplicate of it among the swarming populations of the globe! * * * Upon this haft [of the murder dagger] stands the assassin's natal autograph, written in the blood of that helpless and unoffending old man who loved you and whom you all loved. There is but one man in the whole earth whose hand can duplicate that crimson sign."

⁵ See Laufer, *History of Finger-Print System*, ANNUAL REPORT, SMITHSONIAN INSTITUTION 631 (1912). In this article the author shows that the art of fingerprint identification was known in great antiquity by the Chinese and brought over by them into India.

⁶ *People v. Jennings*, 252 Ill. 354, 96 N. E. 1077 (1911). In allowing the fingerprint evidence the court recognized the case as one of first impression in the appellate courts of the United States, but noted that such evidence had been approved by the appellate courts of Great Britain, India and certain European countries.

⁷ See *State v. Tew*, 234 N. C. 612, 68 S. E. 2d 291 (1951). For a most interesting article on the history and development of the art of fingerprinting

In determining whether or not evidence of speed gained through the use of the new scientific device of radar is to be admitted, it behooves us to consider the philosophy which has motivated the courts in allowing into evidence the results obtained through other scientific devices or processes. The second appellate court decision in the United States which sanctioned the use of fingerprint evidence was *State v. Cerciello*.⁸ There the New Jersey court said:

"In principle its admission as legal evidence is based upon the theory that the evolution in practical affairs of life, whereby the progressive and scientific tendencies of the age are manifest in every other department of human endeavor, cannot be ignored in legal procedure, but that the law, in its efforts to enforce justice by demonstrating a fact in issue, will allow evidence of those scientific processes which are the work of educated and skillful men in their various departments, and apply them to the demonstration of a fact, leaving the weight and effect to be given to the effort and its results entirely to the consideration of the jury."^{8a}

That the law shall keep pace with science is in short the philosophy expressed by the New Jersey court. No one would deny that principle. But if the alleged scientific device or process is still in the experimental and unproved stage, the law with its inherent conservatism will reject the evidence. What is experimental and unproved today becomes demonstrable and a fact tomorrow. What was asserted by a minority yesterday is proclaimed by the majority today.

If the development of the scientific instrument or process has not yet reached the stage that it is either generally or universally accepted as reliable in the particular field to which it belongs, it is necessary that expert testimony be introduced which will assert its reliability before the ultimate results shown by the instrument or process will

see Polson, *Fingerprints and Fingerprinting*, 41 J. CRIM. L. & CRIMINOLOGY 495, 690 (1950-51). For an earlier article describing the science of fingerprinting and the gradual acceptance of fingerprint identification evidence by appellate courts see Inbau, *Scientific Evidence in Criminal Cases, Fingerprints and Palm-Prints*, 25 J. CRIM. L. & CRIMINOLOGY 500 (1934-35).

⁸ 86 N. J. L. 309, 90 Atl. 1112 (1914).

^{8a} *Id.* at 314, 90 Atl. at 1114.

be admitted in evidence. At this stage of the development of the scientific device or process it is readily conceivable that contrary expert evidence will be offered which will assert the unreliability of the scientific instrument or process in question. The mere fact that there is this contradiction in the expert opinion on the subject does not in itself mean that the evidence shall not go to the jury. As in every other instance of dispute on the facts the jury will be asked to pass upon the validity of the expert testimony. Thus in *McKay v. State*,⁹ which involved a prosecution for driving while intoxicated, an expert called by the state testified that in his opinion the Harger breath test for determining intoxication was accurate and reliable. He admitted that there were others who disagreed with the accuracy of the test. In sustaining the admission of the expert's testimony the court said:

"Dr. Beerstecher testified that the instrument in question is accurate and he gave his reasons for it. He admitted that there are others who disagree with its accuracy. The objection to his testimony, therefore, goes to its weight and not to its admissibility."^{9a}

On motion for rehearing the court further said:

"It is shown that some of the states use this Harger test while others do not; that some scientists refuse its recognition while others accept it as reliable. . . . [W]e think that the reluctance of the jurisprudence of some of the states to accept such a conclusion based on that test goes to the weight thereof rather than its admissibility."^{9b}

If the scientific device or process is in fact reliable, it eventually passes through the period of doubt and conflicting expert opinion and reaches the point of general, if not universal acceptance by those learned in the field. It may go still further and be accepted as reliable not only by those learned in the field but by the public in general. The most frequently asserted principle is that before the court should admit into evidence the results shown by the scientific

⁹ 155 Tex. Cr. R. 416, 235 S. W. 2d 173 (1950).

^{9a} *Id.* at 421, 235 S. W. at 175.

^{9b} 155 Tex. Cr. R. 416, 422, 235 S. W. 2d 173, 176 (1950).

device or process in question, it must appear that the said device or process has gained "general acceptance" in its particular field. Thus in *Frye v. United States*¹⁰ the court said:

"Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, *the thing from which the deduction is made* must be sufficiently established to have gained *general acceptance in the particular field in which it belongs.*"¹¹ (Italics supplied.)

If in this day of rapidly advancing scientific progress the courts are to keep pace with science, they must take judicial notice of that which is generally accepted as true by those learned in the scientific fields in question. They cannot wait until every single individual acquiesces in the scientific truths acknowledged by those skilled in the particular science. How can the judge know what the status of acceptance of a scientific device or process is among those learned in the field? Of course he can take expert testimony in each case and inquire from the experts as to the acceptance of the device or process.¹² He might resort to the encyclopedia and scientific treatises on the subject.¹³ He might

¹⁰ 293 Fed. 1013 (D. C. Cir., 1923).

¹¹ *Id.* at 1014.

¹² When the expert is produced, he may explain the device or process and certify to its general acceptance for reliability by those skilled in the science, or he may, without explaining the operation of the device or theory of the technique, certify that it is generally recognized as accurate and reliable by those learned in the field.

¹³ It is a well established principle of the doctrine of judicial notice that the matter in question need not be such common knowledge that it is known by the public in general. Nor need it be within the actual knowledge of the judge. The court may inform itself of the facts, theories and conclusions which have come to be established and accepted by the specialists in the areas of the scientific knowledge in question. To inform itself the court may refer to encyclopedias and scientific treatises or pamphlets and other sources which can be deemed authoritative. See *Dwinnell-Wright Co. v. National Fruit Product Co.*, 140 F. 2d 618 (1st Cir., 1944) and 9 WIGMORE, EVIDENCE §256 (3d ed., 1940).

For the convenience of those wishing to inform themselves by reading a scientific article on Radar Speedmeters there is published in this *Law Review* at 343, *supra*, an article by Dr. John M. Kopper, a learned authority in the field. Dr. Kopper received his doctorate degree in Electrical Engineer-

attend some institute or be advised by a specially created ministry of justice as to the present status of various scientific discoveries.¹⁴ He might simply be told by the legislature that it in its own wisdom requires he admit the evidence.¹⁵ But surely he cannot bury his head in the sand and wait until the force of an aroused public opinion compels him to see and acknowledge that which by then has become the common knowledge of the street.

Today the use of photographs and x-rays is every day court practice. It was not always so. Thus, in *People v. Jennings*,¹⁶ our first reported case sustaining fingerprint evidence, the court said:

“When photography was first introduced it was seriously questioned whether pictures thus created could properly be introduced in evidence, but this method of proof, as well as by means of x-rays and the microscope, is now admitted without question.”^{16a}

A reference to photography requires that we consider the anomalous position of such evidence in the North Caro-

ing from Johns Hopkins and is currently on the staff of that University. For twelve years he taught electrical engineering both at the undergraduate and graduate levels including courses on automatic control. He has for years been and currently is engaged in electrical research and has on several occasions appeared in court as an expert witness on the science and nature of radar speedmeters. See, for example, *People v. Katz*, 205 Misc. 522, 129 N. Y. S. 2d 8 (Ct. Spec. Sess. Yonkers 1954), *People v. Sarver*, 205 Misc. 523, 129 N. Y. S. 2d 9 (Ct. Spec. Sess. New Rochelle 1954) and *State v. Dantonio*, 31 N. J. Super. 105, 105 A. 2d 918 (1954), in which cases Dr. Kopper's testimony was accepted by the court as establishing the accuracy and reliability of the radar speedmeter. In the *Sarver* case the court said, “On the evidence before the court, it conclusively appears that the radar or electronic speedmeter is an accurate and reliable instrument for the measurement of velocity”, 205 Misc. 523, — 129 N. Y. S. 2d 9, 13.

