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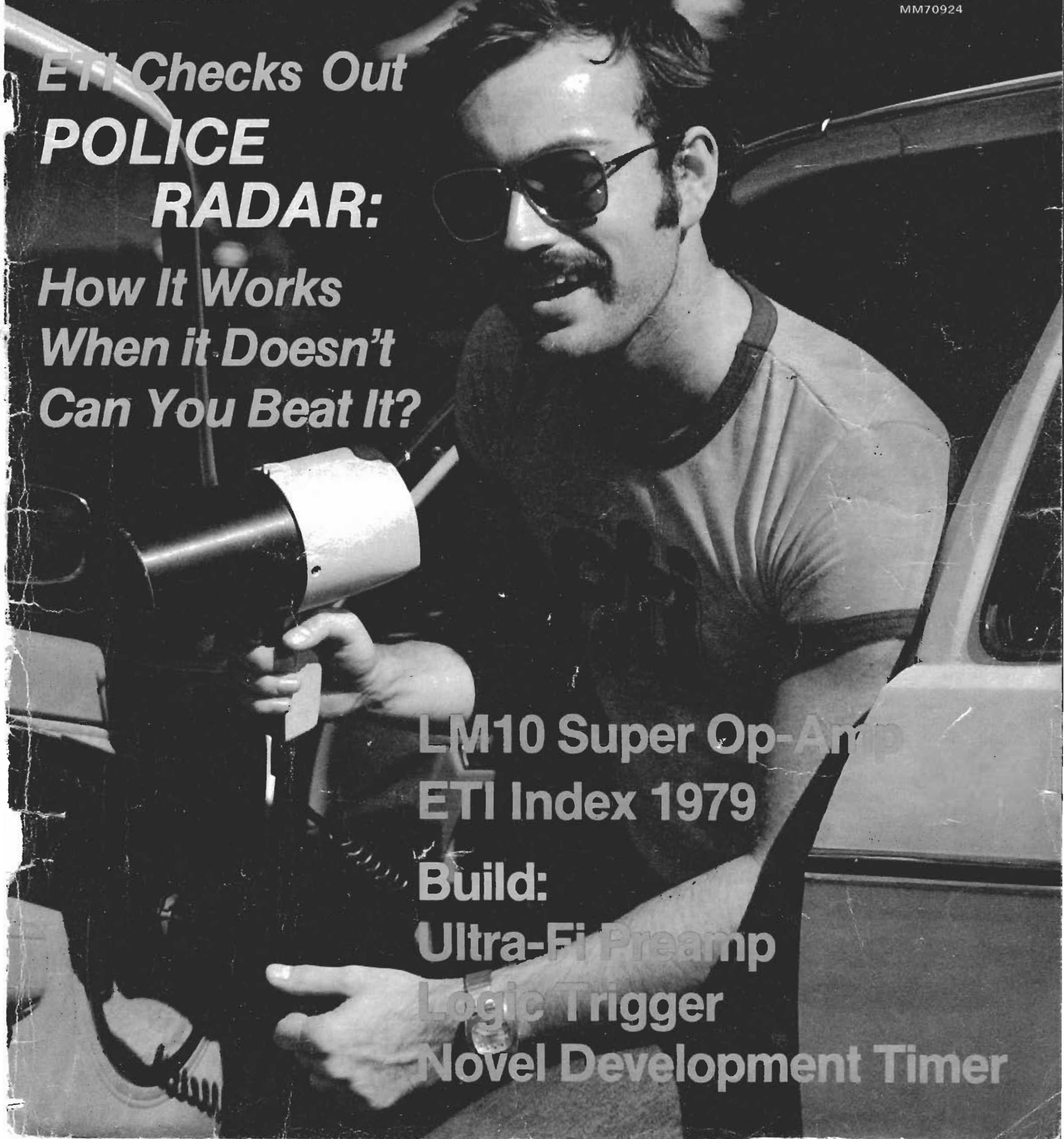

ETI Checks Out POLICE RADAR:

How It Works

When it Doesn't

Can You Beat It?

LM10 Super Op-Amp

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Build:

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Novel Development Timer

Special Report

Police Radar Speed Meters

This ETI Special Report covers all aspects of Radar Speed Meters, from the State of the Art to the Art of the State.

IF YOU'RE READING this magazine, then it's a sure bet that you've been in an automobile. And if you've been in a car it's also a sure bet that you've seen, or worse yet been stopped by, a police radar speed "trap". Well, so have we, and being curious sorts, we decided to look into the subject further, and find out how these speed meters work. (and whether we really *did* deserve those tickets!). Naturally, we were also interested to find out whether these meters can perhaps be fooled, and to see what kind of a chance you have if you are caught by the men in blue.

Very fortunately for us, one of the world's leading companies in radar speed meters, Tribar Industries, is located right here in Toronto, and we were able to make the very pleasant acquaintance of their Service Manager,Mr. Ross Brimbecom. He assisted us greatly in the preparation of this article, and lent us a Tribar T3 Radar "Gun" (Fig.1.) to try out. Let's get into the subject by first describing how one uses the T3 Radar unit, a good example of the way most radar meters would be used.

THE TRIBAR T3

To put it conservatively, the T3 is incredibly easy to operate. As can be seen in Fig.1, it has 2 switches, 2 pushbuttons, a digital display, and a trigger switch. All you have to do is to plug the cord into the car cigarette lighter socket, (or portable battery pack), switch on, and point the thing at a moving object, such as a car (what imagination!). The speed is registered on the digital display. Both kph and mph models are available. Pull the trigger and that number is remembered, and the display flashes the number on and off to show that you are in

Fig. 1. The Tribar T3 hand-held radar gun. (Photo courtesy of Tribar.)

"remember" mode. Pull the trigger again and you're back in "measuring" mode.

The toggle switch on the left gives you high or low distance ranges, which are 1500 to 5000 feet for the high range, and about one third that for the low one, which is more suited to city traffic situations.

The two push buttons allow you to test, producing readouts of 25 or 100.

An additional feature is that in "flashing" mode, (ie: trigger pulled once) the radar transmitter is not operating. When the trigger is pulled again the transmitter starts operating again and a reading is taken. This is of course useful in catching those dastardly types who have radar detectors ("fuzzbusters") mounted in their Firenzas.

And that's all there is to it! There is no mystique or trickery, it's simply a measuring instrument. As such, of course, it's readings are subject to interpretation. Just as you would not expect a police officer to vaguely wave a ruler at your car and claim that you had parked too close to a fire hydrant, you would also expect him to be knowledgeable about the techniques necessary to obtain a meaningful reading from the meter. More on this later.

So the T3 is a nice portable speed measuring device, but you can't use it from a moving vehicle. Let's take a look at Tribar's most sophisticated model, a microprocessor controlled unit which has this capability.

TRIBAR MDR-1 "TRACK RADAR"

Pictured in Fig.2 is probably the most sophisticated speed radar available today. As can be seen it is composed of a dash-board mounted control and display box, and remote antenna, mounted externally on the car.

As a stationary unit, operation is similar to that of the T3, although with more sophisticated signal processing.

Used in a moving vehicle it really comes into it's own. It functions as two radar meters, one measuring "patrol" vehicle speed, the other measuring relative speed between partrol car and "Target" vehicle. The microprocessor makes the addition or subtraction and displays both patrol speed and target speed. Switches allow operator to "remember" a reading, to put radar transmitter on standby, to observe vehicles in same or opposite direction, and to look only for vehicles traveling at speeds above that preset on the front panel. Range is up to 2 miles when used in stationary mode, and ¾ to 1¼ miles when moving.

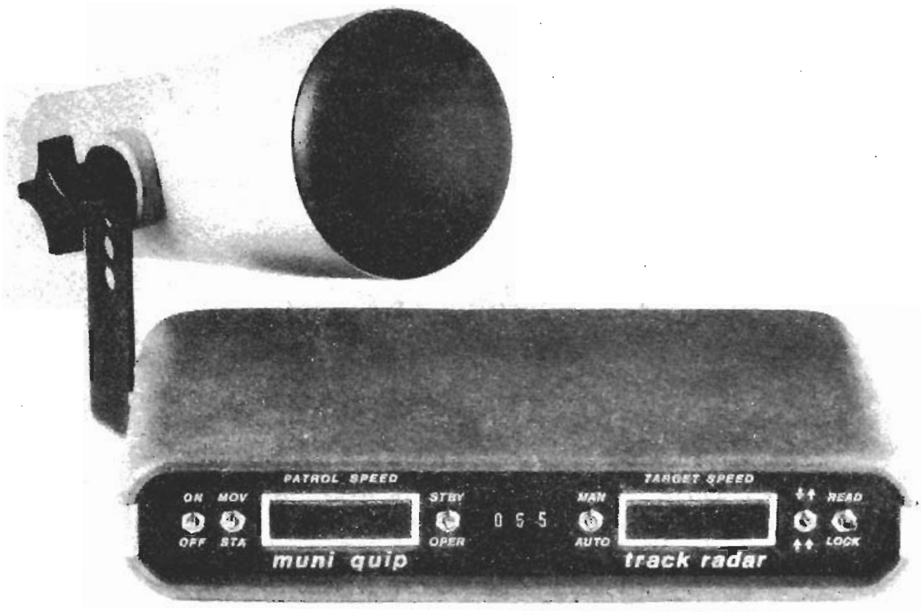


Fig. 2. "Track Radar", the Tribar MDR-1. (Photo courtesy of Tribar.)