¹⁴ See Pound, *A Ministry of Justice as a Means of Making Progress in Medicine Available to Court and Legislatures*, 10 U. OF CHIC. L. REV. 323 (1942-43). Dean Pound suggested such an agency as a means of keeping the judicial profession abreast of medical science. Such institutions are available in European countries and are a means of keeping the judiciary informed in various scientific fields. See McDermott, *The Proof of Paternity and the Progress of Science*, 1 HOWARD L. REV. 40 (1955).

¹⁵ See, for example, N. C. GEN. STAT. §8-50.1 (1953) commented on in 27 N. C. L. REV. 456 (1949) where the North Carolina legislature in 1949 provided that in cases involving paternity the court shall under certain conditions admit evidence of the result of blood grouping tests. The statute makes no provision as to the weight to be given such evidence. Whether a negative finding of paternity on the basis of blood tests would require the setting aside of a verdict of paternity has not yet been decided in North Carolina.

¹⁶ 252 Ill. 534, 96 N. E. 1077 (1911). And see the opinion of Chief Justice Clark in *Lupton v. Express Co.*, 169 N. C. 671, 86 S. E. 614 (1915).

^{16a} *People v. Jennings*, 252 Ill. 534, 548, 96 N. E. 1077, 1082 (1911).

lina courts. In most states the photograph or x-ray is admitted as substantive evidence — that is, as proof of the fact to be established. In North Carolina the peculiar doctrine of not according photographs the standing of substantive evidence, but restricting their use to explaining or illustrating the testimony of the witness, runs into difficulty when the court is confronted with x-ray evidence. The theory of the North Carolina court in regard to photographs is that the witness refers to the photograph merely to illustrate his testimony and to make it more clear to the jury. The witness saw the object, the photo reveals a picture of the object, the witness states it is an accurate representation and through its use illustrates his oral testimony. But, the jury is admonished, the photograph is not to be considered substantive evidence.¹⁷

What happens when the x-ray is used?¹⁸ The witness has not seen through the skin and flesh of the individual

¹⁷ See *Hunt v. Wooten*, 238 N. C. 42, 76 S. E. 2d 326 (1953) where the North Carolina view is restated and cases are collected. See excellent article by Gardner, *The Camera Goes to Court*, 24 N. C. L. REV. 233 (1946) in which the North Carolina view of refusing to admit photographs as substantive evidence is criticized. See also McCORMICK, EVIDENCE 388 (1954) where the learned author in referring to the North Carolina distinction according photographs illustrative qualities but not substantive weight says, "It is believed that this distinction is groundless and that the photograph as part of the descriptive testimony is just as much substantive evidence as the testimony of a witness describing the features of a scene or object without a photograph would be. It may be correctly described as both 'illustrative' and 'substantive'."

¹⁸ It is worthy to note that while the courts are sometimes accused of being slow to accept the benefit of new scientific inventions, unusual speed in acceptance was shown in connection with the x-ray. The x-ray process was discovered by Professor William Konrad Roentgen of Wurtsburg, Germany in 1895. One year later x-rays photos were admitted in evidence in this country in *Smith v. Grant*, tried in the District Court of Colorado, First Division, on December 3, 1896. The opinion of Judge Lefevre, who sat as trial judge in ruling on the admissibility of the x-ray photos, is reported in 29 CHICAGO LEGAL NEWS 145, issue of December 26, 1896. Certain portions of this first ruling on the admissibility of x-rays are worthy of quotation. After noting that the x-ray differs from the normal photograph in that no one can certify that he saw what the x-ray shows, Judge Lefevre says:

"We . . . have been presented with a photograph taken by means of a new scientific discovery, the same being acknowledged in the arts and in science. It knocks for admission at the temple of learning and what shall we do or say? Close fast the doors or open wide the portals? . . . The law is the acme of learning throughout the ages. It is the essence of reason, wisdom and experience. . . . We must not, however, hedge ourselves round about with rule, precept and precedent until we can advance no further. Our field must ever grow as trade, the arts and science seek to enter in. . . . Let the courts throw open the door to all well considered scientific discoveries. Modern science has made it possible to look beneath the tissues of the human body and has aided sur-

to the bone beneath. It is not the eye of the witness that has penetrated to those depths but the eye of the x-ray. That instrument has revealed on the x-ray plate the break in the bone not discernible to the human eye. The doctor takes the stand, he testifies to the broken bone, not as he saw it, but as seen by the x-ray.¹⁹ The physician is unable [to] say, "I saw the broken bone as this x-ray illustrates", which is what the witness does when using the ordinary photograph. Instead he says, "I did not and could not see the bone to tell whether or not it was broken. But this x-ray photograph shows the bone is broken." Clearly the x-ray is being used as substantive evidence, and instead of the x-ray photo explaining and making clear the testimony of the witness to the jury as in the ordinary photograph case, the physician is explaining and making clear to the jury the significance of the x-ray itself. The position of the substantive and the explanatory is reversed.

In *Spivey v. Newman*,²⁰ the North Carolina court said:

"Expert evidence as to what a duly authenticated x-ray picture shows is undoubtedly admissible where it tends to aid the jury to understand the nature and extent of injuries involved in the action on trial."

Perhaps a realization by the court that necessity has compelled it to permit the use of x-rays as substantive evi-

gery in telling of the hidden mysteries. We believe it to be our duty in this case to be the first, if you please to so consider it, in admitting in evidence a process known and acknowledged as a determinate science. The [x-ray] exhibits will be admitted as evidence."

While the x-ray picture itself must, of course, be authenticated, *Spivey v. Newman*, 232 N. C. 281, 59 S. E. 2d 844 (1950), it is no longer necessary for a witness to testify to the reliability and trustworthiness of the x-ray process as such. Thus in *Call v. City of Burley*, 57 Idaho 58, 73, 62 P. 2d 101, 107 (1936), the court said:

"The science of X-ray skiagraphy is too well founded and generally recognized to render it any longer necessary for a witness to testify to the reliability and trustworthiness of X-ray skiagrams as such before admitting them in evidence."

See to similar effect *Lupton v. Southern Express Co.*, 169 N. C. 671, 86 S. E. 614 (1915) and 3 WIGMORE, EVIDENCE §795 (3d ed., 1940). See also *Scott, X-ray Pictures as Evidence*, 44 MICH. L. REV. 772 (1946).

¹⁹ With his usual aptness for Biblical quotation, Justice Clarkson in *Eaker v. International Shoe Co.*, 199 N. C. 379, 386, 154 S. E. 667, 671 (1930), illustrated the characteristic of the x-ray by saying, "The x-ray pictures are not like the man that looks in a glass. . . . 'For he beholdeth himself, and goeth his way, and straightway forgetteth what manner of man he was.' James 1:23, 24."

²⁰ 232 N. C. 281, 285, 59 S. E. 2d 844, 847 (1950).

dence to be explained by the witness, may some day lead to the abandonment of the "for illustrative purposes only rule" applied to other photographs.²¹

The importance of a consideration of the evidential value of x-rays in relation to radar is readily apparent. The x-ray through the use of electrical waves or impulses has revealed the broken bone, the imbedded bullet, etc., which the physician could not see. The radar through the use of radio waves has revealed the speed of an object which the unaided human eye and brain could not determine with any degree of accuracy. The lines and shadows on the x-ray plate disclose the broken bone or bullet; the calibrated needle or the permanent graph of the radar speedmeter reveals the speed of the passing car.^{21a}

Turning to another scientific development utilizing electric waves, we might mention the electro-encephalogram. Since its development in the late nineteen twenties and early thirties the electro-encephalogram has become well recognized in the field of medicine as a reliable apparatus for discovering the existence of brain injury. Through the use of electrodes applied to various portions of the subject's cranium tracings are made. By proper interpretation of the waves made by those tracings, brain injury can be discovered.

Epilepsy is one of the conditions which can be discovered by the use of the electro-encephalogram. In a British murder trial in the early nineteen forties, the defense was interposed that the killing was perpetrated while the accused suffered an epileptic seizure. It was important to establish the fact that the accused suffered from epilepsy. During his

²¹ There was a time, indeed, when the court itself gave an indication that it was prepared to abandon the distinction. Thus in *Simpson v. American Oil Co.*, 219 N. C. 595, 600, 14 S. E. 2d 638, 640 (1941), the court said, "The thin line between the substantive and auxiliary function of photographs in this connection which this Court seems still, on occasion, to regard, was not violated." And see *STANSBURY, NORTH CAROLINA EVIDENCE* 53 (1946).

^{21a} There are different types of radar speedmeters. On some there is a calibrated dial, as found on the usual automobile speedometer, and as the car passes through the radar beam the needle on the meter advances to a point showing the maximum speed of the car. Other types not only have the calibrated dial with the moving needle, but also have connected therewith a graph machine which records in permanent form a graph of the speed of the passing car. See detailed reference to this latter type of radar equipment in *State v. Dantonio*, 31 N. J. Super. 105, 105 A. 2d 918 (1954).

period of incarceration and surveillance following his arrest he suffered no such seizure. But an electro-encephalogram tracing was made of the individual which showed the accused was suffering from epilepsy. Upon this evidence being introduced, the jury returned a verdict of "guilty but insane".²²

More recently an American court has held that the trial judge must accept in evidence the testimony of a physician interpreting the tracing of an electro-encephalogram. Thus in *State v. Shiren*,²³ the accused was being prosecuted in a New Jersey court for driving while intoxicated. By way of defense the accused claimed he was not intoxicated but ill. In support of this position he offered the testimony of a neurologist to the effect that he had made an electro-encephalogram of the accused, and that the brain wave pattern as shown by that instrument revealed the accused was suffering from a disease of the brain. The trial court refused to allow this evidence. In reversing, the appellate court declared that the exclusion of the evidence of the encephalogram tracings as interpreted by the neurologist was a deprivation of substantial rights of the accused.

Not all scientific developments have received judicial recognition. Most prominent in the field which has thus far failed to meet with the approval of the courts is the polygraph, or lie detector. Although accepted by some trial judges rules of such tests have been systematically excluded by the appellate courts in the absence of a consent stipulation to their use.²⁴ Efforts to introduce into evidence results

²² *Middle Templar, From an Office Window*, 20 CAN. B. REV. 794, 798 (1942), where the author concludes by saying, "Thus the electro-encephalograph may save a man from being hanged for a crime of which he was not even conscious. The plea is accordingly put forward that the use of the electro-encephalograph should be allowed at the public expense in serious cases if the doctor certifies that there is a *prima facie* case for suspecting epilepsy."

²³ 15 N. J. Super. 440, 83 A. 2d 620 (1951). In discussing the principle to be applied to the admission of scientific evidence, the court quoted with approval what had been said in the fingerprint case of *State v. Cerciello* as found in the body of this article at note 8, *supra*.

²⁴ Illustrative cases cited in chronological order: *People v. Becker*, 300 Mich. 562, 2 N. W. 2d 503 (1942); *State v. Cole*, 354 Mo. 181, 188 S. W. 2d 43 (1945); *People v. Wochnick*, 98 Cal. App. 2d 124, 219 P. 2d 70 (1950) and *Henderson v. State*, 94 Okla. Cr. 45, 230 P. 2d 495 (1951). A discordant note is found in the concurring opinion of Justice Chappel in *Boeche v. State*, 151 Neb. 363, 37 N. W. 2d 593 (1949). The majority of the

obtained by the use of hypnosis or so-called truth serums as scopolamine and sodium pentothal have likewise met with failure.²⁵ Much has been written both for and against the use of the results of polygraph lie detector tests as evidence of veracity.²⁶ However, it seems to be generally agreed, even by the proponents of such evidence, that there is some area of inaccuracy or indefiniteness in the polygram patterns in from one to 25 per cent of the cases.²⁷

It is not the purpose of the writer to argue the merits or demerits of lie detector tests. It is sufficient at this point to show that not all scientific developments are accepted by the courts as sufficiently accurate to warrant their results being introduced in evidence. Whether the courts choose to reject such evidence on the theory that lie detectors have not gained a sufficient reputation for accuracy by those skilled in the science, or whether the courts exclude such evidence because of possibility of creating jury prejudice, is at this moment of no concern.²⁸ Suffice it to say that re-

court was adverse to admitting results of lie detector tests in evidence, but Justice Chappel thought this might be done in a proper case. Where the state and accused stipulated to the taking of a lie detector test and the introduction in evidence of the results obtained, the ruling of the trial court admitting such evidence offered on the part of the state was sustained in *People v. Houser*, 85 Cal. App. 2d 686, 193 P. 2d 937 (1948). For an opinion of a trial court ruling in favor of admission even in the absence of stipulation see *People v. Kenny*, 167 Misc. 51, 3 N. Y. S. 2d 348 (Queens County Ct. 1938). For an excellent discussion of the theory of the polygraph, its reputed accuracy, and complete listing of cases in which the appellate courts have passed on evidence obtained by lie detector tests up to the year 1953 see, Wicker, *The Polygraphic Truth Test and the Law of Evidence*, 22 TENN. L. REV. 711 (1953). See also the symposium which follows Dean Wicker's article in the aforesaid *Law Review*, pp. 728 to 774. Expert testimony as to the theory and accuracy of lie detector tests has not led to the admission of the results of such tests. See *Frye v. United States*, 293 Fed. 1013 (D. C. Cir., 1923) and *State v. Bohner*, 210 Wis. 651, 246 N. W. 314 (1933). Also in this connection see the annotation to *People v. Becker*, *supra*, in 139 A. L. R. 1174 (1942).

²⁵ See *Depres*, *Legal Aspects of Drug-Induced Statements*, 14 U. OF CHI. L. REV. 601 (1946-47); *People v. McNichol*, 100 Cal. App. 2d 554, 224 P. 2d 21 (1950); *State v. Lindemuth*, 56 N. M. 257, 243 P. 2d 325 (1952) and *Orange v. Commonwealth*, 191 Va. 423, 61 S. E. 2d 267 (1950).

²⁶ See INBAU, *LIE DETECTION AND CRIMINAL INTERROGATION* (2d ed. 1948). See also Wicker, *supra*, note 24; Streeter and Belli, *The "Fourth Degree": The Lie Detector*, 5 VAND. L. REV. 549 (1951-52); and Reid, *The Lie Detector in Court*, 4 DE PAUL L. REV. 31 (1954).

²⁷ See INBAU, *LIE DETECTION AND CRIMINAL INTERROGATION* 77 (2d ed. 1948). Mr. Inbau points out that although accuracy is found in 75 per cent of the cases, actual error is probably not present in more than 5 per cent, but that the remaining 20 per cent are of such indefinite character that no diagnosis can properly be made on the basis of the tracings.

²⁸ See the capable analytical discussion in MCCORMICK, *EVIDENCE* §174, particularly at page 373 (1954).

sults of lie detector tests are in general excluded whereas results of blood tests,^{28a} urine analyses,²⁹ fingerprints,³⁰ ballistic tests,³¹ x-rays,³² and electro-encephalograms³³ are generally admitted.

In the light of this situation we may properly ask in what category we are to place the results gained through the use of radar. To the author the answer seems clear. Radar falls in with the x-ray and related scientific developments. It deals with the physical fact of the defendant's speed and not with his mental processes. Its task is not to read the mind of the defendant, nor to explore whether or not he is withholding what he knows to be true and declaring that which he knows to be false. It is not concerned with his state of mind but only with the physical speed of the object he is driving.

It is not within the scope of this paper to discuss all the scientific devices and processes on whose evidentiary value the courts have been called upon to rule. The literature is abundant in the over-all field.³⁴ But rather it is thought

^{28a} Ladd and Gibson, *Legal-Medical Aspects of Blood Tests to Determine Intoxication*, 29 VA. L. REV. 749 (1942-43); Ladd and Gibson, *The Medico-Legal Aspects of the Blood Test to Determine Intoxication*, 24 IOWA L. REV. 191 (1939); and Rowell, *Admissibility of Evidence Obtained by Scientific Devices and Analyses*, 5 U. OF FLA. L. REV. 5 (1952). Several states have enacted statutes which establish standards of proof. Thus the New York statute provides, among other things, that fifteen hundredths of one per centum or more by weight of alcohol in blood is *prima facie* evidence that the defendant was in an intoxicated condition. N. Y. VEHICLE & TRAFFIC LAW c. 71, §70(5). A bill incorporating these provisions of the New York statute was introduced in the Senate of the North Carolina Legislature on February 25, 1955. For a very descriptive, diagrammatic illustration of the effect of various percentages of alcohol in the blood, see the illustrations in *Lawrence v. City of Los Angeles*, 53 Cal. App. 2d 5, 127 P. 2d 631 (1942). Case authority sanctioning the admission of evidence of blood tests to establish intoxication is abundant. It will suffice to cite the recent decision of *State v. Willard*, 241 N. C. 259, 84 S. E. 2d 899 (1954) to that effect.