BASIC PRINCIPLES BEHIND SPEED METERS

The central part of any radar speed meter, is a transmitter and a receiver, using a common, and fairly directive, antenna arrangement.

The transmitter directs a beam of radio waves toward the target, and the target reflects them back to the receiver. If the target is moving towards the radar unit, the returning waves will be compressed, this is known as the Doppler effect. The radar receiver will thus pick up a signal of higher frequency than that which was transmitted. Similarly for a receding target, the returning waves will be "stretched out", seen at the receiver as a signal of slightly lower frequency.

The "front end" of the radar receiver mixes the reflected signal with a portion of the transmitter signal. This has the effect of "demodulating" a low frequency signal which is the difference between transmitted and received frequencies. The frequency of this low frequency signal is proportional to the absolute speed of the target. (Speed meters can't tell the difference between advancing or receding vehicles, except by antenna aim.)

The frequency of this "speed signal" is dependant also on the transmitter frequency , and is:

$$F_{speed}(Hz) = 2 \times Speed(mph) \times F_{trans}(Hz) / C$$
$$C = \text{speed of radio waves} = 6.696 \times 10^8 \text{ mph}$$
$$F_{speed} = 2.986 \times Speed(mph) \times F_{trans}(GHz)$$

The two commonly used radar bands today are centred at 10.525 GHz ("X band") and 24.150 GHz ("K band") which, plugging into the above formula gives 31.4Hz per mph for X Band, and 72.1Hz per mph for K Band.

This speed signal is amplified and filtered, then fed to a frequency counter, scaled for either mph or kph, giving a digital readout of speed.

In order for a display to appear, a number of consecutive readings are taken and compared. If they are reasonably constant the display is activated indicating that the speed meter considers the reading valid.

MDR-1 SOPHISTICATIONS

The "Track Radar" has to have some additional sophistication, since it has to be able to distinguish between the signal returned from the road and that from the target.

For this purpose the low frequency signal is treated somewhat differently. Refering to Fig.4. the circuitry is faced with interpreting a number of different frequency components. The tricky part of the MDR-1 is it's programmable band pass filter. Under control of the microprocessor, this filter may be made to select the frequency bands corresponding to each mph or kph up to 256.

To look at it another way , imagine that there are 256 frequency "windows", from one to 256 mph.

The microprocessor can "look" in each one to see if there is any signal there. If there is, the microprocessor knows that something is moving with respect to the patrol car, at a speed corresponding to the number of the window.

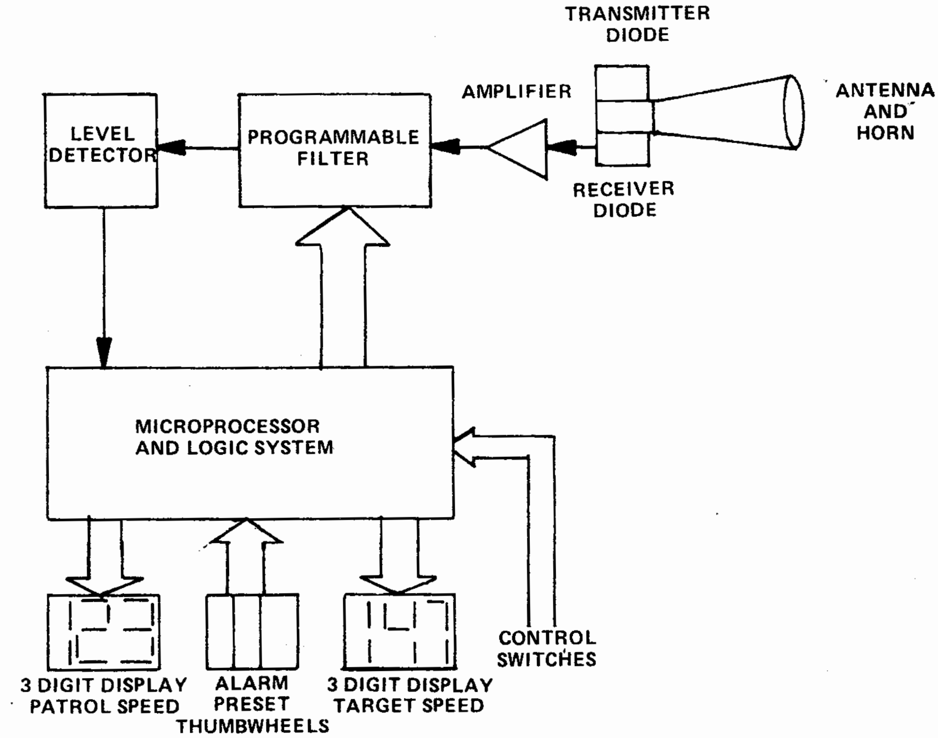


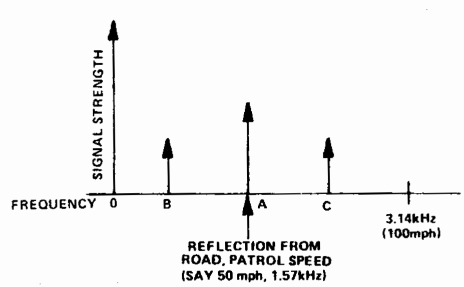
Fig. 3. Inside the MDR-1 is a microprocessor system, and programmable filter which together are able to find and track speed signals with great selectivity.

OPPOSITE DIRECTION

As an example, suppose the patrol car is moving at 50 mph (see Fig.4.) and the MDR-1 is switched to "opposite direction" operation. The mpu looks in all the windows and finds the biggest signal in the 50 mph slot. Then it scans from there to find signal C. Subtracting A from C it finds the speed of the vehicle.

This is considered to be the "standard mode" of operation, with antenna aimed forward to observe oncoming vehicles. In this case, the scanning for a target starts at the top

Fig. 4. Example of signals demodulated by radar in moving application.
A: Reflection from road gives patrol car speed.
B: Signal reflected from car going same direction, at speed A+B or A-B relative to road.
C: Signal reflected from car going opposite direction at speed C—A relative to road. It could also be from a car going at A+C, but this is pretty quick!



and proceeds downwards until a target is found, or the patrol speed (A) is reached, in which case the scan starts again. In this way the highest speed target is found.

SAME DIRECTION

If the MDR-1 is used to track cars going in the same direction the antenna may be faced behind or in front, and reads the speed of cars approaching from behind, or passing respectively. In otherwords refering to Fig.4, after finding the patrol speed it scans down to find the highest frequency below that, adds the two (A+B) for the resulting target speed.

TRACKING

In each case, once the patrol and target "windows" have been found, the MDR-1 keeps track of each one by repeatedly looking in these and adjacent windows to follow the two speeds as they vary up or down.

ALARM AND PRESET

Using thumbwheel switches on the front panel, the operator can select a target speed above which the display will be activated and an alarm sound.

CHECKING TUNING

All speed meters we have seen are tuned in the same way, with a tuning fork! The units are supplied with a tuning fork designed to vibrate at the frequency corresponding to, say 100 kph. All the operator does is to bang the fork against a piece of wood or hard rubber (metal is unsuitable since it has a tendency to cause oscillations in the fork other than the fundamental) and then hold it in front of the speed meter. 100 kph pops up on the display showing correct calibration.

How does this work? The vibrating fork prongs frequency modulate the radar beam, which produces strong "sidebands" offset from the transmitter frequency by the fork frequency (see Fig.5).

Because this is frequency modulation there will be other sidebands, but these are of lower amplitude so are ignored by the meter.

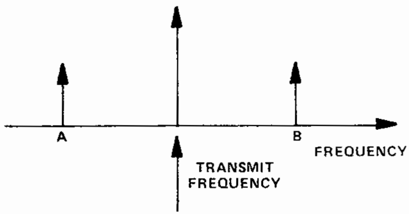


Fig. 5. Calibrating a radar speed meter.
These are the signals reflected from the tuning fork:
A and B : Reflected components at "100kph" offsets, for example.

Do Speed Meters Make Mistal

As we mentioned before, this is like asking does a ruler make a mistake? We will look at some of the possible sources for error in using a speed meter. These can briefly be broken down to: Calibration error, Angle error, Wrong vehicle error, "Operator Interference" Mechanical Interference, and Electrical Interference.

CALIBRATION ERROR

In the meters we looked at there appeared to be little room for calibration error, either the thing would work or it wouldn't. The only way that an *incorrect* reading could occur would be if the transmitter frequency drifted miles from it's intended value, or the crystal timebase for the frequency counter drifted off. The first is quite unlikely since it is the resonant cavity which determines resonant frequency, and the oscillator would only be able to function at very limited output at other frequencies. The second is also pretty unlikely, but possible.

These are pretty easy to check however. If you are stopped, you are quite entitled to look at what the radar

akes?

is reading (your speed should be "locked on") and to challenge the calibration. Ask the officer to test the unit with his tuning fork and show that the display is correct, as marked on the tuning fork. (Calibration forks are marked with speed reading, not frequency!) This is a useful exercise anyway: we have heard of cases which were thrown out because the officer did not have his tuning fork with him, and this could not have checked the calibration of his unit before and after use, as he is supposed to!

It has been claimed that rough usage could throw off these tuning forks, which would be a problem if the particular radar meter concerned is actually recalibrated against the fork. (This could not really be done with the units we saw, but may be possible in other cases, if there is a calibration adjustment) In this case, perhaps you should carry your own tuning fork of known accuracy, a musical one will do, and you can work out what reading should result, according to its note.

MECHANICAL AND ELECTRICAL INTERFERENCE

First--mechanical. Obviously, any moving, reflective (to radio waves) object is capable of giving a reading on the meter. This includes metal fans, swinging advertising signs etc. However, these do not add to, and are almost always less than the speed of your vehicle. At most, they will activate whatever automatic level control the meter has, making it less sensitive.

Remember, even 20 mph corresponds to 628Hz (for X Band), or over 37,000 rpm for a fan for example! But then it's hard to predict exactly what effect a fan will have. But suffice it to say that mechanical interference, even vibration of the police car upon which the radar meter is mounted are very unlikely to get you into trouble.

It has been reported that whistling loudly into the radar antenna can cause a false reading. We could not do this, and find it hard to believe. We can only hypothesize that such a result could occur if the sound waves were so strong as to vibrate some part of the receiving apparatus, or the whistler's gold fillings.

Electrical interference is another story, however. Referring to Fig.7, circuit diagram for the receiver front end, anything that will cause a high audio frequency to appear at the "output to counter" will do you in.

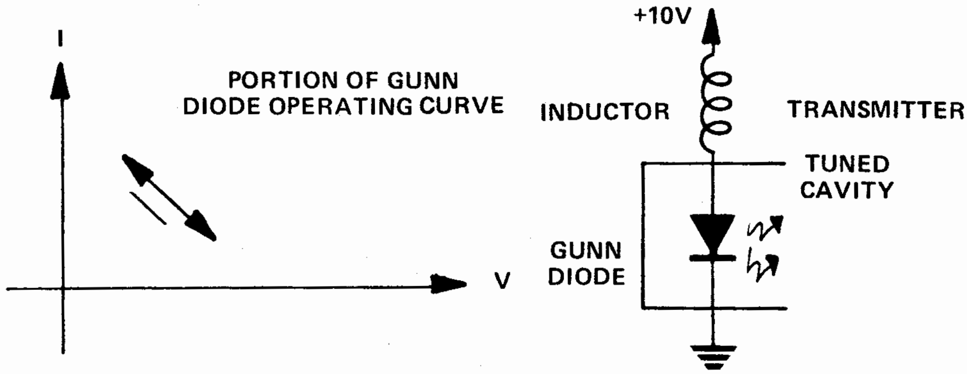


Fig. 6. The "Gunn Diode", used in most microwave transmitters of this type, is a "negative resistance" component. That is to say, over a part of it's characteristics, as current increases voltage decreases, and vice versa. So all you have to do is get it into that part of the curve and it'll oscillate! But at what frequency? The diode is mounted in a "resonant cavity", tuned to the appropriate frequency. This cavity acts very much like a square bathroom with hard tiles. If you sing a certain note you hit a resonance and the sound is much stronger. Technically, in both cases this is due to the ability for the particular size of space to accomodate standing waves of sound, or electromagnetic energy at that frequency. In any case, the resonant cavity encourages oscillation at one particular frequency, and discourages others.

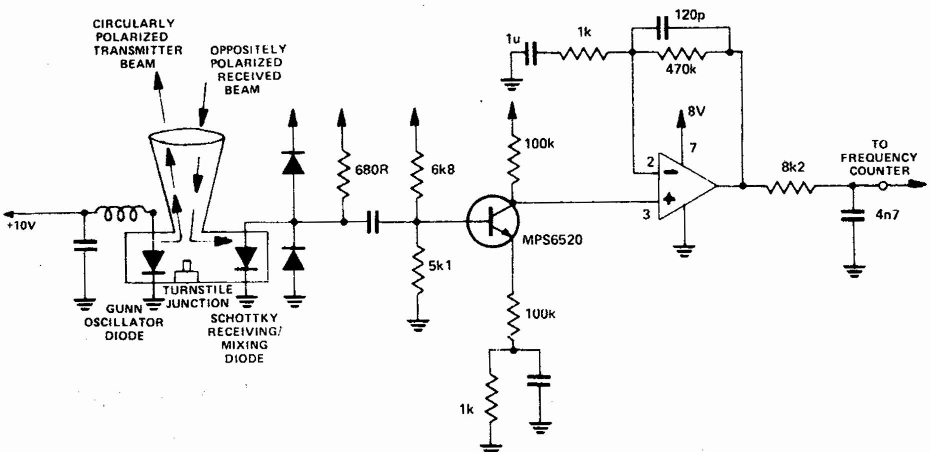


Fig. 7. The resonant cavity feeds through a "turnstile junction" to fire out through the horn. The final output is 100mW concentrated in a 16 degree cone. It is circularly polarized in one orientation, and when reflected is returned oppositely polarized. Hence it feeds down the horn and through the turnstile junction the opposite way to the receiver diode. The receiving antenna pattern is the same as the transmitter's, and the combination of patterns means that the overall pattern quoted for the instrument (angle of "half effectiveness") is 8 degrees. The remainder of the receiver "front end" is a fairly standard amplifying arrangement using transistor and op-amp. Combined in the op-amp circuitry is a filtering feedback loop, the overall effect being to roll off low and high audio frequencies.

(This is how the tuning fork works after all).

An improperly grounded or connected set with separate antenna could possibly manage to end up with noise on this line, 60Hz, or from the automobile electrical system. The Tribar set appeared very unlikely to have this problem, though this has been mentioned in connection with older sets of other makes.

Flashing neon or fluorescent lights have reportedly caused false readings on some sets. The plasma reflects the radar waves variably as it is ionized and de-ionized. The T3 we tested has no such problem, but it's sensitivity appeared markedly reduced inside ETI's office under fluorescent lights.

What about nearby CB sets or other transmitters? We couldn't make our CB do it, but refering again to Fig.7. we'll explain how radar sets with insufficient RF rejection might respond.

Normally the Schottky receiving diode acts in such a way as to mix the received signals direct from transmitter and reflected from target. As such it is dealing with very small signals. However, if a very powerful AM signal was to arrive, got through the tuned cavity and landed on poor defenseless receiver diode, the high amplitude of said signal would cause the diode to rectify and detect the modulating signal. (Like crystal radio!) So, you stand near victim radar unit, switch on CB, whistle a 100 mph sine wave into the mike, and your unsuspecting neighbour is nabbed. Since 27 MHz is pretty far removed from 10.525GHz, we feel that you'll have to be pretty darn close to have much effect.

Fig. 8. The cosine error in action. Suppose A was 10 degrees, cos(10)=.985 , thus the reading would be 49.2mph. Even at 30 degrees, reading would be 43.3mph.

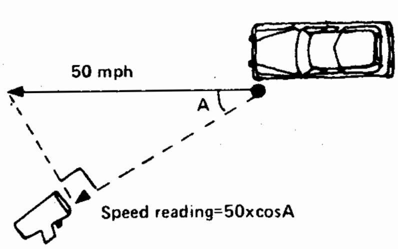
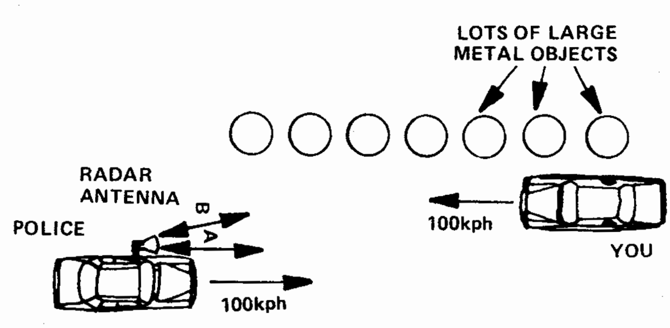


Fig. 9. Cosine error in moving radar situation.
A: Looks at you, at 0 degrees to direction of travel, reads your speed as coming toward police car at 200 kph (relative to police car!)
B: Supposed to look at road but is distracted by metal objects at side of road, reads police car speed as 100 kph x cos(8 degrees at worst) = 99 kph.
Subtracting, your speed looks like 101 kph instead of 100 kph. Oh dear.



The Tribar sets are fairly well protected against this sort of thing, and at worst will simply not give a reading. Tribar's "Operational Notes--Muni Quip T3" do caution officers against using AM transmitters while taking a reading for this reason.

More on this subject later.

ANGLE ERROR

Suppose that the radar is aimed at an angle to the roadway, it will still register a speed reading when you come along, but it only sees the component of your speed in it's direction (Fig.8). As you can see, the error is in your favour.