²⁹ *State v. Slater*, 242 Iowa 958, 48 N. W. 2d 877 (1951); *State v. Cash*, 219 N. C. 818, 15 S. E. 2d 277 (1941); and *Toms v. State*, 239 P. 2d 812 (Okla. Cr. 1952).

³⁰ See note 7, *supra*.

³¹ WIGMORE, *THE SCIENCE OF JUDICIAL PROOF* §157 (3d ed. 1937) and Inbau, *Scientific Evidence in Criminal Cases, Firearms Identification — Ballistics*, 24 J. CRIM. L. & CRIMINOLOGY 825 (1933-34).

³² See note 18, *supra*.

³³ See notes 22 and 23, *supra*.

³⁴ See, for example, WIGMORE, *THE SCIENCE OF JUDICIAL PROOF* (3d ed. 1937); Rowell, *Admissibility of Evidence Obtained by Scientific Devices and Analyses*, 5 U. OF FLA. L. REV. 5 (1952), also reprinted in 6 ARK. L. REV. 181 (1952); and Smith, *Scientific Proof and Relations of Law and Medicine*, 10 U. OF CHI. L. REV. 243 (1943).

that a discussion of a few of the leading scientific discoveries will illustrate the principles heretofore applied and illuminate the path the courts should take and the pitfalls they should avoid in passing on the admissibility of radar evidence. We shall, accordingly, discuss but one more scientific process, namely the blood grouping tests as a means to establish non-paternity. We select this process both because it illustrates what one writer has called the "cultural lag"³⁵ of certain of our American courts, and because it raises most acutely the third aspect of the problem, namely, what weight is to be given to the fact established by the scientific device or process once it has been admitted in evidence.

Modern blood grouping had its origin with the discovery of human blood groups by Landsteiner in 1900.³⁶ Further discoveries in this area were made from time to time. The gist of these is that by blood grouping tests made of the mother, child and alleged father it may be affirmatively shown that the accused male is not the father. The test results will not exclude parentage in all cases. They will never prove parentage. But in many instances the groupings will incontrovertibly establish the impossibility of paternity of the child in question by the accused.³⁷

As early as 1924 German courts³⁸ admitted results of blood grouping tests as relevant evidence in paternity cases and, after the discovery by Landsteiner and Levine in 1927³⁹ of the previously unrecognized M and N factors in human blood, results of such tests were admitted in the high courts of England and the leading continental countries.⁴⁰ The

³⁵ Britt, *Blood-grouping Tests and the Law: The Problem of "Cultural Lag"*, 21 MINN. L. REV. 671 (1937).

³⁶ *Ibid.*

³⁷ See explanation of the process in detail as found in Hooker and Boyd, *Blood Grouping as a Test of Non-Paternity*, 25 J. CRIM. L. & CRIMINOLOGY 187 (1934-35) and as also found in Britt, *supra*, note 35.

³⁸ McDermott, *The Proof of Paternity and the Progress of Science*, 1 HOWARD L. REV. 40 (1955).

³⁹ Hooker and Boyd, *supra*, note 37.

⁴⁰ The appellate courts in Germany, Denmark, Sweden, Switzerland and Italy had accepted the results of blood grouping tests in evidence before any appellate court in this country did so. See Hooker and Boyd, *supra*, note 37. In the first reported case in New York, *Beuschel v. Manowitz*, 151 Misc. 899, . . ., 271 N. Y. Supp. 277, 281 (1934), the court quoted from an opinion of the Supreme Italian Court of Cassation, in which that court said:

"As regards the reliability of the results obtained by this method the latest studies and investigations show that though the determination

courts of the United States were not as quick to grasp the significance of blood grouping tests.

The first decision of a court of last resort in the United States on the admissibility of such tests in paternity cases was *State v. Damm*⁴¹ rendered by the Supreme Court of South Dakota in 1933. The accused requested that blood grouping tests be made of himself, the mother (who incidentally was his adopted daughter), and her child. A medical expert was called who testified to the ability of the tests to establish non-paternity in certain cases. The trial court had refused to order the blood grouping tests. In sustaining the conviction below the Supreme Court said:

"It appears that evidence as to blood tests in paternity cases has been accepted in Continental countries. We can find no record of the question being passed upon by any courts of last resort in the United States. . . . [W]e think it insufficiently appears that the validity of the proposed test meets with such generally accepted recognition as a scientific fact among medical men as to say that it constituted an abuse of discretion for a court of justice to refuse to take cognizance thereof, as would undoubtedly be the case if a court today should refuse to take cognizance of the accepted scientific fact that the fingerprints of no two individuals are in all respects identical." (Italics supplied.)⁴²

Thus the first decision of a court of last resort in the United States rejected what had for several years been accepted by the leading tribunals of Europe. The subsequent history of *State v. Damm* is noteworthy. A rehearing⁴³ was had in 1936 and then the same South Dakota Supreme Court appears to have caught up with scientific knowledge, for it said:

"We therefore say, without further elaboration or discussion, that *it is our considered opinion that the*

of the blood groups affords no positive evidence for a declaration of filiation in a given case, it does, on the other hand, furnish incontrovertible evidence for the exclusion of this relationship when the child's blood group does not agree, according to a definite scheme, with that of the supposed father."

⁴¹ 62 S. D. 123, 252 N. W. 7 (1933).

⁴² *Id.* at 132, 133, 252 N. W. at 11, 12.

⁴³ *State v. Damm*, 64 S. D. 309, 266 N. W. 667 (1936).

reliability of the blood test is definitely, and indeed unanimously, established as a matter of expert scientific opinion entertained by authorities in the field, and we think the time has undoubtedly arrived when the results of such tests, made by competent persons and properly offered in evidence should be deemed admissible in a court of justice whenever paternity is in issue." (Italics supplied.)⁴⁴

What German courts had accepted in 1924, what the South Dakota Supreme Court had rejected as inadequately established in 1933, becomes incontrovertible in 1936!⁴⁵ Shall we presume the conviction was reversed? No, let us not be too hasty, for the South Dakota court continues and says:

"Notwithstanding these views, however, we continue to believe that we were right in our former ruling . . . We are far from willing to say that it was error for a trial judge in South Dakota at the time of the trial of this case [1931] to fail or refuse to take judicial notice of the reliability of blood grouping tests."^{45a}

In the years following the aforesaid decision on rehearing of the South Dakota court, innumerable state courts took judicial notice of the scientific value of blood grouping tests to establish non-paternity, and evidence of such tests was admitted in case after case. Here and there, however, the light of scientific learning had not penetrated certain judicial minds, and thus we find that as late as 1949 the Supreme Court of Iowa in a bastardy proceeding referred to blood grouping tests in the following language:

"In this case the record is devoid of any evidence whatever showing general scientific recognition of the value of these tests. [The court, however, cited and presumably read the opinion on rehearing of the South Dakota court in *State v. Damm*.] Nor was it shown that at the present time the tests are of sufficient general acceptance for general scientific recognition as to be a matter of which the court would take judicial notice."⁴⁶

⁴⁴ *Id.* at 312, 266 N. W. at 668.

⁴⁵ If this article will aid some court in avoiding the embarrassing position in which the South Dakota court found itself in 1936, it will have served its major purpose.

^{45a} *State v. Damm*, 64 S. D. 309, 318, 266 N. W. 667, 671 (1936).

⁴⁶ *Dale v. Buckingham*, 241 Iowa 40, 43, 40 N. W. 2d 45, 47 (1949).

Partly to overcome such lapses of learning on the part of the judiciary, and partly to avoid them, the legislatures in many states have enacted statutes providing for blood grouping tests in paternity cases and for the admission of the results of those tests in evidence.⁴⁷

While the passage of these statutes has paved the way for the admission of the results of blood grouping tests they have not disposed of the third aspect of the problem, *i.e.*, what weight is to be given to test results which establish non-paternity? If the blood grouping tests establish that the accused could not have fathered the child in question, shall we permit a jury verdict to the contrary to stand and convict the defendant when the incontrovertible scientific data shows he could not have been guilty? It is here that our American courts are still at odds with one another.