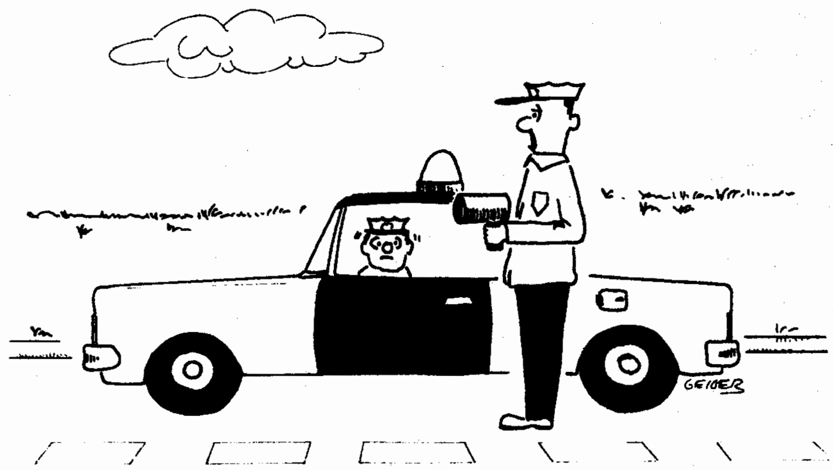
There is one case where it's not in your favour. Suppose a moving radar is being used in the "opposite direction" mode, looking at oncoming cars. Then it's possible to have a cosine error on the patrol speed. With a typical radar beam width of 8 degrees, Fig.9, shows the worst case error, with the antenna aimed 4 degrees off straight ahead. Unfortunately for you the error against you is only 1%, unlikely to get you off the hook as an excuse.

WRONG VEHICLE ERROR

Many speed meters respond to the strongest signal received, the T3 included, as you might guess from the diagram of it's front-end. (There is also some low frequency rejection.) Assuming yours is the only vehicle in range, the reading the operator sees is for your vehicle. Generally the strongest reading is for the closest vehicle, and thus you can really only be stopped if you are the only car, or the "lead vehicle", if a number of cars are involved. However, suppose you are cruising along at 80 kph in your Austin Mini, and a transport truck is hustling along at 100 kph about 200 yards behind as you enter a speed trap. It's very likely that the meter is going to read 100, and you just might wind up with the truck's ticket. And remember, the hypothetical truck could have been a vehicle going in the *other direction*! As we said, the speed meter does not distinguish between coming or going. On the other hand, with a beam width of 8 degrees it is possible to be fairly selective of lanes.

This type of error is even more important when dealing with the radar units which are less dependant on signal amplitude, such as the MDR-1 or Kustom Signals KR11.

In otherwords, you are very much dependent on the training and experience of the operator in making sure your speed was properly measured. Unfortunately, speeding ticket cases deal only very cursorily with this aspect.



Y'KNOW, THERE MAY BE SOME TRUTH TO THE RUMOUR THAT THESE RADAR SPEED DETECTORS ARE INACCURATE; I JUST CLOCKED A '63 CHEVY AT WARP FACTOR SEVEN.

If the officer says the meter read X, and he says it was your car, and he says he calibrated his set, then this is almost always accepted. After all, how many traffic court judges, or even defendants know the above facts? How many defendants checked the radar meters calibration when they were stopped? Etc. etc.

To top this off, police officers are not required to take a course in using the speed meter. Tribar recommends that they do, and even run such a course, complete with written material to educate the officers in proper usage. Tribar's Brimbecom says that police officers are supposed to be able to estimate speeds by eye, and Tribar's equipment is to be used to accurately verify that a suspected speeder is indeed breaking the law. In other words, it's not intended to simply be a fishing rod, dangled at the roadside awaiting a nibble.

OPERATOR INTERFERENCE

We now turn to the somewhat unpleasant topic of deliberate misuse to cause a false reading. While we don't like to think of our police officers as dishonest, the very fact that "quotas" of tickets are in some cases expected, might be enough to tempt those less than perfect humans on the force to some trickery. The public should at least be aware of the possibilities.

The most obvious way to create a false reading would be to take a reading off someone who is speeding, "remember" that reading on the radar unit and then await the next car to stick with a ticket. A high reading could also be made on the T3 for example, by the patrol vehicle driving at a high speed with the T3 aimed at the ground to get the high reading.

Then there are the test buttons giving readings of 25 or 100. (that would look a bit suspicious though!) Or there's the tuning fork, (but this too would be suspicious.)

At ETI we were able to generate any reading we wanted with a simple battery powered signal generator feeding a 3 inch speaker with household aluminum foil glued to its cone. Held in front of the radar unit, the T3 cooperatively showed anything we chose to dial up.

Maybe we should vote the police a raise to make sure they stay honest.

Evading A Radar Speeding Ticket

First, why are we going to look at ways of evading speeding tickets in the first place? There are several reasons: We think there are strong arguments that lowering speed limits to save gas is a very makeshift measure, and a very heavy handed one. For example, in the interests of gas conservation one should be allowed to speed downhill, to build up speed to go up the next incline. Yet where does one find speed traps? Right. Lower speed limits mean higher transportation costs for the goods we consume. Lower speed limits do *not* encourage the design of more energy efficient vehicles.

A very interesting article appeared in the Feb. 79 issue of "Car and Driver", entitled "The Cost of Going 55", written by Charles A. Lave, chairman of the economics department, and member of the Institute of Transportation Studies at the University of California--Irvine. (The article was apparently reprinted from Newsweek) He details the almost insignificant effects of the reduced speed limits in gasoline saving, and strongly supports an incentive scheme to get people into smaller and more fuel efficient cars. He says why not reward those driving more efficient cars by allowing them to drive faster? If this sort of scheme could be practicalized, it seems to be a much more civilized way of dealing with the problem.

We also object to the absolute faith the courts appear to place in radar evidence, inspite of the fact that the radar operator is not required to have any training. We also do not like the outlawing in some provinces of radar detectors--more on this later. So we'd like "the other side" ie: us, to have some more support.

Don't get us wrong however, we are not condoning fast driving where it may be dangerous. We believe that speed limits should guide the driver as to what is a safe speed. To make the limit less than that is to reduce the driver's respect for the limit, and cause him eventually to ignore all limits. This situation occurs already on certain expressways in Toronto, and no doubt in your town as well.

OK, so let's get down to how the speed meter can be evaded.

VARIOUS METHODS

There are various classes of evasion, which can be summarized as: Radar detectors; Make your car invisible; Passive methods of radar interference; Active methods of interference. Some of these are more or less illegal, and as we shall see, under Ontario's legislation all are illegal.

RADAR DETECTORS

Basically radar band receivers with a buzzer and light attached, these devices have been bought by the millions of drivers sufficiently interested in slowing down for radar traps. The "Fuzzbuster" (this is actually a brand name) is widely disliked by police forces for this reason, although certain forces reportedly consider them an asset, feeling they tend to make drivers go slower. Some areas have gone to the extreme of placing decoy radar transmitters along highways to set off motorists detectors, causing them to either slow down, or ignore their detectors.

Anyhow, detectors are considered by many motorists as great highway buddies, but if you're in the market for one, be aware that there are big variations in their effectiveness.

The most complete review of radar detectors we have seen was done by Car and Driver, again in their February 79 issue. They appear to have thoroughly tested, on both X and K band, all the detectors they could find. The report makes interesting reading. All we can add is why one design is better than others.

TO HET OR NOT TO HET

The major difference exists between so called "passive" detectors, and those employing superheterodyne circuitry. These two types are outlined in Figs. 10. and 11.

The other differences between detectors are principally in the sensitivity of the horn-receiving diode combination, and the ability of the signal processing circuitry to distinguishing between a radar signal and false alarms. Effectiveness of the warning light or buzzer, in other words, ease of use also enter the picture.

It appears that ultimately most radar detectors will be of the superhet variety, as it makes the difference between a detector that tells you in enough time to slow down, and one which tells you you're about to get caught.

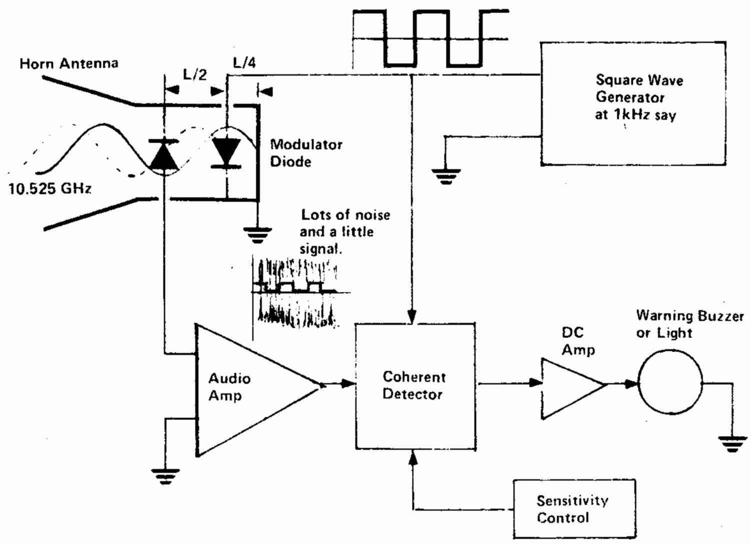


Fig. 10. "Passive" Radar Detector. In this design, a modulator diode is used to create a "false back" in the resonant cavity. When radar waves enter the antenna, standing waves occur in the cavity. If the modulator diode is switched off, the receiving diode is at a maximum. If the modulator diode is switched on, the receiving diode is at a minimum. The remainder of the circuitry detects this change in signal level occuring at the square wave generator frequency, which is only present if radar signals are picked up.

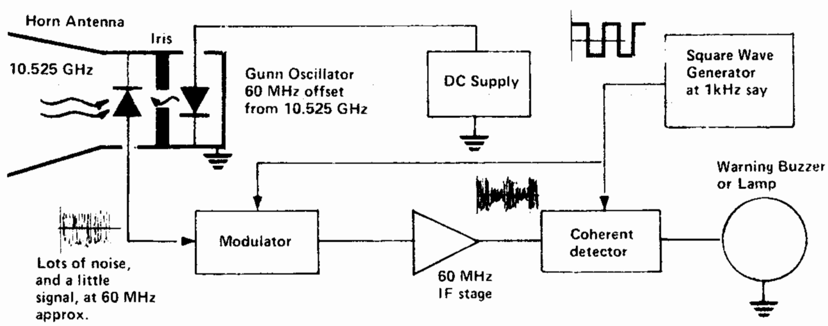


Fig. 11. "Superheterodyne" Radar Detector. This is as the name implies simply a version of the trusty old superhet principle. The Gunn diode provides a "local oscillator" signal which is mixed with the received signal at the receiver/mixing diode. This mixing, or multipling, results in a much easier-to-handle signal at 60MHz. The rest of the circuitry detects whether there is any signal present at this 60 MHz intermediate frequency.

In both this and the "passive" detector arrangement, K band detection can be added with a second horn, cavity and diode(s) assembly.

WHO'S WINNING

There are apparently new radar meters coming up whose beams are pulsed, and of course we already have those units which can be switched on instantly with trigger or pushbutton. Both are claimed to completely foil radar detectors, which of course they do if consistently used in these ways. Then there are the dummy radar transmitters. It appears that the deck is stacked on the side of the police's equipment.

Yet many people are using radar detectors, even in Ontario where they are illegal. We were quite amused to be able to slow down groups of cars by firing our borrowed T3 at them from a concealed location!

THE INVISIBLE CAR

For the radar to operate it is of course necessary for your car to reflect some of the radar beam, back towards the radar unit. So you could travel around in an all-plastic car, or one very low to the ground. Or you could try attaching metal surfaces to your vehicle at a very acute angle to the direction of travel, thereby deflecting the radar waves largely away from the radar unit. This approach definitely reduces your reflectivity somewhat, but how much we don't know. It *does* make your car more streamlined so you'll probably save gas though!

On the other hand, it is possible to obtain radar absorbing material, it's used by the airforce, and also by research establishments in making microwave "dark rooms". (Like an anechoic chamber, but for microwaves.) It looks like foam rubber, and it is impregnated with a conductive substance such as carbon particles. The impregnation varies from sparse to dense from the front to the back of the material, matching it electrically to the air. It's available in sheets and you can stick it all over the front of your car. Trouble is you can't stick it over the windshield, headlights, wheels etc, and it's murder in the car wash. But it does cut down your radar visibility. A good job might reduce your readable range to say half or quarter the distance.

You can also reduce the reflectivity by creating a surface such as that in Fig. 12. Sets of equal area reflective surfaces are placed so that one set is a half wavelength behind the other. Waves reflected from each of these will cancel. This is quite a practical idea, except you need one set of spacings for X Band (14.2 mm) and another for K Band (6.2 mm), however this may be arranged, with more levels of surface.

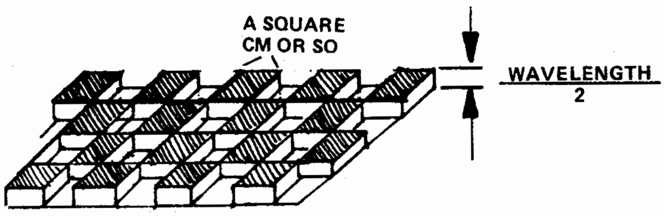
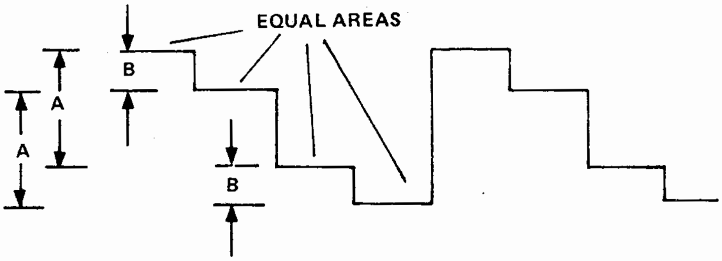


Fig. 12. Wave cancelling surface for one frequency (above). For multi-frequency operation arrange one pair of planes for each. (Lower) A is Wavelength "a" /2, and B is Wavelength "b"/2.



OK so you're cruising down the highway in your Alfa ZK 3000, loaded to the hilt with carbon sponge and radar absorbing surfaces, doing 120 kph, and behind you there's a Ford LTD at 140 kph. The radar can't see you, but the police sure can, and they'll assume the reading they're getting is from you, unless they take a real close look, and are also radar experts. You see the problem.

PASSIVE INTERFERENCE

A radar beam is heading for your car. Quick, how are you going to interfere with the reflection so as to give either no reading, or a ludicrously high reading on the meter?

The giant fan fixed on the roof is quickly ruled out. How about a surface of variable reflectance? This could be achieved in a couple of ways: mount hundreds of tiny dipoles, of length suitable for radar frequency, and alternately switch the centre load in and out, at a rate corresponding to say 100 kph. (This will add to your real speed). They just won't believe your 63 Valiant could be doing 197! Trouble is, you need two sets of dipoles, for X and K bands, and you're dealing with microwaves, so ordinary resistors, transistors and diodes just won't work. But it's a possibility.

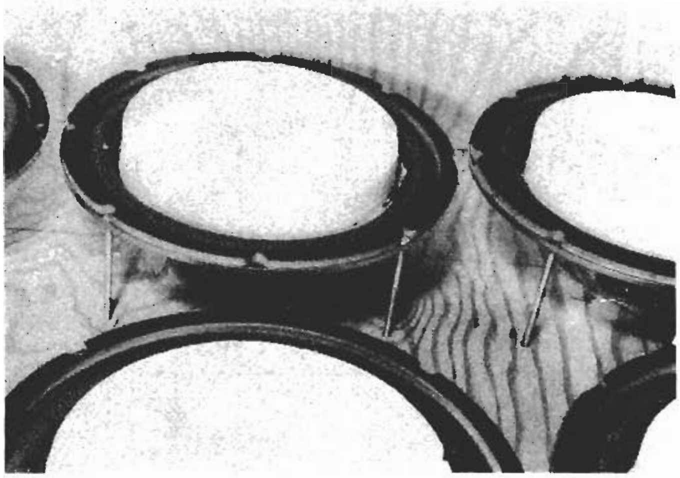
The other reflecting method is by a plasma screen, alternately ionized and de-ionized at sufficient high rate. Whole bunches of neon or fluorescent tubes might do the trick, but we unfortunately could not try this since we couldn't find a 2kHz power supply for them.

What about turning your car into a giant tuning fork? This looked like a possible, so we tried it. Twenty ten inch speakers were obtained and mounted in a 4' by 5' frame; suitable for mounting on the front of a VW van. (VW van was chosen since 40% of the ETI fleet are these, and they represent 100% of those vehicles capable of exceeding the speed limit).

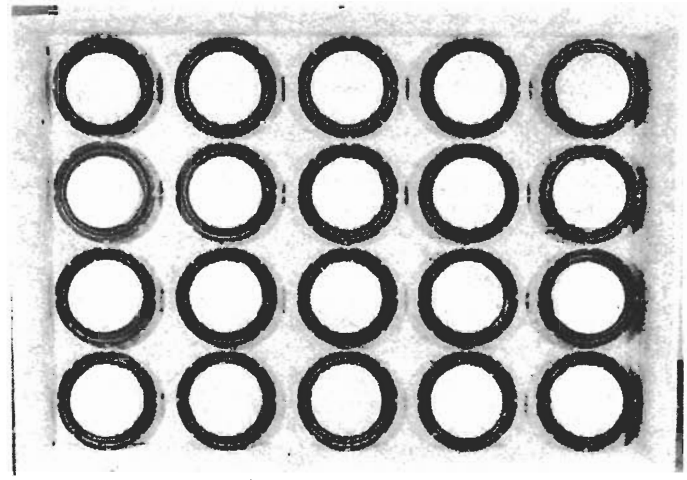
Next special styrofoam blocks were cut and glued to the speakers to turn the vibrating cones into vibrating flat surfaces. Finally, aluminum foil was glued to the front of the styrofoam.