Thus in 1946 in the much publicized bastardy case of *Berry v. Chaplin*⁴⁸ the California court permitted a verdict of the jury finding paternity on the part of the defendant Charles Chaplin to stand despite the fact that blood group-

⁴⁷ See, *e.g.*, N. C. GEN. STAT. §8-50.1 (1953), which provides:

"In the trial of any criminal action or proceedings in any court in which the question of paternity arises, the court before whom the matter may be brought, upon motion of the defendant, shall direct and order that the defendant, the mother and the child shall submit to a blood grouping test; provided, that the court, in its discretion, may require the person requesting the blood grouping test to pay the cost thereof. The results of such blood grouping tests shall be admitted in evidence when offered by a duly licensed practicing physician or other qualified person.

"In the trial of any civil action, the court before whom the matter may be brought, upon motion of either party, shall direct and order that the defendant, the plaintiff, the mother and the child shall submit to a blood grouping test; provided, that the court, in its discretion may require the person requesting the blood grouping test to pay the cost thereof. The results of such blood grouping tests shall be admitted in evidence when offered by a duly licensed practicing physician or other duly qualified person."

⁴⁸ 74 Cal. App. 2d 652, . . . , 169 P. 2d 442, 451 (1946). Note the following language of the court: "The report and the evidence of the physicians were not controverted by any scientific evidence but were before the jury to be considered with all of the other evidence in the case. . . . But the blood tests were not conclusive evidence. . . . When scientific testimony and evidence as to facts conflict the jury or the trial court must determine the relative weight of the evidence."

In a later case, *Hill v. Johnson*, 102 Cal. App. 2d 94, 226 P. 2d 655 (1951), the California court held it was error to admit the results of blood grouping tests showing the husband was not the father since it was contrary to a conclusive presumption of legitimacy where it was shown the husband had access to his wife during the period of conception, citing CAL. CODE CIV. PROC. §1962(5) which provides for the conclusive presumption.

ing tests indisputably showed the defendant could not have been the father. Similarly an Ohio court⁴⁹ held that blood grouping tests which showed the alleged father could not have been the parent were not entitled to conclusive weight, but were only to be considered with other evidence in the case.

More recently, however, the absolute injustice of convicting a man of bastardy in the face of evidence of properly conducted blood grouping tests establishing non-paternity has induced certain of our courts to set aside verdicts of guilty. Thus in 1949, the Supreme Judicial Court of Maine⁵⁰ declared that a jury verdict of paternity could not be permitted to stand when the evidence of blood grouping tests which had been properly and accurately made established that the defendant was not the father. To similar import is a decision of a New York court⁵¹ in 1950 where Justice Shientag remarked in his concurring opinion:

"The legislature has not thus far seen fit to make conclusive the blood grouping test where definite exclusion of paternity is established. Despite that, however, *the courts may not ignore the universal scientific opinion that such tests, resulting in exclusion, are, in fact, conclusive on the issue of paternity. . . .* Such scientific exclusion should, assuming the test to have been competently and accurately made, be accepted as conclusive by the trial court, notwithstanding the strength, as in this case, of the nonscientific testimony to the contrary."⁵² (Italics supplied.)

And thus we see our courts have travelled the complete gamut. From the holding by the South Dakota court⁵³ in 1933 to the effect that results of blood grouping tests were not entitled to be given consideration by the jury to estab-

⁴⁹ State v. Holod, 63 Ohio App. 16, 24 N. E. 2d 962 (1939). The results of the blood grouping tests were admitted under a state statute which, like that of North Carolina, made no provision for their conclusiveness.

⁵⁰ Jordan v. Mace, 144 Me. 351, 69 A. 2d 670 (1949).

⁵¹ Commissioner of Welfare v. Costonie, 277 App. Div. 90, 97 N. Y. S. 2d 804 (1st Dep't 1950). See also United States v. Shaughnessy, 123 F. Supp. 674, 676 (S. D. N. Y. 1954), where by way of dictum the court said: "Blood tests, properly taken, can absolutely exclude the possibility of paternity in certain cases." For further discussion of this aspect see McDermott, *supra*, note 38.

⁵² 277 App. Div. 90, . . . , 97 N. Y. S. 2d 804, 806 (1st Dep't 1950).

⁵³ *Supra*, note 41.

lish lack of paternity, we arrive at the holding of the Maine⁵⁴ and New York⁵⁵ courts in 1949 and 1950 that not only are the blood grouping tests to be considered but they are conclusive when they establish lack of paternity notwithstanding a jury verdict to the contrary.

In the light of the foregoing discussion showing the responses of the courts as to the evidentiary value of various scientific devices and processes, we shall now examine in detail the few reported cases in which the courts have ruled upon the admission of evidence of speed determined by a radar speedmeter. Some of these are decisions of trial judges and others are opinions of appellate courts. We shall consider them in chronological order.

The first of the reported cases is *State v. Moffitt*.⁵⁶ The report consists of the charge given by a Delaware trial judge in September 1953. The state had offered evidence of two highway troopers to the effect that they had clocked the speed of the defendant by means of a radar speedmeter which showed defendant was driving 63 miles per hour in a 50 mile per hour zone. The state also had produced an expert witness who had testified in detail as to the construction and operation of the speedmeter and who had also advised of means for testing the accuracy of such meter.

The defendant made two objections relative to the radar evidence of speed. First, he said that the radar speedmeter had never been recognized as being a reliable instrument to record speed of vehicles on the highway, and second, that even if evidence of speed obtained through the use of the meter were admitted it should not be held, standing alone, to be conclusive evidence of the defendant's speed.

The trial judge overruled defendant's objections, admitted the evidence of speed as shown by the radar speedmeter, and in charging the jury, said:

"Based upon the testimony of the expert, I concluded that the evidence as to the accuracy of the speed meter was admissible . . . subject, of course, to your

⁵⁴ *Supra*, note 50.

⁵⁵ *Supra*, note 51.

⁵⁶ 100 A. 2d 778 (Del. Super. Ct. 1953).

determination as to its accuracy in measuring the speed of the defendant's vehicle under all the circumstances of the present case."⁵⁷

Referring to the fact that the detection of the defendant's speed had been made by highway troopers and not by the radar speedmeter expert, the court said:

"The mere fact that the test in the present case was made by a person not skilled in electronics is not of sufficient import to render the speed meter inadmissible in evidence."⁵⁸

As to the value of the radar speedmeter as a scientific instrument to record speed, the court said:

"I conclude, therefore, that an electronic speed meter of the make and kind used in the present case, if found to be properly functioning and being operated in a proper fashion, is a device that the jury may find to be a correct recorder of speed. . . . It falls in the category of recognized instruments used to determine the speed of a moving vehicle, such as a speedometer."⁵⁹
(Italics supplied.)

After further instructing the jury that they must be satisfied the radar instrument was accurate as established by tests reasonably near to the date in question, the court, in relation to defendant's second objection, instructed the jury that the evidence of violation of the speed limit as shown by the radar speedmeter would, standing alone, "furnish sufficient evidence for the conviction of the defendant".⁶⁰

The second reported case, which is the first decision of an appellate court in this country on the radar speedmeter, is the New York decision of *People v. Offerman*,⁶¹ rendered in October 1953. The defendant had been convicted in the City Court of Buffalo for violating the speed limit. The trial had been without a jury. The trial judge had admitted

⁵⁷ *Id.* at 779.

⁵⁸ *Ibid.*

⁵⁹ *Ibid.*

⁶⁰ *State v. Moffitt*, 100 A. 2d 778, 780 (Del. Super. Ct. 1953).

⁶¹ 204 Misc. 769, 125 N. Y. S. 2d 179 (Sup. Ct. 1953).

evidence given by officers making up a radar team to the effect that the dial of the radar speedmeter showed the defendant was traveling 41 miles per hour in a 30 mile an hour zone. The sole evidence of speed was the reading on the dial. No expert witness was called, as in the *Moffitt*⁶² case, to testify to the construction, theory and accuracy of the speedmeter. Instead, one officer testified that after the radar instrument had been set up, a test car was run through the beam and the speed as shown on the speedmeter dial in his control was the same as reported to him by the officer of the test car as shown by the speedometer of that car. The officer in the test car also testified that as his car went through the beam he noted the speed on his speedometer and it agreed with the reading on the radar speedmeter as reported to him by the officer in control of the meter.