This monster was tested on the ground, and we were able to get a "dial-your-own-speed" range of about 300 feet with a 50 watt amplifier driving it. (Fig.13) We decided that this was not sufficiently encouraging to go on with the "mobile" tests.

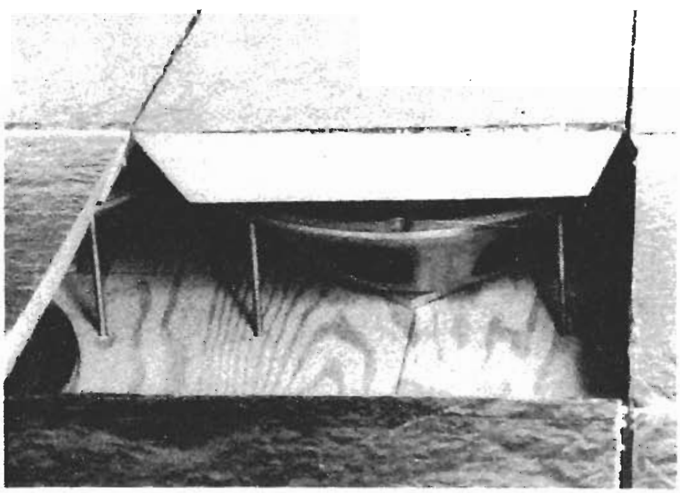
The major drawback with reflection modulators is that there will still be a large true speed component -- see Fig. 14. It is theoretically possible with a vibrating surface (analogous to FM) to completely eliminate the true speed component. However, this requires a relatively large surface deflection, not practical with loudspeakers, and very, very loud! Conclusion: reflection modulators are impractical. One thing is for sure though: with several hundred dollars worth of speakers on the front of their car, who's going to speed?



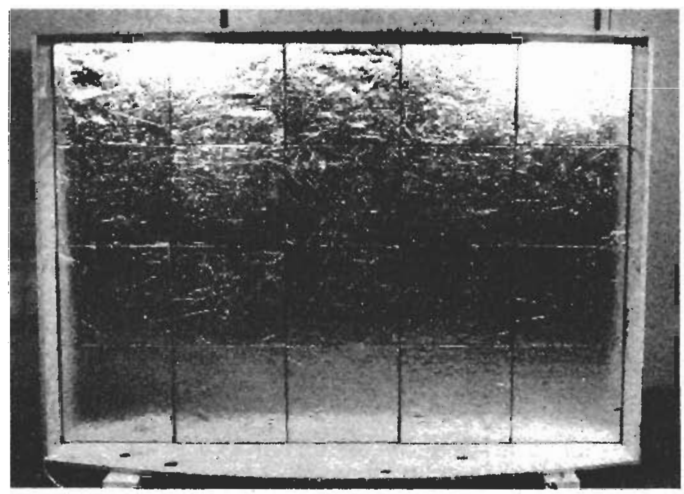
Close-up view of individual speaker mounting.



How it looked with all the speakers in place.



Speakers with styrofoam "cone-to-flat" adapters. Aluminum foil covers the front.



The final product. Specs: 50 kph at 1.73 kHz, 50 WRMS and 500ft.

Fig. 13. ETI speaker project? Wally wouldn't have approved. Twenty hefty ten inch speakers were bolted to a plywood frame, destined ultimately (we hoped) for the front of a VW van. It was a great idea while it lasted, unfortunately static results were not sufficiently encouraging to go all the way. We never did figure out how to hold the back wheels down . . . .

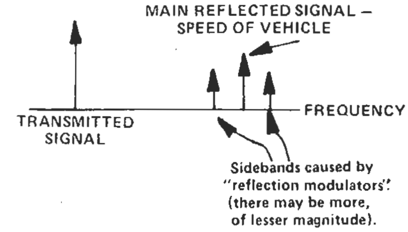
ACTIVE INTERFERENCE

We are of course talking about transmitters. These are of course relatively illegal. They have of course been built. We have heard such a unit is "commercially" available, but haven't seen it, though the principle is pretty straightforward.

The first thought would be to make an unmodulated transmitter which operates at an offset from 10.525 GHz representing whatever speed you like. This notion can quickly be discarded since we are talking about an offset of only a kHz or so, that is 0.000001GHz. Needless to say the radar unit is not going to be that dead on 10.525!

We've already seen how a CB radio could cause an erroneous reading. But it has to be very close since the signal is greatly attenuated going through the horn and resonant cavity system. So what about a transmitter operating at approximately 10.525 GHz, modulated by the speed signal of your choice. (See Fig.15) Being poweful it marches right into the radar receiver front end where the receiver diode demodulates the nice tone and out sprouts your legal speed reading. For added sophistication, couple your speedometer to the modulating signal generator to subtract a constant 20 or 30 mph from your actual speed. Be sure to turn off when parked. You'll also need one for X and one for K band.

Fig. 14. The problem with most reflection modulating schemes is that there will still be a dominant component from the actual speed.



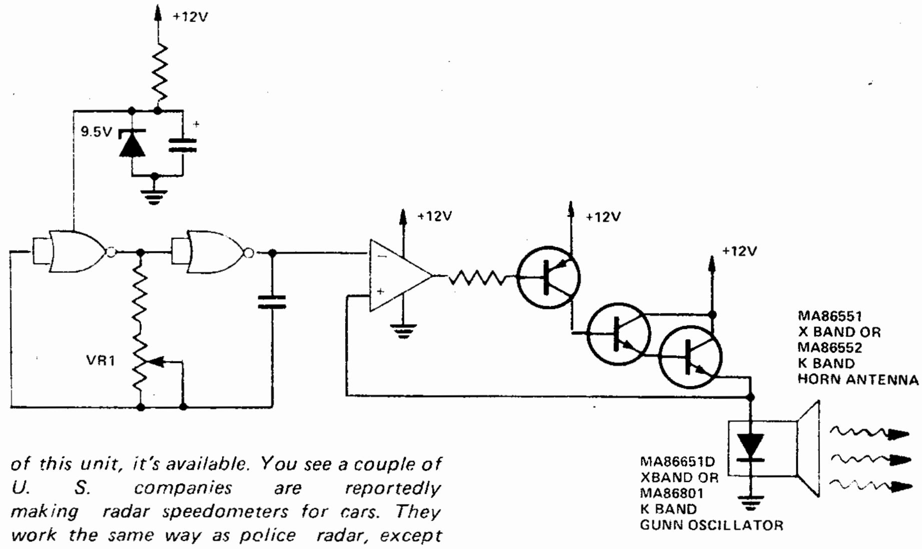


Fig. 15. 55 MPH FOR EVERYONE! This diagram shows the relevant parts of a microwave transmitter, pulse modulated at whatever frequency you like, up to several tens of kHz.

Adjusting VR1 so that the pulse frequency is 1.73 kHz, and an X band speed radar in the vicinity will read 55 mph. Or set it as you desire. You could even link it up to your speedometer to subtract 20 mph from your speed, or ??? Carrier frequency is not critical, for this purpose the radar meter receiver front end tuning, the cavity, is quite broadband.

Sophisticated moving radar speed meters however can be set to ignore legal speeds, and look only for illegal ones. We figure that if it picked up this signal it could ignore it, but the front end would be so overwhelmed that detection of other signals (your real speed) would be fairly unlikely.

The MA parts are made by Microwave Associates, available in Canada from M A Electronics Canada Ltd., 3135 Universal Drive Mississauga Ontario L4X 2E7.

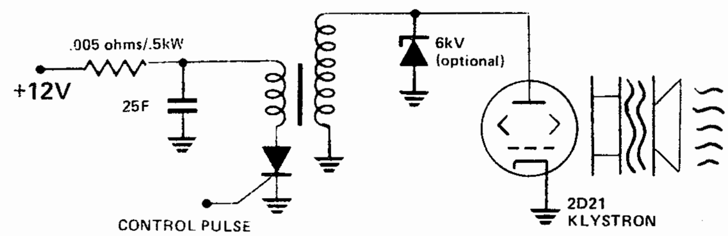
This transmitter is of course illegal as a transmitter, which is why we've deliberately left off some of the component values. If you fill them in you have only yourself to blame for getting in trouble with the DOC.

If you'd rather have a commercial version of this unit, it's available. You see a couple of U. S. companies are reportedly making radar speedometers for cars. They work the same way as police radar, except they look at the road, and the readout gives you your speed. There's a test button, which pulses the transmitter beam, so that the returning beam is modulated, and (when you're stationary) gives a readout that should be the one preset by the factory, thus verifying the operation of the system. And gee whiz, if one of those test speeds isn't 55 mph!

The do-it-your-self approach may be more attractive in the long run however, since you can select the transmitter power specs to suit your requirements.

NOTE: IF YOU ARE GOING TO PLAY WITH MICROWAVES, PLEASE BE AWARE OF THE CAUTIONS MENTIONED UNDER "MICROWAVE RADAR: IS IT SAFE?"