While no expert in electronics was produced, the state did offer the testimony of a third police officer. The state attempted to qualify him as an expert on radar speedmeters but the trial judge ruled he was not an expert since he was not an electronics engineer, had had no formal training in radio or engineering but had merely installed the radar equipment in the police cars. Thereupon, both sides moved for an adjournment so that an expert could be produced, but these motions were denied by the trial court. Instead, he permitted the aforesaid officer who had not qualified as an expert to testify as to the construction, operation and accuracy of the radar device. The only other material in the case relating to accuracy of the speedmeter was a statement by the trial judge that he had himself made a test of the device by running his own car through the beam of such a meter and found that it was accurate "on the nose".⁶³

Four aspects of the case are considered on appeal. *First*, the court found that the trial judge committed error in permitting the two officers making up the radar team to testify that the speed as shown on their speedmeter, or speed-

⁶² *Supra*, note 56.

⁶³ *People v. Offerman*, 204 Misc. 769, . . . , 125 N. Y. S. 2d 179, 184 (Sup. Ct. 1953).

ometer respectively, was the same as the speed shown on their co-officer's meter as reported to them at the time of the test. Clearly the court was correct in stating that the officer in the test car could not testify to the speed shown on the radar speedmeter as reported to him by the other officer. And the converse is likewise true. However, this element of hearsay, while declared error, was not said by the court to be sufficient in itself to warrant a reversal. Indeed, proper trial procedure would simply require that each officer testify as to the speed shown on his respective meter when the test was made and it is a simple process for the jury to determine from the identical nature of this testimony that the two instruments were recording the same speed.

Secondly, the appellate court found that the trial court abused its discretion when it failed to grant an adjournment so that the evidence of an expert could be obtained as to the nature, operation and accuracy of a radar speedmeter. *Thirdly*, the court held it was error for the trial judge to permit the third officer who had not qualified as an expert to testify as to the accuracy of the radar speedmeter. *Fourthly*, the court found the statement made by the trial judge as to his own test of the accuracy of the radar speedmeter device to be objectionable, both because it necessarily had to be founded on hearsay information as to what had appeared on the speedmeter when he drove his own car through the beam, and further because the judge had taken into consideration his private knowledge on a subject which "does not lie within the field of judicial notice under the circumstances of this case as the operation of this device is not a practical application of scientific facts which are generally known or ought to be known".⁶⁴

Clearly, again, the court was correct in that the trial judge could not know of the accuracy of the radar speedmeter by making a personal test in driving his car through the beam without accepting the hearsay statement of the person in charge of the meter. However, the critical portion of the court's opinion is that which declares the radar de-

⁶⁴ *Ibid.*

vice does not lie within the field of judicial notice on the ground that the operation of such device is not a practical application of scientific tests which are generally known or ought to be known. The court concluded its opinion by referring to the New York Traffic Law,⁶⁵ wherein the legislature had provided that a certain percentage of alcohol in the blood is *prima facie* proof of intoxication, and suggested that perhaps some day in the future the legislature may provide that the reading of speed as shown on a radar speedmeter shall be considered *prima facie* the speed of the vehicle in question:

“By such legislation the people will be relieved of the burden of proving the accuracy of the electrical time device upon each trial and by expert testimony. The traveling public will be protected against convictions based upon the reading of an unproven and possibly inaccurate device and of equal importance the rules of evidence will not be violated.”⁶⁶

From the above analysis of the decision of the first appellate court passing on the radar speed meter, it is apparent that the basic objection was the lack of expert testimony in the trial court. It is clear, also, that the court was of the opinion that as of the then date, in the absence of legislation on the subject, expert evidence would have to be introduced as to the accuracy of the operation of the speedmeter before its results could be considered by the court or jury.

*People of the City of Rochester v. Torpey*⁶⁷ is the third reported case on the radar speedmeter. It is a decision of an inferior appellate court in New York rendered in December, 1953. The defendant had been convicted in the City Court of Rochester of violating the speed laws. The People introduced the testimony of police officers, who had manned the radar unit and observed the defendant's car passing, that in their opinion it was going 45 miles per hour, and further introduced evidence to the effect that the

⁶⁵ See note 28a, *supra*.

⁶⁶ *People v. Offerman*, 204 Misc. 769, . . . , 125 N. Y. S. 2d 179, 185 (Sup. Ct. 1953).

⁶⁷ 204 Misc. 1023, 128 N. Y. S. 2d 864 (Monroe County Ct. 1953).

radar speed device which had been trained on the car in question showed a reading of 43 miles per hour as the defendant's speed. Either of those speeds was well above the city speed limit. The court pointed out that the testimony of the police officers' personal opinions as to speed was in itself sufficient to convict the defendant, but it then went on to discuss the admissibility of the evidence of the reading on the radar speedmeter.

In this connection the court noted that no expert testimony had been introduced as to the accuracy of radar for the purpose of measuring speed. There had been evidence by the police officers that they had tested the meter by running a test car through the beam and by comparing the readings on the speedometer and speedmeter. Also evidence was introduced to show that the speedometer on the test car had been tested and found in good working order.^{67a} In the light of the personal opinion testimony of the officers, plus the testimony aforesaid as to the reading on the radar

^{67a} It will be noticed that the state in cases where it is using a radar speedmeter invariably puts in evidence to the effect that the speedmeter was checked with the speedometer of a test car that was run through the beam. Upon finding the two speed readings were the same, it is presumed in some cases that the readings on the radar speedmeter were accurate. In certain instances the state may go further and offer evidence showing that the speedometer on the test car had recently been tested and been found correct. Further than that the proof has not gone. But one may ask, "What about the accuracy of the instruments, stop watch, or otherwise, that were used in testing the accuracy of the speedometer in the test car. And going back still further, what evidence is there of the accuracy of the instruments or process used in checking the stop watch, that checked the speedometer in the test car, that checked the radar speedmeter?" It is apparent that at some point in the checking process the accuracy of the instrument which is the checking authority must be taken for granted, for if not we would eventually be brought to the point of questioning the accuracy of the steel tape or surveyor's device which measured off the test mile area. In this connection, the English case of *Nicholas v. Penny*, [1950] 2 K. B. 466 (C. A.) also reported and annotated in 21 A. L. R. 2d 1193 is of considerable interest. While the instrument used by the police in determining the accused's speed was not a radar speedmeter but the customary speedometer found in automobiles, the court held that a conviction based upon evidence of speed readings on the speedometer in the police car, which followed the defendant's car at an even distance, would be sustained even though there was no evidence of the accuracy of said speedometer, since, in the absence of contravening evidence, the readings on the speedometer in the police car would be deemed to be *prima facie* correct.

The author of the annotations to this case states that there apparently are no American cases directly holding that evidence of measurements by mechanical instruments will be presumed correct in the absence of any evidence that the instrument has been tested for accuracy within a reasonable period. He accounts for this dearth of authority by noting that in many American cases no objection was raised as to the accuracy of the

speedmeter, the county court held there was sufficient evidence to sustain the conviction of the defendant.

But the court took pains to point out that if the People's sole evidence of speed on the part of the defendant was the reading on the radar speedmeter, expert testimony would be needed to establish the accuracy of such device. Particularly the court said:

"The use of radar is comparatively new as a means of bringing about the arrest of violators of ordinances pertaining to the speed of automobiles and *until such time as the courts recognize radar equipment as a method of accurately measuring the speed of automobiles*, in those cases in which the People rely solely upon the speed indicator of the radar equipment, it will be necessary to establish by expert testimony the accuracy of radar for the purpose of measuring speed." (Italics supplied.)⁶⁸

The fourth case in chronological sequence is *People v. Katz*,⁶⁹ a decision of a trial court in Yonkers, New York, rendered in March, 1954. Testimony of police officers was to the effect that one of them in charge of the operation of the radar apparatus observed that when defendant's car passed through the radar beam the recording dial on the speedmeter showed the defendant was exceeding the speed limit, and that this information was passed on to an officer further down the highway who served the defendant with a summons. In addition, the prosecution offered in evidence the testimony of an electronics expert, Dr. John M. Kopper, who testified in detail regarding the construction of the radar speedmeter and fully explained its operation. He also testified that the operator of the recording equipment can tell when it is out of calibration, and may quite easily determine when the machine is not working properly.

measuring instrument and that in the others proof of accuracy was submitted. In certain states statutes expressly provide that where a police speedometer has been tested and certified as accurate as required by the statute, no proof of its accuracy need be submitted. See *Commonwealth v. Parish*, 138 Pa. Super. 593, 10 A. 2d 896 (1940).