The Last Word: Rimmer's "Retaliator"



We asked Steve Rimmer what he thought, and he said ...

RADAR DETECTORS are, by and large, a passive, spineless sort of defense against the onslaught of the law. Radar "confusers" are better, but what is really called for here is a weapon of at least as much cunning as traffic radar itself. Outlined here is the REU, or Radar Evaporation Unit.

The REU is comprised of two units, these being the detector unit and the retaliatory unit. The detector is of the standard type, with which we are all familiar. The retaliatory system is really what makes the concept unique.

The system is built around the 2D21 klystron. While basically a low power tube, it can produce outputs of up to 55 KW at very short pulse durations with slow repitition rates. If directed in a relatively narrow beam, this power level is quite sufficient to completely evaporate any of the commonly used microwave detectors, as found in police radar sets, not to mention peeling the paint off the police car and melting its tires. God help anyone or anything that gets between the cops and your car when the thing lets loose.

The REU system is usually trunk mounted. It begins with a capacitor bank, which is used to provide the high energy pulses that power the klystron. The exact number of capacitors used will be determined largely by available space. About twenty five farads is the nominal value. These of course, are charged by the automobile's electrical system. A resistor may have to be inserted in the supply line to keep the charging current down below thirty amps so that the headlights don't dim out every time the thing fires a blast. Usually this is made by wrapping thirty feet of number three insulated bridge cable around a baseball bat.

When the capacitors are fully charged, they are discharged through the primary coil of a toroidal transformer by a standard 2Kilo-amp, 15 volt SCR. The transformer, however, requires considerable attention. The core is formed by packing approximately seventy five pounds of powdered ferrite and epoxy into an old tire and letting it harden. The ferrite powder can either be obtained from a neighbourhood powdered ferrite dealer, or by smashing up the cores from about 150,000 AM loopstick antenna coils. When hard, the core may be left in the tire, which acts to insulate the transformer against core shorts. If a steel belted radial tire is used, the belts may increase permeability slightly.

The primary of the transformer consists of three turns of four inch cold rolled steel bar around the core. The secondary is about ten thousand turns of insulated number three bridge cable. One side of the secondary is, of course, grounded, and the other is run directly to the klystron oscillator. For added stability, a forty amp, 6000 volt zener diode may be used to regulate the supply.

The microwave energy from the tube is brought to a roof mounted horn antenna by waveguide hardware. The antenna should be aimed toward the right hand side of the car, about fifty yards distant.

As a final point, it should be noted that motorists finding themselves stranded can cook with this little jewel. Just suspend your burgers, franks, or family pet in front of the horn and depress the "fire" button.

Triba r: Canadian Company Sells To The Orient

Thi: s is always a badge of success. Let's s start from the beginning.

On ce upon a time (since the fifties) there was a U.S. manufacturer of police radar, by the name of Muni Quip. They were hot on the trail of perfecting the first digital-readout unit (all solid state!) when financial problems folded the company.

Tribar's president George Payne was handling distribution of Muni Quip products in Canada, and recognized a good idea when he saw it. So in 1968 he took the idea and prototype to a friend of his by the name of Fritz Engler. Engler was to feature in Tribar's success, first working in his spare time to work the bugs out of Muni Quips unit, then to join Tribar as Chief Engineer.

Tribar kept the Muni Quip name, and through the years developed a number of different models. Most recently "moving radar" proved to be an enticing challenge.

The story goes that Engler went on a two week "family fishing trip" with an RCA 1802 COSMAC kit (fish 'n' chips?) to learn about microprocessors. Tack this onto an active programmable filter system (lots of op amps and analog switches), distil many thousand lines of program down to a 1K ROM, and there (eventually) he had it.

THE MDR-1 TOUGH PROBLEMS

Ross Brimbecom told us that one of their toughest problems has not been necessarily the electronics, but how to enable the electronics to survive the tough treatment it tends to get. The ultra-heavy duty case on the T3 certainly looks and feels like it would be difficult to damage, and the MDR-1 has a dense foam covering (similar to that used for car dash boards) unlike cheaper models of other manufacturers, Brimbecom warns.

We figure the other problem they had was getting the electronics into the boxes. Both T3 and MDR-1 were packaging delights.

A near future project is the transition to K-Band operation, where decreased size of antenna and associated hardware, means smaller overall bulk, and more convenience.

SALES AND EXPORTS

Tribar sells over 500 radar units per year, 60 to 70% of these go overseas to Europe, Africa and Asia.

The remainder are sold in Canada. What, none to the US? Brimbecom estimated a market of 2-3000 units per year to the US, yet few Tribar sets are sold there. This he says is because Tribar sets cost more than sets made in the US, although Brimbecom claims higher quality, reliability, and more features than comparable US made units. It's the problem of dealing with essentially uneducated buyers who can't tell, or don't care, that Tribar's may be better.

And, as we mentioned, while we chatted with Ross Brimbecom, he was directing (with his other ear and hand) the production of a large order of units for shipment to Taiwan. Nice going!

BUY OR RENT?

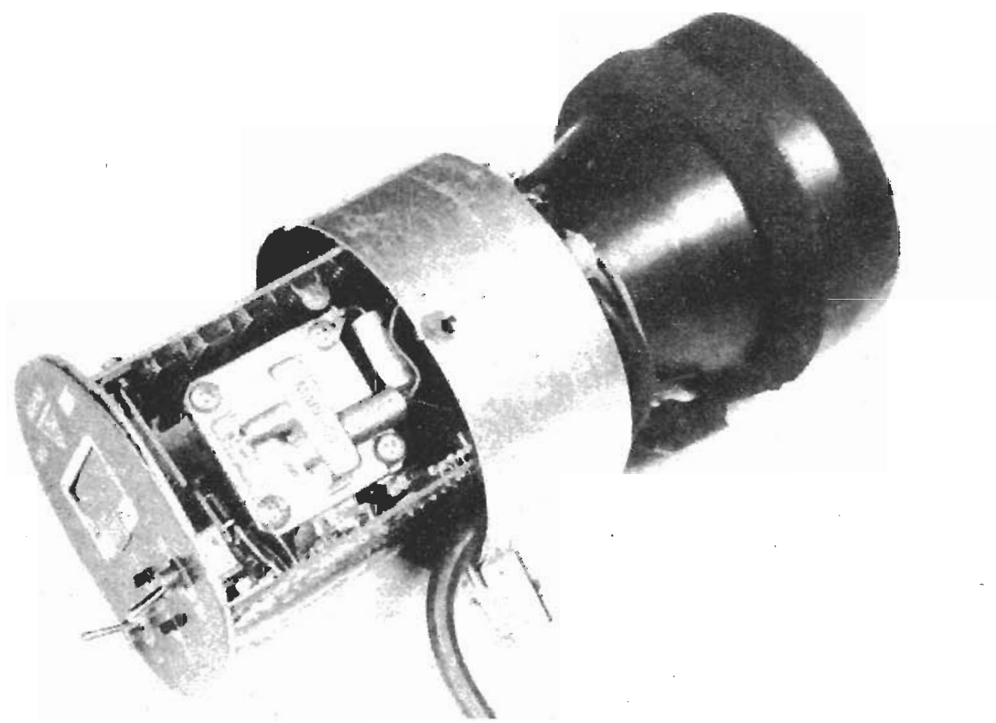
Interested in buying a set? You can get a T3 for about $1400, or how about an MDR-1 at $3000. At last, something your friends don't have! (You'll have to convince the DOC that you need a licence however.) A 2 year warranty is included, except for only 1 year on the Gunn diode, and 90 days on the receiving diode.

If you wish you (yes, anyone!) can rent a set for as little as $75 per week, or $150 per month, but be sure to book in advance. Contact Tribar Industries, 3650 Weston Road, Weston, Ontario M9L 1W2. (416) 749-6000.

WHO USES THEM?

Not only the police are interested in the speeds of things. Brimbecom reports that Tribar's units have been used for many purposes. These range from precisely measuring speeds of crop-dusting aircraft for correct spray adjustment, to the measurement of hockey puck speeds for the between-periods show on one of the network NHL series.

Radar systems have also been used in railway and ship speed measuring applications, and even for traffic light control.



Inside the T3: a packaging dream (nightmare?)

An Act To Amend The Highway Traffic Act ....

BILL 112 **1977**

HER MAJESTY, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows:

1. *The Highway Traffic Act*, being chapter 202 of the Revised Statutes of Ontario, 1970, is amended by adding thereto the following section: *s. 52a. enacted*

52*a*.—(1) In this section, "radar warning device" means any device or equipment designed or intended for use in a motor vehicle to warn the driver of the presence of radar speed measuring equipment in the vicinity and includes any device or equipment designed or intended for use in a motor vehicle to interfere with the transmissions of radar speed measuring equipment. *Interpretation*

(2) No person shall drive on a highway a motor vehicle that is equipped with or that carries or contains a radar warning device. *Radar warning device prohibited*

(3) A police officer may at any time, without a warrant, stop, enter and search a motor vehicle that he has reasonable grounds to believe is equipped with or carries or contains a radar warning device contrary to subsection 2 and may seize and take away any radar warning device found in or upon the motor vehicle. *Powers of police officer*

(4) Where a person is convicted of an offence under this section, any device seized under subsection 3 by means of which the offence was committed is forfeited to the Crown. *Forfeiture of device*

(5) Every person who contravenes subsection 2 is guilty of an offence and on summary conviction is liable to a fine of not less than $50 and not more than $500. *Penalty*

(6) Subsection 2 does not apply to a person who is transporting radar warning devices in sealed packages in a motor vehicle from a manufacturer to a consignee. *Exception*

WELL! Is that what Her Majesty thinks! Obviously not, but those acting in her name in several provinces do, and we find it very distasteful. There are a number of reasons why.

1. There is something basically sacred-feeling about the "right to receive", and a receiver is what a radar detector is. It's as basic somehow as freedom of speech. There are no other instances in North America of prohibition on radio reception. The U. S. F.C.C. agrees with this, and forced several states to drop their anti-radar-detector legislation, this being under Federal jurisdiction.

2. In Canada such a matter also comes under the jurisdiction of the Federal government we feel, (Department of Communications) and not the provincial government. This matter has been contested several times before, and this same conclusion reached. In the particular case of the Ontario Highway Traffic Act legislation, Lyntronics (Canadian distributors of the "Fuzzbuster") is funding the fight to again establish this point. In mid-September an appeal was heard from Lyntronics in the Divisional Court of the Supreme Court of Ontario. Lyntronics lost, because the judges felt that the use of a radar detector constituted a hazard analagous to having a TV set in the front seat of the car, also prohibited by the OHTA. No studies were quoted on the hazards caused by radar detectors. No attention was paid to the fact that the audio sense allows multiple inputs, while the video sense allows just one. Ie: we don't feel convinced.

3. We feel people should have the opportunity of avoiding radiation if they choose, whether deemed hazardous by the authorities or not.

4. We have already stated that radar operators are not required to take a training course, and hence the readings of these easy-to-use meters can be misinterpreted. Given that this state of affairs exists, we would like the opportunity of avoiding radar traps altogether.

5. The act is rather badly written with respect to technical points, and subject to large amounts of interpretation. For example, a device which would "interfere with the transmissions of radar . . ." is hardly a "radar warning device", yet it is sneaked in here.

And could one claim that one intended to use one's eyes to warn the driver about a radar trap, and consequently have them confiscated?

You probably didn't know that there is a precedent (albeit American) which establishes that it is illegal to warn oncoming motorists of a radar trap by flashing your lights.

And how is a police officer to know what is, or is not a "radar warning device"? Ham equipment can look quite similar. (A police officer is not for example expected to know if your vehicle is roadworthy, if he suspects not he sends you for a proper inspection by experts.)

This was clearly a difficult piece of legislation to implement. The government is not trying to stop people from speeding, it's trying to stop them from *not* speeding in radar traps. It's not even an attempt to stop a person from escaping justice for something illegal they were observed doing. It's an attempt to have the culprit continue breaking the law while the police are around, if that was what he was doing before.

May we draw the following analogy: Suppose a burglar intends to rob ten houses. It is found that such a burglar will stop robbing and run away when he hears police cars arriving. So the solution is to confiscate the ears from every citizen?

But ears are obviously of much greater value than radar detectors you argue? In this case we are using ears to represent the right to hear, and radar detectors to represent the right to "hear" radio waves. ie: to receive. Whether or not you agree with the use of radar detectors, the real issue is much larger than just this one piece of equipment. It smacks of the government having just a little too much say in our lives.

See also Bill Johnson's comments in QRM this month: the Ham's point-of-view.

Microwave Radar: Is It Safe?

No doubt you've heard the controversy over leakage from microwave ovens. So what about that radiation from the radar antenna, which after all is *designed* as a transmitter.

While we would be most amused to see the chaos caused if we announced that police officers were slowly being cooked by their speed meters, let's not get so alarmed yet.

First let's get one thing straight. MICROWAVE RADIATION HAS VERY LITTLE TO DO WITH NUCLEAR RADIATION! Electromagnetic radiation is divided into two classifications; "Ionizing radiation: that which can ionize molecules, and thus for example change the structure of human skin molecules; "Non-ionizing radiation": that which cannot change molecular structure. The Three-Mile Island scare was about the former, microwave radiation belongs to the latter class.

EFFECTS

Microwave radiation is well known for its heating ability. To get an idea of power levels involved in such heating, a typical diathermy treatment might expose the body to a power density of 100 to 500 mW/cm^2, applied for 10 to 20 minutes. A microwave oven concentrates 600 W on a piece of steak, for times in the minutes for cooking.

DAMAGE

Damage which may result to the body from excessive exposure is in the form of burns to the cells of the skin, eye or whatever, either on the surface, or below it. Some damage, such as eye cataracts may be irreversible. According to the International Microwave Power Institute "Microwave Safety: Hazards in Perspective" (IS-2 Dec 75) it is thought at least 100mW/cm^2 applied for many minutes is required to produce such damage. Levels around 10mW/cm^2 may be felt but are not hazardous.

Also according to the IMPI report, certain Eastern European standards associations allege that temporary headaches and irritability may result from microwave exposure at even very low levels.

STANDARDS

Probably the most well known safety standard is that of the American National Standards Institute, known as C95.1. It specifies a safe unlimited duration exposure level for the whole body as 10mW/cm^2; or for any 0.1 hour period 1 mW-hour/cm^2. This they believe is at least a factor of ten below damaging levels.

In Canada, we have a safety code put out by Health and Welfare-Canada, called "Safety Code-6: recommended safety procedures for the installation and use of radio frequency and microwave devices in the frequency range 10MHz--300GHz".

This code specifically does not apply to portable transmitters of less than 50W output , but there is no reason why the *power density* (mW/cm^2) warnings should not be heeded. In fact, no reason is given why lower power units are not included, which is surprising when you consider that the smaller units, such as police radar, are easy to stand next to or lean against.

The relevant parts of this standard are given in Fig.16, which gives, for example a limit of 1mW/cm^2 for the general public.

Fig. 16 Maximum exposure levels established by Health and Welfare Canada, 1 GHz to 300 GHz.

	Microwave Workers	*General Public*
Whole or partial body (except extremities) 1 hour average	*5 mW/cm^2*	
Same, but 1 minute ave.	*25 mW/cm^2*	*1 mW/cm^2*

Finally, Eastern European limits go as low as a long-term average of .01mW /cm^2 exposure. As usual, no one has the definitive answer as to how much for how long is bad for you.

RADAR OUTPUT

Referring to Fig.17, this gives an area covered by the radiation of 100 mW, and the corresponding power per square cm. This is the "power density", the figure measured for safety regulations.

Actual power densities will be slightly lower than these calculated values, since a small part of the transmitted power falls outside the 16 degree cone.

d, Distance (cm)	*Area, A (cm^2)*	*Power Density (mW/cm^2)*
15	*14*	*7.16*
18	*20*	*5.0*
30	*56*	*1.78*
40	*100*	*1*
400	*10000*	*.01*

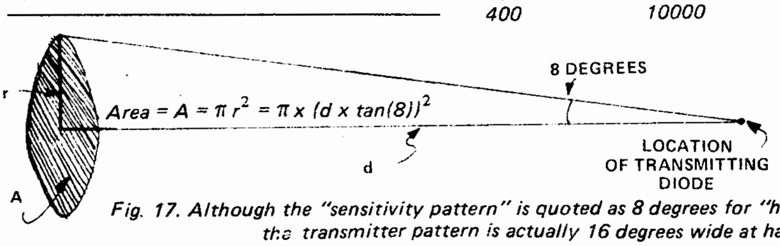


Fig. 17. Although the "sensitivity pattern" is quoted as 8 degrees for "half effectiveness", the transmitter pattern is actually 16 degrees wide at half power points.

As can be seen the power levels are not immediately dangerous, but at close distances do excede some of the "Code-6" safety standards.

The plastic covered front of the "radome", radar antenna assembly is at about 15cm, this is the closest you can get to the radiating source. At this position the power density is some 7mW/cm^2, exceeding two of the "safety code 6" standards mentioned. At about 40 cm all North American standards are met, and at 4 meters (12 feet) even the East Europeans would be satisfied.

DANGER?

So is a radar unit dangerous? We've never heard any complaints, and it seems to us that radar can be operated with complete safety. However we would like to recommend certain procedures in handling radar units, so as not to subject oneself to radiation levels felt by safety authorities to be of "unknown" safety, to be absolutely sure.

1. Do not leave the radar operating when you don't need to. (It wears it out anyway, particularly the receiving diode.)
2. Do not operate the radar transmitter with your body in front of it. Especially avoid cradling an operating radar gun in your lap, or leaning against the outside of the patrol car with the antenna pointing at you, or your "customer", as examples.
3. Avoid operating the radar inside a vehicle in a position where excessive amounts of the radar beam can reflect back (from metal work) at your body. (This again will shorten the life of the receiving diode anyway.)

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