⁶⁸ *People of City of Rochester v. Torpey*, 204 Misc. 1023, . . . , 128 N. Y. S. 2d 864, 866 (Monroe County Ct. 1953).

⁶⁹ 205 Misc. 522, 129 N. Y. S. 2d 8 (Ct. Spec. Sess. Yonkers 1954).

At the end of the foregoing testimony the defendant moved to dismiss the case on the ground that the evidence offered was insufficient to establish his guilt beyond a reasonable doubt. The reported decision is the court's ruling on that motion. In denying the same the court referred to *People v. Offerman*⁷⁰ discussed, *supra*, and said:

"The objectionable and incompetent evidence which warranted a reversal in that case is, in my opinion, not present in the instant case.

"The Electromatic Speedometer herein described is a scientifically reliable device which if properly operated and properly functioning falls in the category of recognized instruments used to determine the speed of moving vehicles."⁷¹

Three weeks later, on March 31, 1954, the Court of Special Sessions of New Rochelle, New York, decided *People v. Sarver*.⁷² In support of the prosecution, evidence of a permanent graph recording of the speed of defendant's vehicle as made by the electromatic speedmeter was introduced. In addition expert testimony of Dr. John M. Kopper, the same electronics expert who had testified in the *Katz*⁷³ case, and who is the author of the scientific article on radar speedmeters appearing in this *Law Review*, was introduced, which described in detail the construction and operation of the electronic speedmeter. Evidence was also admitted to the effect that the speedmeter was calibrated or tested on the morning of the day of the alleged violation, that it had been acquired six months before the day in question, that it was manufactured by the Automatic Signal Division of Eastern Industries, Inc., at Norwalk, Connecticut, and that it had been frequently tested and found to be accurate when compared with the conventional speedometer. Although no special significance seems to have been placed on the fact, the court points out that the officer in charge of the radar apparatus held a United States Govern-

⁷⁰ *Supra*, note 61.

⁷¹ *People v. Katz*, 205 Misc. 522, . . . , 129 N. Y. S. 2d 8, 9 (Ct. Spec. Sess. Yonkers 1954).

⁷² 205 Misc. 523, 129 N. Y. S. 2d 9 (Ct. Spec. Sess. New Rochelle 1954).

⁷³ *Supra*, note 69.

ment Radio Telephone Operator's License, First Class, had been a Chief Radioman in the Navy, and for two years studied electrical engineering at New York University.

In its motion to dismiss, the defense relied on two grounds: (1) that the defendant had not been properly identified, and (2) that the radar speedmeter was inaccurate and unreliable. As to the first contention the court said:

"Defendant contends that Officer Rabbitt, who directed the arrest [and who was in charge of the radar speedmeter] could not identify the defendant. The testimony showed that Officer Rabbitt saw a green truck which approached and passed him at an excessive rate of speed as recorded on the speedmeter's graph. This information was passed on to Officer Burkhardt, who arrested the driver of the green truck, who is the defendant. The circumstances conclusively established the defendant's identity. No further identification is necessary."⁷⁴

In overruling the second objection of the defendant, the court referred to *People v. Offerman*,⁷⁵ discussed, *supra*, and noted that the conviction in that case had been reversed "because there was no competent evidence as to the accuracy and reliability of the radar speedmeter. Such is not the case here".⁷⁶ Then the court found that the radar speedmeter has found its place among those scientific instruments accepted as reliable and accurate. It states:

"On the evidence before the Court, it conclusively appears that the radar or electromatic speedmeter is an accurate and reliable instrument for the measurement of velocity. *It must take its place along with the ordinary mechanical speedometer as a device which accurately measures the speed of a moving vehicle. . . .* The radar speedmeter is no different than any other scientific device. Admissibility of tests made by it depends entirely on its accuracy and reliability."⁷⁷ (Italics supplied.)

⁷⁴ *People v. Sarver*, 205 Misc. 523, . . . , 129 N. Y. S. 2d 9, 11 (Ct. Spec. Sess. New Rochelle 1954).

⁷⁵ *Supra*, note 61.

⁷⁶ *People v. Sarver*, 205 Misc. 523, . . . , 129 N. Y. S. 2d 9, 12 (Ct. Spec. Sess. New Rochelle 1954).

⁷⁷ *Id.* at . . . , 129 N. Y. S. 2d at 13.

People of the City of Buffalo v. Beck,⁷⁸ decided in April, 1954, is the next case in sequence. At the trial, which was held without a jury in the Buffalo City Court, the prosecution offered the testimony of four policemen to the effect that they had personally observed the defendant's car in motion and were of the opinion it was travelling 40 miles per hour in a 30 mile per hour zone. In addition the prosecution introduced evidence of the speed of defendant's car as shown by the radar speedmeter. No expert evidence was introduced as to the construction, operation or accuracy of the meter. The trial judge, however, stated that he would take judicial notice of the operation and accuracy of radar devices to establish the speed of automobiles and found the defendant guilty.

On appeal, the conviction was reversed by the New York Supreme Court, Erie County, Justice Ward holding that the trial judge had committed error in taking judicial notice of the radar speedmeter as a device for accurately measuring speed. As Justice Ward saw it the trial judge was a bit premature.

It is doubtful if many of us understand the scientific principles which are involved in the operation of the x-ray. The writer also doubts that Justice Ward would reverse a trial judge who took judicial notice of the reliability of the x-ray as a means of revealing hidden bone injury. Yet, Justice Ward seems to be of the opinion that before a judge can take judicial notice of a radar speedmeter as an accurate device for measuring speed, the public at large must understand the mysteries of electronics and their particular application to the operation of a radar speedmeter. Thus, in reversing the conviction below, he said:

"I must hold that the theory of the operation of this electrically operated device and the accuracy of its measurement of speed is not a proper subject for judicial notice *at this time*. Electronics is a recent development in the science embracing the mysteries of electricity. . . . Certainly it cannot be said that such knowledge is 'notorious' as above described or that it is 'the general knowledge of the country' nor is the opera-

⁷⁸ 205 Misc. 757, 130 N. Y. S. 2d 354 (Sup. Ct. 1954).

tion of this device 'a practical application of scientific facts which are generally known or ought to be known'." (Italics supplied.)⁷⁹

Although the evidence of the four officers independent of the radar evidence showed a violation, Justice Ward ruled there had to be a reversal because he could not tell whether the trial judge had relied on the officers' testimony or on the radar evidence.

The next case in sequence and the last reported one as of this writing on the radar speedmeter is *State v. Dantonio*.⁸⁰ It is a decision of a New Jersey criminal court holding a trial *de novo* following a conviction of the defendant in an inferior municipal court. At the trial *de novo* expert testimony of the same Dr. John M. Kopper heretofore mentioned was introduced relative to the operation and accuracy of the radar speedmeter. In addition evidence of state troopers was introduced to the effect that they had duly set up the radar equipment, tested it by running a test car through the beam, found it accurately calibrated and proceeded to check oncoming traffic. The speeding charge was predicated on a recording of the radar speedmeter and graph machine connected therewith made as defendant's truck passed through the beam. The defendant contended that (1) the trial court permitted hearsay testimony to be given by the officers in relation to tests made of the radar device's accuracy, and that (2) the trial court permitted testimony to be given concerning the accuracy of the radar device by one who was not qualified as an expert.

It will be noted that the first objection as to hearsay is the same objection the court discussed in *People v. Offerman*,⁸¹ *supra*. The court properly disposed of the objection against the defendant in the *Dantonio* case by saying:

"Each officer testifies as to independent facts. The patrol car officer testifies as a fact to the speed of the patrol car as shown by his speedometer. The radar operator testifies as to the recording of the electric

⁷⁹ *Id.* at . . . , 130 N. Y. S. 2d at 357.

⁸⁰ 31 N. J. Super. 105, 105 A. 2d 918 (1954).

⁸¹ 204 Misc. 769, 125 N. Y. S. 2d 179 (Sup. Ct. 1953).

speedmeter and the graph machine and of his own visual observation of the car making the test. Radio communication [between the test car and radar operator] is merely incidental."⁸²

As to defendant's second contention, the court pointed out that Dr. Kopper was an expert in electronic speed devices and fully qualified. It also brought out the fact that on Dr. Kopper's testimony given under cross examination, it appeared that any defects in the radar equipment, such as defective tubes, condensers or low voltage in the battery, would all tend to decrease the number of electrons emitted from the heat surfaces within the tubes and give a lower and less than true reading. Thus, the court concluded, "All defects in the equipment resolve in favor of the motorist."⁸³

The court referred to the first case reported, *State v. Moffitt*,⁸⁴ and said it was in full agreement with that portion of the *Moffitt* case which stated that the mere fact the test was made by a person not skilled in electronics is not of sufficient import to render radar speedmeter evidence inadmissible.

Reviewing the above cases on the radar speedmeter, we find that in all seven of them the evidence of speed as shown by the speedmeter was admitted in the trial court. An expert in electronics familiar with the theory and operation of the radar speedmeter testified in four of the cases.⁸⁵ In the two New York state superior appellate cases⁸⁶ which reversed the trial court, no such expert had testified. In the one New York case⁸⁷ in which a conviction was sustained by an inferior appellate court, and in which no expert had testified, the court based its affirmance on the fact that there was other evidence of speed in the case, but admonished that if the radar evidence were the sole evidence of speed, there would be a reversal.

From a consideration of all of the opinions it is clear that the linchpin in the prosecution's case *at the time of*

⁸² 31 N. J. Super. 105, . . . , 105 A. 2d 918, 921 (1954).

⁸³ *Ibid.*

⁸⁴ 100 A. 2d 778 (Del. Super. Ct. 1953).

⁸⁵ These are the *Moffitt*, *Katz*, *Sarver* and *Dantonio* cases.

⁸⁶ These are the *Offerman* and *Beck* cases.

⁸⁷ This is the *Torpey* case.

these decisions was expert testimony as to the construction, theory, operation and accuracy of the radar speedmeter. Without the aid of expert evidence, certain of the courts would not recognize the said speedmeter as an instrument that accurately registers the velocity of a moving vehicle. But it is apparent from the decisions of those courts that had such expert evidence been introduced, the evidence of the defendant's speed as shown by the speedmeter would have been admitted. Thus the radar speedmeter has already surpassed the lie detector in judicial recognition.⁸⁸ It is equally apparent that even those overly cautious judges who in their decisions found that expert testimony was a prerequisite to the admission of the speedmeter's readings did not mean to imply that such testimony would always be essential. Thus, Justice Ward in the *Beck* case stated that the radar speedmeter was not a "proper subject for judicial notice at this time".⁸⁹

Some day those judges will say, "The time has now come when we must take judicial notice of the radar speedmeter without the assistance of expert testimony." And then they will solemnly declare that the radar speedmeter falls in the category of recognized instruments which accurately determine the speed of moving vehicles, thus adopt-

⁸⁸ For, as we have seen, evidence of lie detector tests is generally excluded even though there is expert testimony introduced as to the construction, theory, operation and accuracy of the device. See *supra*, note 24. Accordingly, referring to the three aspects of the problem stated at the outset of this paper, we can definitely state in regard to the first and second that all courts will receive evidence of speed as shown by a radar speedmeter if expert testimony has been given as to the construction, theory, operation and accuracy of the device, and that some courts will admit evidence of speedmeter readings without requiring such expert testimony. As to the third aspect of the problem, namely, what weight or value is to be accorded the data revealed by the speedmeter, it is self evident that in these criminal prosecutions for violating speed laws a jury verdict of not guilty, even though in the face of evidence of radar speedmeter readings establishing guilt, would not be set aside. This is the inherent nature of our criminal procedure. The only way in which the court would be called upon to consider a radar speedmeter reading as having such conclusive force that a jury verdict of guilty would be set aside, as was done in the Maine and New York paternity cases (see *supra*, notes 50 and 51), would be for the state to prosecute the accused for violating the speed limit on the basis of testimony of an observer not using a meter, and for the accused to introduce evidence that a radar speedmeter reading made of the speed of his car at the time in question showed he was not violating the speed limit. From the very nature of events this situation is most unlikely to occur.

⁸⁹ *People v. City of Buffalo v. Beck*, 205 Misc. 757, . . . , 130 N. Y. S. 2d 354, 357 (Sup. Ct. 1954). (Italics supplied.)

ing as their own the language of the trial judges which they now find premature. Until that day has arrived, however, the careful law enforcement officer who would be certain of sustaining a conviction based on radar evidence of speed, would be well advised to have an electronics expert in court to prove the construction, theory, operation and accuracy of the radar speedmeter used in the particular case.⁹⁰

In both the *Offerman*⁹¹ and *Dantonio*⁹² cases the court suggested that expert testimony could be dispensed with if the legislature by statute would provide that a reading on a radar speedmeter, which has been certified as accurate by the authority designated by the legislature, is to be admitted as *prima facie* evidence of the speed of the vehicle driven by the accused. While such legislation would certainly relieve the courts of responsibility, it appears to the writer that if the courts properly perform their function, said legislation is no more needed in the case of radar speedmeters than in the case of x-rays.

It is submitted that there is now more than adequate knowledge of the operation and accuracy of radar speedmeters in the area of science to which these devices belong to warrant their being accorded judicial recognition without the aid of expert testimony or legislative direction. No longer need the judge be in ignorance of the theory and operation of these devices. Such scientific papers as that of Dr. Kopper which appears in this *Law Review* should be of material aid to the courts in determining the position that the speedmeter has in the scientific fields to which it belongs.

To require the production of an expert in electronics at every trial involving the use of radar evidence is to delay

⁹⁰ Whenever the results obtained through the use of a new scientific device or process are offered in evidence, the court at first may and frequently should require expert testimony. Later, as case after case has been tried and the results of the device or process have repeatedly been introduced following the explanation of the expert, the courts will take judicial notice of the accuracy of the scientific device or process in question, and it is then no longer necessary to produce the expert. Until, however, a particular appellate court has said it will judicially notice the particular scientific device or process counsel cannot safely proceed without the expert.

⁹¹ *People v. Offerman*, 204 Misc. 769, 125 N. Y. S. 2d 179 (Sup. Ct. 1953).

⁹² *State v. Dantonio*, 31 N. J. Super. 105, 105 A. 2d 918 (1954).

justice, create unnecessary expense and ignore the admitted progress of science. A court so doing may well find itself in the very unenviable position of the Supreme Court of South Dakota when,⁹³ in 1936, as we have heretofore seen, it was compelled to declare the complete reverse of its "unenlightened" decision of 1933 in which it had refused to recognize judicially the efficacy of blood grouping tests. Let us hope that at this late date in the use of radar speedmeters no court will be so "unenlightened" as to lay the foundation for the duplication of such an unfortunate experience!*

⁹³ State v. Damm, 64 S. D. 309, 266 N. W. 667 (1936), discussed *supra*, p. 367.

* [*Editorial comment*: Subsequent to the publication of the above symposium in the North Carolina Law Review, the *Dantonio* case, discussed by Mr. Baer, (*circa*, fns. 1, 13, 27a, 80, 85, 92), was appealed to the Supreme Court of New Jersey, *State v. Dantonio*, 18 N. J. 570, 115 A. 2d 35 (1955). The Court quoted the above article with approval and affirmed the decision of the Appellate Division of New Jersey, concluding that like X-ray machines, cardiographs, fingerprints, and similar scientific devices, radar speedmeters have become established as accurate scientific devices and properly should be received in evidence upon a showing that the radar device was properly set up and tested by police officers "without any need for independent expert testimony by electrical engineers as to its general nature and trustworthiness" (p. 40). The later *Dantonio* case was noted in 10 Rutgers L. Rev. 454 (1955).

Compare *In Re Beamer*, 283 P. 2d 356 (1955), where the District Court of Appeal of California (First Dist.) denied a writ of *habeas corpus* to a petitioner convicted of speeding largely on evidence obtained by a radar speedmeter. Petitioner claimed that such evidence violated Section 751 of the California Vehicle Code prohibiting admissibility of evidence obtained through the use of a "speed trap". The Court held that a radar speedmeter device is not a "speed trap" as defined by the Code, and by *dictum* mentioned that such evidence obtained by the use of radar devices when coupled with expert testimony on the subject, has been held admissible in the few jurisdictions that have decided the question. This case was noted in 43 Calif. L. Rev. 710 (1955).

For recent discussions in periodical literature since the above symposium was published, see *Admissibility of Radar Evidence — Need for Legislation*, 5 Am. U. Intra. L. Rev. 1 (1955); Adams, *Radar — Black Magic To Catch Speeders*, 9 Wyo. L. J. 122 (1955); Carosell and Coombs, *Radar Evidence in the Courts*, 32 Dicta 323 (1955).]